3RD EDITION

BIG BLUE BOOK OF BICYCLE REPAIR

By C. Calvin Jones

BBB-3

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OF BICYCLE REPAIR

A Do-It Yourself Bicycle Repair Guide from Park Tool

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Park Tool Company

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Special thanks to the manufacturers of components and bicycles featured within this publication.

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Park Tool®

The year was 1956. My father Howard and his partner Art Engstrom had just bought a small fix-it shop on the east side of St. Paul, Minnesota, named Hazel Park Radio and Bicycle. Both loved to get their hand dirty. So the shop seemed to be a good fit with their skills. Along with the lawn mowers and ice skates, the shop sold bicycles, although neither new much about bikes. As they dug in to their new venture and bicycles evolved to include hand brakes and shifting systems, Howard and Art soon tired of working on bikes turned upside down while squatting on the floor. With the help of a longtime friend, Jim Johnson, they designed their first bicycle repair stand. Soon, they realized there was a need for other tools that could make their lives easier, and a tool business was born. At first Howard and Art produced tools under the Schwinn label, then shortened Hazel Park Cycle Center Repair Stand Company into Park Tool Company. So begins our history.

Today, Park Tool produces and supplies over 400 different bicycle specialty tools to more than 70 countries worldwide. Go into any bike shop in America or just about any shop around the globe, and you'll find our famous Park Tool Blue tools in use in the back room and for sale on the showroom floor. Our goal is simple: Build the best bicycle tools. We are constantly improving and expanding our line to meet the expectations of team and professional mechanics as well as those doing their own work at home or on the trail.

This, the third edition of our Big Blue Book contains new chapters, new photos and most importantly advice and mechanical procedures using some of the newest components and parts available alongside hundreds of other repairs and basic maintenance instruction. While we love to sell tools, we feel strongly that information and knowledge are the most valuable tools of all. Once you gain some of this knowledge and the confidence to use it, a whole new side of bicycling opens up to you. With a basic understanding of the bicycle and how it works you'll be free to ride longer and farther. You'll understand what makes one bike or one component better than another. You may even take apart your bike and put it back together just for fun. This manual is designed to give you a complete, well-rounded look at the mechanics of a bicycle. We've designed the BBB-3 to help guide you through a wide variety of repairs from flat tires to bearing replacement; from repairing a chain to lacing spokes; and from truing a wheel to dropping in a headset. Road or mountain, recumbent or kids bike, tandem or city bike, whatever you ride, we've included information that can help you maintain or repair your bike.

Our author, Calvin Jones, is truly one of the world's most qualified mechanics and instructors. With over 40 years in the industry, Calvin lives, eats, and breathes bicycles. Here is a short list of his qualifications:

- US Olympic Team Mechanic, Los Angeles 1984
- 15-time National Team Mechanic and Manager of National Team Mechanics at MTB World Championships
- Instructor at USA Cycling Mechanics Licensing Clinics at the U.S. Olympic Training Center in Colorado Springs, Colorado since 1985
- Eight years instructor at Barnett's Bicycle Institute for Bicycle Mechanics
- Author, Park Tool School Manual: Park Tool's in-store clinic presented by your local bike shop
- Park Tool Director of Education since 1997
- Mechanical advisor for countless bicycle industry manufacturers, professional racing teams, and retailers

We're sure you'll agree that Calvin has done his homework and created a complete and concise manual. It's sure to be a reference for nearly any mechanical procedure you choose to tackle. This is the book Howard and Art could only dream would ever be written. With a special thanks to Calvin for all his hard work, late nights and early mornings we're proud to present the 3rd Edition of The Big Blue Book of Bicycle Repair.

Eric Hawkins
Owner
Park Tool Company

I think the bicycle is possibly the perfect combination of simplicity and complexity. To me, it is more than just a vehicle that transforms your muscular energy into motion. The bicycle provides transportation, exercise, a way to escape, and a way to be together with friends. I view the bicycle itself as a system of numerous levers, bearings, pivots, and parts that require proper care and maintenance. I know that if you don't have a basic understanding of these parts and how they all work together, fixing your bike can be intimidating, but I also know that gaining that understanding is easier than you think. Knowledge of the mechanics of the bicycle will change the way you ride. It gives you the confidence to ride longer and farther, the skills to do trail or roadside repairs, and the ability to maintain your bike yourself and get it ready for the next ride.

Whether you own a single, high-end bike or a fleet of bikes for the family, the third edition of the Big Blue Book of Bicycle Repair is designed to help you, the home mechanic, keep your equipment in top-notch condition. This book is a natural for Park Tool Company, where we've been designing and manufacturing bicycle tools for professional and home mechanics since 1963. Now, with the Big Blue Book 3, we are giving you more than five decades of knowledge about bicycle repair in one comprehensive, easy-to-use manual.

This latest Big Blue Book of Bicycle Repair-3 is updated with information on the newest technologies. The modern crank and bottom bracket standards and their service are reviewed in this edition. We cover the new and major changes in derailleurs, such as 11-speed systems, and the new electronic shifting systems from Campagnolo® and Shimano®. Thru-axle hubs are now more popular, so we include them in this edition. Brake systems are also updated and expanded. You will also find more information on headsets than in earlier editions. The headset was once a simple system, which has now become complex with many different standards.

You can find specifics for your repair and the relevant page number at the beginning of the book in the detailed Table of Contents. The book is organized by "systems" rather than by type of bike, such as "MTB" or "Road Bike." Both mountain bikes and road bikes have crank systems, and both types are covered in the same chapter.

Creating a bicycle repair book is like creating a new bicycle tool. It takes time and effort and the process is never as straightforward as one would hope. I want to thank Eric Hawkins, owner and President of Park Tool Company, for his continued support and patience as we worked through this new edition of Big Blue. My editor, Bill Gibson, and our Park Tool Graphic Artist, Joel King, were indispensable in this project. I have also received invaluable help and advice from the technical representatives at Mavic®, Shimano®, Campagnolo®, SRAM®, and FSA® regarding the proper procedures to use when preparing or maintaining their products. I also want to thank everyone who emailed or called me with feedback. It makes each edition better when we hear from readers.

Thanks for purchasing the BBB-3 Big Blue Book of Bicycle Repair. This edition carries on as the most comprehensive and easy-to-use bicycle repair manual we have ever published.

Calvin Jones
Park Tool Company

CHAPTER 1

BASIC MECHANICAL SKILLS

Equipment and machinery of all types share many commonalities. Leverage, friction, tension, material strength, and bonding are all parts of automobiles, coffee makers, satellites, and bicycles. Understanding some basic concepts of engineering will help you understand and service any equipment or bicycle.

THREADED FASTENER TENSION & TORQUE

Manufacturers use threaded fasteners to hold many components to the bike, and the bike itself can act as a nut for certain threaded parts. Understanding threaded fasteners (i.e., bolts and screws) is an important part of bicycle maintenance. These fasteners are made of two parts: the external thread, which is the bolt or screw, and the internal thread, which is the nut.

It is important to align threads correctly when you first begin to engage the inner and outer threads. The critical threads are the first ones, and damaging these threads from misalignment can make the component very difficult to install. Take note of the axis of both inner and outer threads and make sure you are rotating the parts square to this axis. One technique for beginning a difficult-to-start thread is to purposely rotate the threaded part backwards to feel the first thread engagement. You will feel a click or give in the part, which tells you this is the beginning of the thread. Rotate in the correct direction after this.

Threads are made in many different sizes. Bolts that appear identical may actually be made for different nuts or fittings. The size of the thread is designated and named by the nominal external thread diameter and pitch of the thread. Thread diameter is measured from the outside to outside of the thread crest. However, the actual, and accurate, measurement is slightly smaller than the common name for the thread size. For example, a ½ inch thread may measure 0.495 inches, not 0.500 inches. It is still referred to as a ½ inch thread.

Metric thread sizing is given in millimeters and given the prefix "M." For example, the M6 thread would measure between 5.8 mm and 5.9 mm.

The pitch is the distance from the crest of one thread to another measured along the length of the thread. Thread diameter can be measured with a caliper, but pitch is best measured with a thread pitch gauge.

The so-called "English" or SAE (Society of Automotive Engineers) threads are designated by the frequency of how many threads are counted along one inch. This is called "threads per inch" and is abbreviated as "tpi." An example of an SAE thread is 9⁄16 in. x 20 tpi (for pedal threads). Metric threading uses the direct pitch measurement in millimeters from thread crest to the adjacent thread crest measured along the thread axis. An example of metric thread would be 10 mm x 1 mm (common rear derailleur bolt).

Threads are made to advance as they rotate. Many threaded fasteners, but not all, tighten when turned clockwise. These are called "right-hand threads." Some threads on the bicycle are made to advance and tighten when turned counter-clockwise and are called "left-hand threads." All threads are made at a slight angle when viewed along the axis of the thread. If the threaded bolt or screw is held vertically, the threads will appear to slope upward toward the bolt's tightening direction. Right-hand threads slope upward to the right, and left-hand threads slope upward to the left (figure 1.1).

FIGURE 1.1

Left-hand threads are seen on left pedal and right-hand threads on right pedal. Threads slope upward toward direction of tightening.

As a fastener is tightened, the fastener and the threads actually flex and stretch, much like a rubber band. This stretching is not permanent. It gives force to the joint, holding it together (figure 1.2). The stretching force is called "preload" or tension. Each fastener is designed for a certain range of tension. Too much tightening will deform the threads or damage the parts. However, a fastener with too little preload will loosen with use, which in some cases can also damage the part. For example, riding with a loose crank bolt will eventually damage the crank. Loose bolts and nuts are also a common source of creaking noises on the bike as the component parts move and rub one another.

FIGURE 1.2

Crank bolts under tension keeps the crank pressed secure to the spindle

Typically it is necessary to lubricate threads. Without being lubricated, the internal and external threads of a fastener rub and scrape together, sticking temporarily, rather than smoothly and fully tightening to create a level of tension in the bolt that holds the fastener firmly until you disassemble it. Lubrication also aids in preventing corrosion. As a rule of thumb, if the threads are relatively small with a fine thread pitch, a liquid lubricant is adequate. If the thread size is relatively large, grease is preferred. For example, a small bolt holding a derailleur shift wire can be oiled, but the large threads of pedals should be greased.

There are exceptions to always lubricating a thread. Either the internal or external thread may have nylon fittings, commonly called "Nylock." The nylon insert in the thread prevents the screw or bolt from turning freely. Nylock systems are used for adjustments when there is low torque or even no torque on the fastener. For example, derailleur limit screws use plastic fittings to prevent the screws from turning and changing the derailleur adjustment. Do not lubricate the limit screws.

Generally, bolts and nuts should be tightened as tight as the weakest member of the bolt-nut component system can withstand. For example, crank bolts are large and can take a very high torque. Cranks, however, are typically made from aluminum and cannot withstand as much pressure as the bolt could potentially generate. The crank is the weak link in that system, and manufacturers limit the recommended torque accordingly.

To prevent overtightening and undertightening, many manufacturers provide specific torque values, best achieved by using a torque wrench (figure 1.3). Torque wrenches are simply a type of measuring tool, like a tape measure or a ruler. Torque wrenches measure the amount of turning effort applied to the bolt or nut. A torque wrench should be part of the bicycle tool kit, but it is possible to work without one at some risk.

FIGURE 1.3

A beam type torque wrench

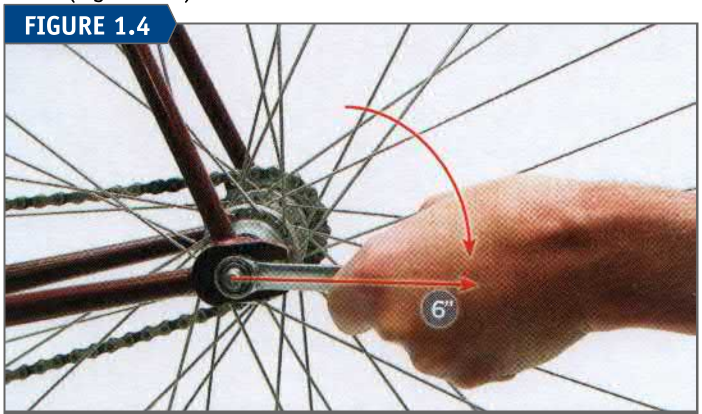
Measured torque may be given in Newton-meter, inch-pound, or foot-pound units. These units of measure refer to the force at the end of a lever. For example, 60 inch-pounds are equal to 60 pounds of force at the end of a 1 inch wrench. If the wrench were 2 inches long, 30 pounds of force would be required to achieve the same torque on the bolt. If force were applied at 12 inches from the bolt, only 5 pounds of effort would be required.

To convert inch-pound units into foot-pound units, divide the inch-pound number by 12. For example, 60 inch-pounds of torque are equal to 5 foot-pounds. To convert foot-pound units into inch-pounds, multiply foot-pounds by 12. Three foot-pounds are equal to 36 inch-pounds. To convert Newton-meters to inch-pounds, multiply Newton-meters by 8.85. There is a list of recommended torque specifications in Appendix C. Use the component manufacturer's recommended torque when available.

With experience, a person may learn the amount of force to apply to a wrench when tightening a fastener. It may require both overtightening and then undertightening fasteners in order to learn acceptable torques. Tightening by feel relies on "perceived effort" and is an important skill to develop and understand. Perceived effort is subjective and will change with the length of the tool used and where the hand holds the tool. Think about lifting a six-pack of 12 ounce beverage cans. The six-pack weighs approximately 4.7 pounds. This effort applied to a wrench held 6 inches from the bolt is about 30 inch-pounds of torque, just about what is required to tighten a derailleur cable pinch bolt. Now consider hefting, with one hand, a 24 count case of 12 ounce beverage cans. Typically, that effort will be close to 20 pounds. That much effort on a wrench held 6 inches from the bolt is 120 inch-pounds, approximately the amount of torque required for hub cone locknuts and a minimum torque for pedal threads. Cranks with a single bolt typically require about 300–400 inch-pounds, which is one of the highest torque values on a bicycle. That is at least 50 pounds of effort holding a wrench 6 inches from the crank bolt.

If you are not using a torque wrench, it is still useful to use torque values as a guideline for perceived effort. To determine the effort, divide the inch-pound torque by the number of inches from the middle of your hand to the bolt or nut. For example, in the image below, a 300 inch-pound torque is desired to hold the wheel to the frame. The hand is holding a wrench 6 inches from the nut. Apply an effort of 50 pounds force (figure 1.4).

FIGURE 1.4



Apply force to wrench according to distance from hand to bolt

FIGURE 1.5

Poor mechanical advantage

It is very useful to understand the concept of "mechanical advantage" especially when working on tight bolts and nuts. The wrench acts as a lever that pivots on the bolt or nut. In situations where two wrenches are used, position the wrenches to form a "V," with the bolt or nut at the point

FIGURE 1.6

Good mechanical advantage

of the "V." This position allows more force to be applied effectively to the bolt head. Avoid positioning the wrench so the levers form an angle greater than 90 degrees. When using one wrench, look for the second lever. This will sometimes be in the form of the opposite crank when working on pedals or the frame tubing while working on the bottom bracket (figure 1.5 and 1.6).

LUBRICATION, THREADLOCKERS, & CLEANERS

Bicycles require various types of lubricants depending upon the component part and how it is used. Lubricants vary in how well they work, what they are composed of, and how they are sold.

Lubrication prevents friction and corrosion, including rust. Engines use motor oil under pressure to ensure that pistons and bearings run smoothly. The car engine has pumps to maintain oil pressure to keep friction between parts low. That's a luxury the self-propelled cyclist cannot afford. Lubrication on bicycles is based on a much simpler system called "boundary lubrication," which refers to a very thin film of lubricant that separates moving bearing surfaces. This boundary of just a few molecules of lubrication is all we have to prevent metal from being ripped off a hub bearing or chain rivet.

A good lubricant should stick to the part requiring lubrication. Unfortunately, that means dirt and grit may want to stick to the part as well. Water tends to wash off lubricants. Liquids such as chain lubricants vary in their resistance to being washed off. It is useful to have available several lubrication choices. A light liquid lubricant will penetrate easier into smaller areas, such as derailleur cable housing. Examples of a light lubricant are Park Tool CL-1 Synthetic Blend Chain Lube and Triflow®. Heavy lubricants stick better in very wet conditions and are good for lubrication where grease is not useful. A chain used in the rain or the internals of a freehub would be good areas for a heavier lubricant. An example of a heavy lubricant would be Phil Wood™ Tenacious Oil™, or Finish Line™ Cross Country™.

Grease is simply oil suspended in a mixture of surfactant, soap, or other compounds. Grease keeps the lubricating oil in place on the component part, but it is the oil in the grease that provides the lubrication. When grease gets pushed out of the way of the bearings, there will be little or no lubrication left. Grease should be changed when it becomes contaminated with grit and dirt or when the oil in the grease becomes old and dry, which reduces its lubricating properties. Water may also wash out grease; the bottom bracket bearings are especially vulnerable to this type of failure.

It can be difficult to know when the grease used in the component parts is contaminated. It will be necessary to simply disassemble a hub or part and inspect. By the time a bearing is making noise, the damage from poor lubrication is already done. As a rule of thumb, the grease should be replaced once a year. If the bike is used for racing or ridden daily, replace the grease two to three times per year.

Grease is commonly sold in tubes or in tubs. Use care to always replace the lid when using the tub so the grease does not become contaminated. Liquid lubricants come in spray aerosol and non-aerosol bottles. The non-aerosol bottles use a tube for dripping the lubricant, which allows the user to place it where it does the most good. Aerosols can easily over-lubricate parts by spraying too much lubrication, but they can be helpful when flushing away dirt. If the bike is ridden in heavy rain, taken through stream crossings, or is washed with soap and water, liquid lubricants should be applied to suspension pivot points. Do not drip or spray oil into greased bearings such as hubs, headsets, and bottom brackets.

Another option for thread preparation and some press fit parts is anti-seize compound. This provides a thick and durable coating for surfaces. Anti-seize solutions are typically made of ground metals such as aluminum or copper that are combined with lubricants. These compounds are not appropriate for moving bearing surfaces such as hubs or headset bearings. Anti-seize compound, such as Park Tool ASC-1 Anti-Seize Compound, tend to outlast grease when exposed to water and makes a long lasting preparation for applications such as bottom bracket shell installations.

Threadlockers and retaining compounds are special liquid adhesives for metal fasteners and fittings. These liquids are available at home improvement centers, hardware stores, or automotive parts stores. Threadlockers are made by the Loctite® Corporation, the Wurth® Company, ND Industries®, and the Devcon® Company. Retailers commonly sell a type of threadlocker called "anaerobic." These liquids cure independently of air and will harden and expand when sealed in the threads of the part. This process is what gives the threadlockers and compounds their special features. It should be stressed, however, that these products should not be used to replace proper torque and pre-load when the clamping load is important. Most threadlockers are designed for use with metals. They may harden and weaken plastic and generally are not intended for that material.

Lighter duty threadlockers are considered "service removable." This means the part can be unthreaded and removed with normal service procedures. An example of a service removable threadlocker is Loctite® 242®. Stronger compounds require extra procedures to disassemble the part, such as treating with a heat gun. In a pinch, even hot water poured on the part can be enough heat to soften the compound.

Retaining compounds are intended for press fit applications. On a bicycle, they may be used for poor cartridge bearing press fits and poor headset cup fits. Retaining compounds tend to have a higher viscosity than the threadlocking compounds. Many retaining compounds require special techniques for removal, such as excess force or mild heat or both. An example of a retaining compound is Loctite® 680.

Retaining compounds are less effective for plastic or carbon fiber press fit situations. When attempting to use a retaining compound, such as on a PF30 bottom bracket press fit, use the special liquid primers from the compound manufacturers, following their directions. These primers allow the compounds to harden and expand. Without use of the primer, the compounds may simply remain liquid and not cure.

Another compound useful on carbon fiber bikes is an "assembly compound," such as Park Tool SAC-2 Super Assembly Compound. These are basically a silicon dioxide (sand-like) material in a liquid or paste carrier. Do not confuse this with grease: it is not lubrication and should never be used as lubrication! It provides extra friction wherever it is placed and can be useful in seat tubes of carbon fiber that have difficulty holding the seat post secure. It can also be useful in clamping a front derailleur bracket to a carbon frame. The grit in this compound will not structurally harm carbon fiber, but you should expect some surface marring.

Servicing bicycle components, such as the chain, will require cleaners and solvents. Never use highly flammable liquids such as gasoline, kerosene, or diesel as cleaning solvent. There are safer solvent choices on the market, including Park Tool CB-2 Chain and Parts Cleaning fluid.

It is possible to reuse solvents for an extended period of time. Save used solvent in a sealed container and allow it to settle for days. The dirt and grit will settle to the bottom. Carefully pour off the solvent and reuse. Scrape the grit from the bottom and dispose of it and spent solvent by contacting your local hazardous waste disposal site, which is typically with a state or county agency.

For cleaning the paint on the frame use mild cleaners, such as window cleaners, or simply soap and water. Isopropyl rubbing alcohol is usually adequate for cleaning rim-braking surfaces. It is important that cleaners for braking surfaces not leave an oily film.

BEARING SYSTEMS

Bearing systems on bikes typically use ball bearings. Round ball bearings are trapped between two bearing surfaces, called races. The two basic ball bearing systems are cartridge bearing systems and adjustable "cup and cone" bearing systems. Neither system is inherently better for use on a bicycle. Adjustable-type systems can be overhauled by disassembly, inspection, and re-greasing.

Even the highest quality bearing surfaces will have slight marks and imperfections from grinding as they are manufactured. Better quality bearing surfaces are ground smoother and will have less friction and resistance to turning. All bearings, however, will have some friction as they rotate. This is normal and does not significantly affect the ride. Generally, the lighter load a bearing is expected to experience, the "smoother" the feel of that bearing. Bearing systems experiencing more stress and pressure will seem to have more drag, even when the adjustment is correct. For example, a bearing for a rear derailleur pulley, which is designed for low stress loads, will seem to have less spinning resistance compared to a bottom bracket bearing, which is designed to handle more load.

The races and balls are greased to minimize wear. The bearing system is commonly shielded from dirt by covers and seals. Exposure to the elements will increase wear on the bearing surfaces and shorten bearing life.

Cartridge bearings use an industrial, or rolling element, bearing. Ball bearings are trapped between inner and outer rotating races (figure 1.7). There should be no play between new bearings at the inner and outer races of the cartridge. With use, however, play will develop between these two races, and then the cartridge bearing must be replaced.

FIGURE 1.7

Typical cartridge bearing shown with outer race cut away. Ball bearings ride on inner and outer curved races.

FIGURE 1.8

Lift cartridge bearing seals from the inside edge to remove and clean bearing

Cartridge-type systems are designed to be disposable and rely on replacement of the entire cartridge bearing rather than cleaning and greasing the existing bearing. However, if the axle or spindle can be removed from the center of the bearing, it is often possible to lift the seal from the inside lip and flush the bearings clean with a solvent (figure 1.8). The bearing should be blown dry and repacked with grease. Return the seal and press into place. If the axle or spindle cannot be removed, it will damage the seal to remove it.

DIAGNOSING & SOLVING MECHANICAL PROBLEMS

As you develop mechanical skills and become more experienced with the technical side of the bicycle, diagnosing particular problems will become easier. To learn this skill, begin by paying attention to your bike while you ride and become accustomed to how it sounds and feels when things are operating properly.

A basic component of diagnosing and discussing technical or mechanical issues is knowing the names of the component parts. Being familiar with what shop mechanics call a part will enable you to converse and provide useful information. Appendix E is a Bike Map, showing the common names of the various component parts of the bike. Additionally, a glossary of bicycle specific terms can be found in Appendix B.

Diagnosing from the saddle, while riding, can be quite useful when repairing the problem later. For example, note if an unusual noise is repetitive or occurs with every pedal revolution. This would place the problem in the crankset area, like the pedal, bottom bracket, or chainring. A noise every second or third revolution might be in the chain, such as a stiff link as it passes by the derailleur pulley wheels. Ask yourself if the noise occurs when pedaling only or also when coasting. Make a mental note if the noise or problem occurs under load, such as on a hill or when you hit a small bump.

It can be very helpful to use another mechanically-minded friend when diagnosing problems. For example, a friend can stress the suspect part of the bike, such as the crank, while you listen and feel for creaking. Creaking can often be felt through the frame and parts as a resonance. It can also be useful to ride with a friend, first describing what you think you are hearing and experiencing before you both ride. Use extra care during these diagnosing/riding sessions so you don't run into each other or into parked cars!

TOOLS & TOOL SELECTION

Having the correct tool for the job makes the work easier. Bicycles require both general maintenance tools common in any toolbox and specialty tools unique to the bicycle industry. There are a wide variety of sources for tools, such as bicycle retailers, department stores, automotive stores, and general tool retailers. In some cities, there are also public workshops that rent special tools and workbench space by the hour.

It is possible to purchase tools only as they are required. This is economical in one sense but not timely in another. When a part fails, the tools to repair the problem must be sought out, which can create a long delay in fixing the bike. Anticipating the use of tools and purchasing them ahead of time means initially spending money, but the tools are there when you need them. Your priorities in purchasing tools depend upon your bike's components, the type of maintenance you want to do yourself, the frequency of the work, and your growing mechanical interests and skill level.

Look for the "Tool and Supplies" icon throughout the book, which lists tools and supplies typically required for the described procedure. Some tools are common, such as screwdrivers. Other tools, such as crank pullers, are more specific to the bicycle industry. Bikes are not all equipped the same and don't require every tool listed in the Tool Box. Keep in mind that older bikes may need special tools as well. Consult your local bicycle professional for recommendations on specific tools.

Tools differ between manufacturers in many ways including tool finish, fit in the hand, type of material, and tool fit to the part. The finish affects both the look of the tool and how it will resist corrosion. A hand tool should fit the hand comfortably and not be awkward to use. The type of material may affect the durability of the tool. Good quality steel will last longer than softer grades. Tools are typically made to a certain size. The size should fit the part correctly without being too large or too small. Bicycle component manufacturers sometimes limit what tool companies can do for tool design. For example, if a component part was poorly thought out and service considered only after the design was completed, a "correct" fitting tool may not be possible.

Box-end wrenches and open-end wrenches fit over the outside of a bolt head or nut. When choosing a wrench for a particular bolt, pick the smallest size that will fit over the head/nut. This also applies to spoke wrenches. Two different wrenches can appear to fit, but the smaller one will grab the part better.

Hex wrenches and screwdrivers (Phillips®, cross-tip, and straight blade) fit inside a screw head. The proper size here is the largest one that will fit inside. Although two different screwdriver tips may fit inside a screw head, always choose the larger one for more engagement to the head.

A complete tool table for a very complete home shop is listed in Appendix A. However, the table does not include some tools professionals might use, such as frame machining equipment.

It is important for all mechanics, whether casual home mechanics or professional mechanics, to always use tools correctly. Wrenches should be placed fully on the nut or bolt head before turning. Hex wrenches should be fully inserted into the socket fitting before turning. Hold wrenches for comfort and good mechanical advantage. When using a file or hacksaw, apply pressure on the forward cutting stroke, not on the backstroke. These basic habits may seem obvious and pedestrian, but they are what make good mechanics.

REPAIR STANDS

The repair stand (work stand) is the basic and most crucial piece of equipment for any shop or home. Getting the bike off the ground makes the repair quicker, easier, and more fun. A

FIGURE 1.9

Park Tool PCS-10 screw-type clamp with an opening cam good work stand brings the work up to the mechanic, instead of forcing the mechanic to bend over to get to the work. Work stands also allow the mechanic to pedal the bicycle by hand and quickly diagnose problems. Many stands come with a rotational feature that allows the bike to rotate up to the mechanic. Repair stands often have a height adjustment feature, which allows for raising and lowering the bicycle.

Some bike frames have oval, square, or other non-round shaped tubing, making it difficult to clamp onto the frame tubing. For certain frames, the bicycle manufacturer may recommend clamping only on the seat post, rather than the frame tubing. Most bikes can be clamped on the seat post.

FIGURE 1.10

Park Tool PCS-9 screw type clamp

FIGURE 1.11

Park Tool PRS-25 screw type clamp with opening cam

FIGURE 1.12

Park Tool 100-3C over-center adjustable linkage clamp

When in doubt, check with the manufacturer for acceptable areas to clamp.

There are several clamp and stand designs available. Models vary in adjustability, range of working height, and how they hold the bike (figures 1.9 to 1.12). There are also repair stands available that do not clamp the bike on any tube (figure 1.13).

FIGURE 1.13

Park Tool PRS-21 holds the bike without clamping any tubes

HOME SHOP SETUP

Home mechanics may enjoy setting up a dedicated repair area or, basically, their own "bike shop." The primary requirement for a shop is space for a workbench, a repair stand, the bike, and enough room to maneuver. A common size for commercial workbenches is 72 inches by 30 inches (182 cm by 75 cm). This is deep enough to hold a wheel. It is possible to use a bench shorter than the 72 inches, but avoid benches narrower than 30 inches deep. If you are building a custom workbench, it can be set for the height of the user. This may range from 32 inches to 40 inches high. For general technical work, the top of the workbench should be approximately 4 inches to 6 inches (100–150 mm) below the height of the user's elbow. The bench top can be made of many different materials, but expect the top to take some punishment during work. It is very useful to bolt the bench to the floor and to a wall. This is especially important if you plan to mount a vise to the bench.

Tools may be mounted to a board on the wall. This allows the mechanic to quickly find the right tool. A pegboard provides a versatile system to hang and arrange tools. Higher quality pegboard measures ¼ inch thick. The pegboard should be at least as wide as the workbench. Hardware stores and home supply stores stock pegboard hooks. A mix of short and long hooks will be needed. However, the short hooks are better, as this avoids stacking too many tools on one hook. A tool magnet is also a very useful item for the work area. It can hold odd shaped steel tools and even bolts that you don't want to lose during a repair.

If possible, select an area with good light. You may need to supplement the work area with extra lighting. Painting the pegboard surface white or off-white will reflect more light onto your work area.

A good repair stand is the most critical part of the repair shop. The repair stand should be positioned next to the work area. Keep the stand close to the workbench to avoid taking even one step to the bike but not so close you are crowded. Be sure to use the rotation and height adjustment features of the stand to move the work area of the bike closer to you, rather than bending over. Save your back for riding.

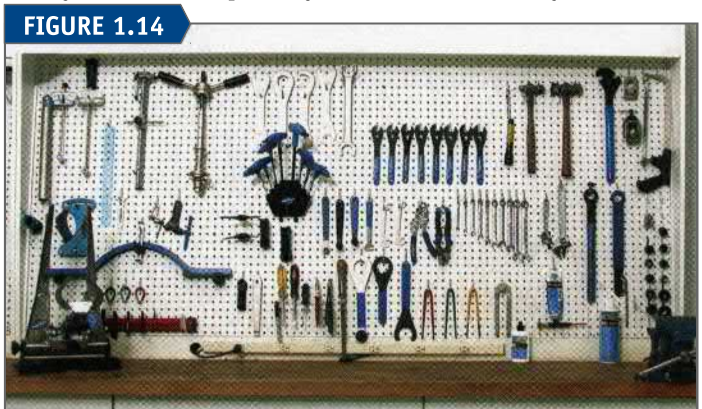
If possible, get a bench-mounted vise. A 4 inch vise is typically adequate for bicycle repair. Mount the vise on a corner of the bench so the non-moving jaw is even with the bench edge.

When arranging tools on the wall, place the tools likely to be used in conjunction with the vise close to the vise. For example, place the axle vise, cone wrenches, hammer, and freewheel tools closer to the vise.

Another very useful piece of equipment is an air compressor. A floor pump can, of course, provide enough air pressure for tires. A small air compressor, however, is useful for drying parts after washing them with a solvent. A compressor is also very useful when inflating tubeless tires.

Tool arrangement preferences will vary from mechanic to mechanic, but try to group specialty tools together. Brake tools should be with other brake tools. Non-specialty tools should be together with hex wrenches grouped together and combination wrenches lined up in order (figure 1.14). With time you will develop the system that is best for you.

FIGURE 1.14



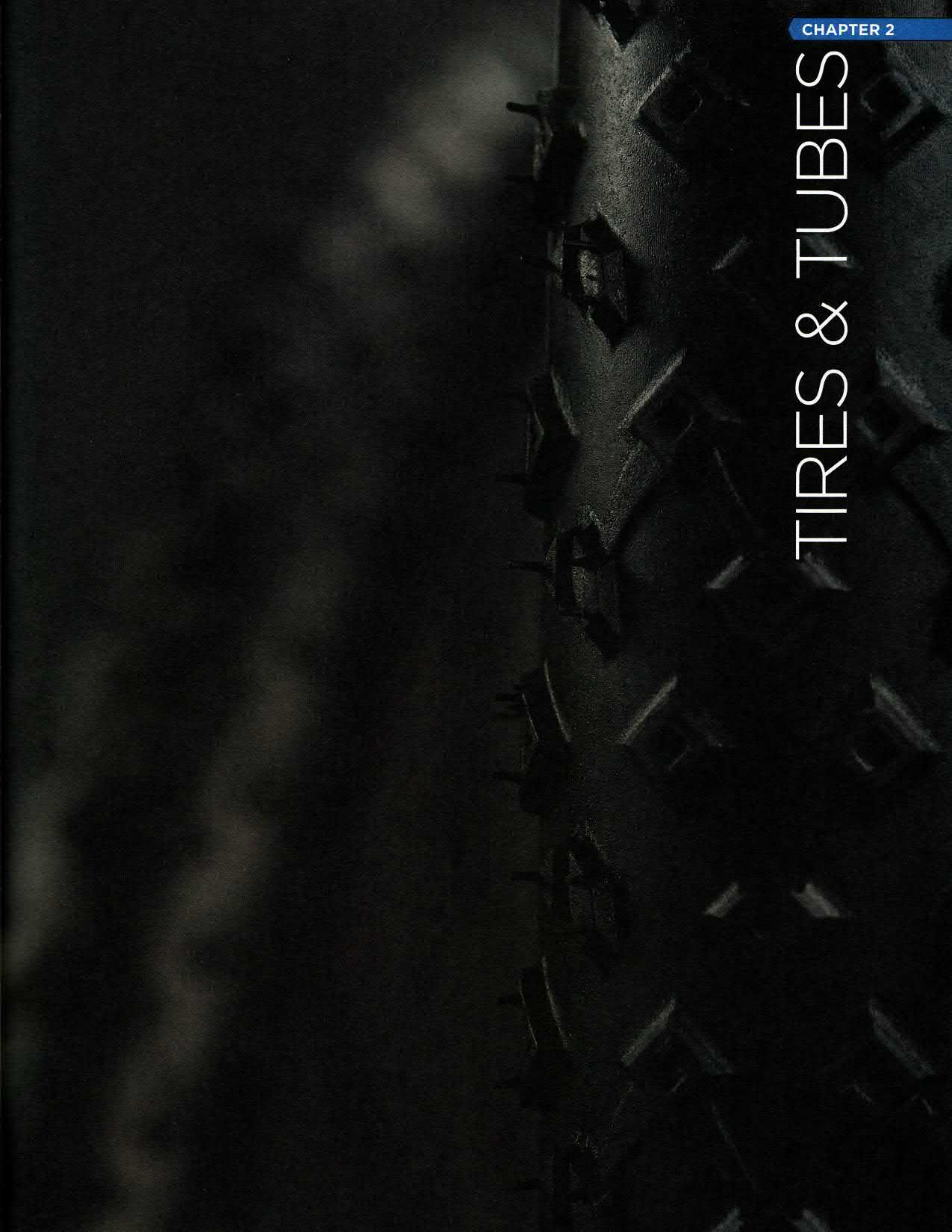
Workbench layout

MAINTENANCE SCHEDULE

The idea of a schedule of maintenance is that it will encourage you to check certain items on a regular basis. No two bikes are used in identical conditions, and your bike may benefit from more checking than a list suggests. If you ride in conditions of rain, mud, sand, dust, salt water, pot-holed roads, or aggressive trails, these will take their toll on the bike. Table 1.1 should be viewed only a general reference. Add your own items to the list that you feel are needed.

TABLE 1.1 *Maintenance Schedule*

Every Ride
1. Check pressure in tires. Use tire gauge when available. Squeeze sidewalls at a minimum.
2. Check tires for tread cuts
3. Grab brake levers with force, note any differences between rides
4. Bounce bike, listening for rattles and odd noises, such as loose headset
5. Spin pedals backwards, note any squeaky or dry chain
6. Clean/wash if very gritty and dirty
Every 100 Miles (160 Kilometers)
1. Check chain stretch
2. Inspect cable for cuts
3. Clean chain if necessary or dirty
4. Inspect brake pads for wear
5. Inspect tires for tread wear, replace as needed
6. Check hand pump for ability to create pressure
7. Check for bearing play in wheel hubs
8.
9.
Every 500 Miles (800 Kilometers)
1. Grab cranks and pull side-to-side
2. Lubricate pivot points
3. Lubricate brake and shifter cables
4. Check crank bolts
5. Full suspension bikes, check swing arm pivot bolts
6. Inspect frame for cracks or other anomalies
7.
8.
Every 1,000 Miles (1600 Kilometers)
1. Inspect rims for wear if using rim calipers
2. If ridden in muddy and hard conditions, overhaul bearings
3. Inspect shoe cleats and replace as needed
4. Remove seat post and clean; re-grease as appropriate
5.
6.
Every 3,000 Miles (4,800 Kilometers)
1. Grease bearings if non-cartridge
2. Remove tires and inspect rim strip
3. Install new cables and housing, especially shifting systems
4. Replace cartridge bearings if worn or play is present
5.
6.



CHAPTER 2

TIRES & TUBES

Tires are the rubber and fabric casings fitted over the wheel rim. The common bicycle wheel uses pneumatic tires referred to as "wired-on" tires or "clinchers." The wheel's rim uses a channel or U-shape to hold the tire beads. The smooth ride of the bicycle is due in large part to the air in the tires. Inside conventional tires is an inner tube to hold the air. The tire's body and casing around the inner tube takes the stress of air pressure, bumps, and bruises of riding. There are also "tubeless" systems using special rims and tires that are similar in design to car tire systems and contain no inner tube. Many professional-level road racers also use sew-up or tubular tire systems that use a tire with tube built inside that are glued to special rims.

Servicing flat tires is a basic skill required for any cyclist. Anything from sharp thorns, glass, or nails can puncture tires and inner tubes, and the tire itself will wear out with use and time.

Tools & Supplies:

- *Wrench of correct size for wheels with axle nuts (15 mm is common)*

WHEEL REMOVAL

The wheel must be removed to replace the tube and tire. If possible, begin by mounting the bike in a repair stand. If no stand is available, the bike should be laid on the non-drive side to avoid damage to the rear derailleur when the rear wheel is removed. Do not stand the bike upright without the rear wheel in place, as this will damage the rear derailleur. The bicycle may be turned upside down on the ground if there is no chance of lever or accessory damage on the handlebar. Bikes with quick-release hubs do not require tools for wheel removal. Bikes with axle nuts will require the correct size combination wrench or adjustable wrench.

Common quick-release wheels use a hollow hub axle fitted with a shaft, a lever that operates a cam mechanism, and an adjusting nut. Swinging the lever to the closed position puts tension on the shaft and pulls both the cam and the adjusting nut tight against the fork or frame dropouts. This tension holds the wheel securely to the frame. The adjusting nut determines the amount of tension on the quick-release lever and cam.

Non-quick-release hubs use a solid axle with nuts outside the dropouts. An axle nut may have a built-in washer, or there may be a separate washer under the nut. If the washer has teeth or a knurled surface, these face the dropout to help secure the wheel. When removing wheels with axle nuts, loosen only the nuts on both sides outside of dropouts. Lubricate the axle threads while the wheel is off the bike.

Common fork or frame designs use an open slot dropout to fit a 9 mm front axle and a 10 mm rear axle. Forks may

FIGURE 2.1

Fork with wheel retention devices cast into dropout end

be designed with retention devices intended to hold a wheel should the axle-nuts or quick-release fail (figure 2.1). The quick-release nut must typically be loosened several turns to allow the mechanism to clear the fork when the quick-release lever is open. Even with these extra design features, the wheel axle should be fully and properly tight in the fork.

Thru-axle frame and fork designs use a closed hole in the fork or frame end. This permits a stronger retention system and precisely positions the wheel and rotor (if any) in the frame. A removable axle is fitted through the frame/fork hole, into the thru-axle hub, and engages the opposite side. Thru-axle forks may use a 15 mm or 20 mm axle, and rear hubs use a 12 mm thru-axle.

A thru-axle hub may be held tight with pinch bolts in the frame, or it may use a quick-release system, such as the "Maxle" which require no tools for removal. For removing thru-axle hubs, see page 25.

Procedure for wheel removal—open dropouts with quick-release:

a. **Rear wheel:** Shift derailleurs to outermost rear cog and innermost front chainring.
b. **Front and Rear:** Release rim brake caliper quick-release, if any (figure 2.2, figure 2.3, figure 2.4, figure 2.5).
c. **Front and Rear:** Release wheel quick-release by pulling quick-release lever outward. If necessary, loosen quick-release adjusting nut to clear any tabs at end of fork (figure 2.6). If the quick-release is used on a thru-axle fork and hub, it is necessary to remove axle completely from hub. For non-quick-release wheels, loosen both axle nuts.

FIGURE 2.2

Side-pull or dual-pivot rim caliper may have quick-release at caliper arm

FIGURE 2.3

Quick-release located at brake lever

FIGURE 2.4

Squeeze linear-pull calipers together and disconnect cable "noodle" from linkage

FIGURE 2.5

Squeeze the cantilever calipers together and disconnect the straddle wire cable

FIGURE 2.6

Puller lever from closed to open position

FIGURE 2.7

Pivot rear derailleur back to clear wheel and cogs of frame

d. **Front:** Guide the wheel through the brake pads and out the fork ends.
   Rear: Pull back on rear derailleur to allow cogs to clear chain (figure 2.7). Lower wheel, guiding the wheel down through caliper brake pads and forward to clear chain and derailleur. **Note:** Some bike dropouts are rear facing. Pull wheel back to remove it from the dropouts. Unhook chain from cog for removal.

There are rear derailleur systems that use a clutch mechanism in their pivots, which could make it awkward to remove the rear wheel without a way to lock the tension cage in a position that lowers chain tension. The Shimano® Shadow Plus® system and the SRAM® Type 2 derailleurs use clutch mechanisms that provide resistance at the lower pulley, which are intended to prevent the chain from bouncing off, slapping the frame, or wrapping around the bottom bracket during rough travel.

When changing the rear wheel with the Shimano® clutch system, look for a lever on the lower pivot of the derailleur body. Pull the lever down to disengage the clutch feature (figure 2.8). The derailleur will now easily pivot backward to release the rear wheel. After the wheel is reinstalled, pull the lever back up to engage the clutch.

FIGURE 2.8

Push on-off lever upward to return derailleur to clutch operation mode

SRAM® Type 2 derailleurs do not use an "on-off" lever. The lower pulley is pushed forward, and a button is pushed to engage and hold the cage forward, creating chain slack (figure 2.9).

Remove the wheel with the cage in the locked mode (figure 2.10.) Reinstall the wheel, and push forward on the lower pulley to release the cage lock and to return the derailleur to the working mode.

FIGURE 2.9

Push forward on lower pulley and depress cage lock button to hold.

FIGURE 2.10

Remove and install wheel with cage in locked mode

REMOVAL OF TIRE & TUBE FROM RIM

Remove the tire and tube (if any) from the wheel for a complete inspection. A mounted clincher tire has two beads that are fitted to the inner walls of the wheel rim. Use tire levers to pry one tire bead up and over the rim sidewall. Tire levers come in different shapes, sizes, and materials. Plastic levers (Park Tool TL-1, TL-4, or TL-6) are typically adequate and will not leave blemishes on the rim. Use only plastic tire levers for carbon fiber clincher wheels to avoid damaging the rim surface.

Some tire and rim combinations are extremely tight and may require a steel lever, such as the Park Tool TL-5. Some cosmetic marring may occur with any metal lever, but this will not harm the function of the rim. To avoid cosmetic damage, you may use Park Tool TL-6 composite-covered steel core tire levers.

When possible, mark the tire at the valve to help in locating any holes in the tube. Use the mark to trace the location back to the tire. However, always inspect entirely all the surfaces of the tire, tube, rim tape, and tire bead seat inside the rim.

Caution:

Do not use a screwdriver, knife or other sharp object as a lever. Doing so could damage the tire or tube.

Procedure for tire and tube removal:

a. Remove valve cap. Fully threaded valve shafts may also have a locking nut next to the rim. Loosen and remove valve locknut before deflating inner tube.
b. Deflate tube completely. Even a small amount of air left in the tube can make it more difficult to get the tire off the rim. For best results, press downward on wheel while depressing the valve. Schrader valves: depress valve plunger with small hex wrench.
c. The tire bead will be pressed tight against rim sidewall. Push both sides of tire toward the center of the rim to loosen the bead (figure 2.11).

FIGURE 2.11

Push the tire bead toward middle of rim

FIGURE 2.12

Engage tire levers under tire bead

d. Engage one tire lever under bead of tire. Engage second lever 1–2 inches (2–5 cm) from first lever then push both levers down towards the spokes to lift the bead up and off the rim (figure 2.12).
e. Disengage one of the levers. Move it approximately 2 inches (5 cm) along the rim and engage this lever under the bead. Push lever to lift the next section of bead off rim.
f. Repeat engaging the lever until the bead loosens. Then slide the lever along the rim under the bead until the bead is completely removed from the rim.
g. Starting opposite the valve, pull inner tube out from inside of the tire. Lift valve from valve hole and remove tube from wheel.
h. Remove second bead from rim, which removes the tire completely from the rim. To fully inspect the tube and tire, it is best to remove the tire completely.

INNER TUBE INSPECTION

When servicing a flat tire, always inspect the tire and tube carefully to locate the cause of failure. If you intend to replace the inner tube, knowing the cause of the flat can help prevent future flats.

Procedure for inner tube inspection:

a. Reinflate inner tube, if possible, to twice its normal width. This extra pressure makes small leaks easier to locate (figure 2.13 and figure 2.14).

FIGURE 2.13

Inner tube before inflation

FIGURE 2.14

Inner tube after inflation for inspection

b. Inspect for air leaks. Slowly move the tube closely past sensitive skin such as the lips or cheeks. Small leaks can also sometimes be heard. Check around the entire tube. If this does not work, then submerge the tube in water and watch for bubbles at the hole.

c. If you plan to repair the inner tube, use a marking pen to make four marks, one on each side of hole (figure 2.15). Do not mark directly on the hole, as the marks may be sanded off, making the puncture's location difficult to find.

FIGURE 2.15

Mark inner tube after location hole

d. Inspect the remainder of inner tube for more holes.

The type of cut or hole in the tube will help determine the cause of the flat. Common cuts and their causes include:

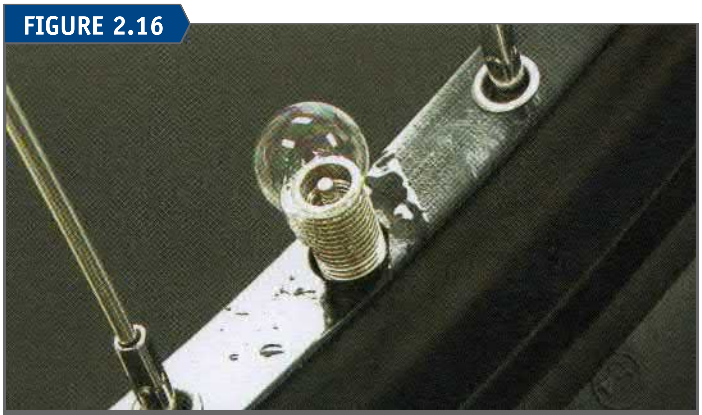
CUT AT VALVE BASE

Misalignment of inner tube in the rim, a crooked valve, or riding with low pressure. Be sure the inner tube valve is mounted straight inside the rim and check tire pressure before every ride.

LEAKY VALVE CORE

Schrader Valves may have loose cores inside valve stem. Test the mounted tube and the tire at full pressure with soapy water or saliva sealing the core. Inspect for bubbles appearing at the core (figure 2.16). Presta valves may have a loose locknut or loose valve core inside stem. Tighten valve cores with a valve core tool such as the Park Tool VC-1.

FIGURE 2.16



Test valve for a leaky core

LARGE SHREDDED HOLE

Tire blowouts are not repairable. Check tire and rim for seating problems. Also check for hole in the tire casing (figure 2.17).

FIGURE 2.17

Shredded hole indicating blowout

HOLE ON THE RIM STRIP SIDE OF TUBE

Rim strip failure. Inspect inside of rim for protruding spokes, sharp points, or lack of rim strip coverage over inner rim holes.

LONG CUT OR RIP

Tire blowout. Inner tube is usually not repairable. Check tire and rim for seating problems. Use care when seating the tire during installation.

SINGLE PUNCTURE OR SMALL HOLE

Thorn, wire, glass. These holes may be repairable. Check tire as well. The cause of the puncture may still be embedded in the tire. Hole typically located against top of tire casing.

DOUBLE SLITS

Rim pinch. Tube was pinched between the rim and an object on the road or trail. Increase air pressure or use wider tires (figure 2.18).

FIGURE 2.18

Two parallel marks show the tube was pinched between rim and struck object

TIRE INSPECTION

It is important to always inspect the tire as well as the inner tube. The cause of the flat, such as a nail or piece of glass, may still be embedded in the tire or tread. Inspect both the outside of the rubber tread and the inside of the casing. Again, mark the tire near the valve core as a reference.

Inspect for protruding nails, pieces of glass, thorns, or other objects. Squeeze any cut to look inside for objects such as slivers of glass. Use a seal pick, scribe, or pointed knife to carefully pick out small pieces of glass or thorns lodged in the tread. Visually inspect the inside of tire casing for nails, glass, or debris. Wipe inside of casing with a rag and then carefully feel inside with fingers. Proceed slowly as there may be sharp objects still in the casing (figure 2.19).

FIGURE 2.19

Carefully feel inside the case with fingertips

FIGURE 2.20

Failure at tire beads cannot be repaired

Inspect tire bead for damage. A broken or cut bead will not permit the tire to hold to rim. Any exposed bead will require tire replacement (figure 2.20).

Check for "tire rot," or a deterioration of the tire casing. Old and rotted tires are more susceptible to punctures and blowouts from sidewall failure (figure 2.21). Even if the tire has an adequate amount of tread, replace rotted tires.

FIGURE 2.21

Cracks in tire casing from tire rot

FIGURE 2.22

Damaged sides will lead to failure under pressure

Inspect sidewall for rips, abrasions, holes, or damage to casing (figure 2.22). Damage to the cords may only be seen when the tire is fully inflated. Failed cords will show as bulges and irregularities in tire shape.

The tires will eventually wear out from use and become very thin at the tread. For tires ridden on pavement, look for a flattening of the tire crown in the middle. For off-road tires, the top knobs will become worn and rounded compared to knobs on the side. If the cord is showing or

FIGURE 2.23

Damaged tread and casing

the casing appears deformed, the tire should be replaced (figure 2.23).

RIM STRIP

The wheel rim may have holes between the rim sidewalls for spoke nipples. The rim strip covers the holes or nipples. It protects the inner tube from nipples and sharp edges in the base of the rim. The rim strip can be made of cloth, rubber, or polyurethane plastic. It should be wide enough to cover the bottom of the rim but not so wide that it interferes with seating the tire bead. Inspect the rim strip whenever changing a tire or inner tube. Look for tears and rips. Make sure the rim strip is centered over the nipple holes and completely covers each hole (figure 2.24).

High-pressure tires require a strong rim strip. Without a sturdy support, the inner tube will push down into the nipple holes, resulting in a blowout. Do not use soft and flexible rubber rim strips in rims with eyelet holes.

FIGURE 2.24

Holes in rim strip will cause flats

INNER TUBE REPAIR

Inner tubes are commonly made of black butyl rubber. Latex inner tubes are lightweight and tend to be a cream or light gray color. The latex material is more porous than butyl rubber and will require air before every ride. Both types can be patched.

Replacing the punctured inner tube with a new tube is always the safest and most reliable procedure. In some cases, it's safe to repair a small hole in an inner tube. If the hole is large, such as from a blowout, it may not be possible to repair. When in doubt, replace the tube.

PRE-GLUED PATCH REPAIR

The Park Tool GP-2 Super Patch Kit uses pre-glued patches. This patch relies on the tube pressing against the tire to seal the puncture. If the inner tube is too small relative to the tire casing, the patch may become too stretched to hold effectively. Double-check to be sure the inner tube is an appropriate size for the tire when using a pre-glued patch.

Procedure for inner tube repair using Park Tool GP-2 pre-glued super patch:

a. Locate the hole marked during inspection. Using a fine emery cloth or sandpaper, clean the tube by lightly abrading the area around hole. Excessive sanding or heavy pressure can cause grooves in the rubber leading to patch failure.
b. If possible, clean the area with a rag and alcohol. Allow it to dry completely.
c. Peel patch from patch backing. Handle patch as little as possible and by edges only (figure 2.25).

FIGURE 2.25

Center patch over hole and press evenly to bond patch to tube

d. Center patch to hole and lay patch flat on tube.
e. Apply pressure for patch to seal. Roll patch and tube between thumb and forefingers.
f. Tube is ready to install. *Do not* test patch by inflating tube while outside of mounted tire. This may stretch the tube body under the patch, which may weaken the patch bond.

INNER TUBE REPAIR WITH SELF-VULCANIZING PATCHES

Self-vulcanizing patches require the application of a thin layer of self-vulcanizing fluid on the tube before the patch is applied. The patch reacts with the fluid to bond with the inner tube, but inner tubes differ in their component chemical compounds. Patching may result in mixed success.

Procedure for inner tube repair with self-vulcanizing patch:

a. Locate hole marked during inspection.
b. Using a fine emery cloth or sandpaper, lightly abrade area around hole. Abrade an area larger than patch size.
c. When possible, clean area with alcohol and allow it to dry completely.
d. Open self-vulcanizing fluid tube and puncture seal. Apply thin coat of self-vulcanizing fluid and spread evenly around hole area (figure 2.26). Use a clean finger or the back of patch to spread the self-vulcanizing fluid evenly over an area that is larger than the size of the

FIGURE 2.26

Spread a thin, wide layer of self-vulcanizing fluid

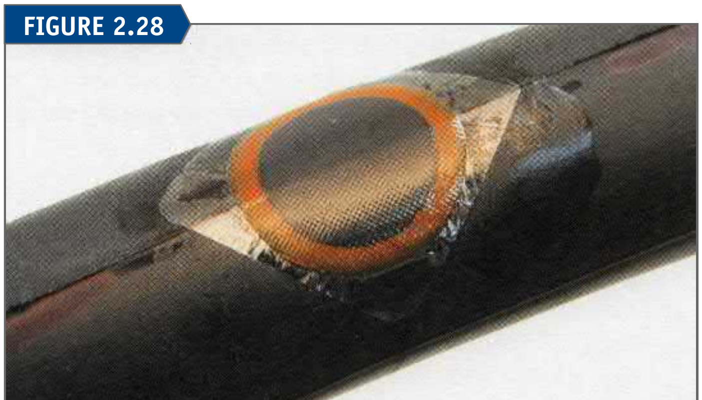
patch. Do not apply too much fluid. The layer should not appear "glopped" on. Return and tighten glue tube cap.

e. Allow self-vulcanizing fluid to dry. This may take several minutes. Test by touching the perimeter area of self-vulcanizing fluid only. Do not touch self-vulcanizing fluid where the patch will contact.
f. Peel patch from backing. Leave clear plastic cover on patch. Handle patch by its edges.
g. Center patch to hole and lay on the tube.
h. Apply pressure to patch, especially at the edges, to seal. If possible, maintain pressure for several minutes.
i. Inspect edges of patch. Edges should lay flat and appear bonded to tube (figure 2.27 and figure 2.28).
j. Tube is ready to install. Do not remove plastic cover from patch. It could pull on the freshly-bonded patch, and cause the repair to fail.

FIGURE 2.27

Edges of patch did not seal well in this poorly bonded patch

FIGURE 2.28



Edges lay flat in a successful patch

INNER TUBE SEALANTS

Liquid sealants can be added to the inner tube. These products are available from various manufacturers and are only intended to seal small holes in the tube. To add sealant to the inner tube, install the inner tube into wheel as normal. For Schrader valves, remove the core using a valve core remover. Only some Presta model tubes use a valve with a removable core. Inspect the Presta valve for two wrench flats below the stem locknut. To remove this valve core from the Presta tube, use the Park Tool VC-1 Valve Core tool or a small adjustable wrench (figure 2.29).

FIGURE 2.29

Inspect end of Presta valve for wrench flats

Place the valve at the four o'clock or eight o'clock position, making the valve slightly downhill (figure 2.30). Inject the sealant according to the manufacturer's directions. Replace the valve and inflate tire. Spin the wheel to spread the sealant. When inflating or deflating the tire, rotate the wheel so the valve is on the upper horizontal section of the rim.

FIGURE 2.30

Rotate valve to allow sealant to easily enter the tube

Installing sealant will make patching the inner tube difficult or impossible. The sealant tends to prevent good patch bonding. The valve core can also become plugged and sealed with time. Sealants can also plug a tire pump head used to pump this tube. Avoid having the valve at the lower section of tire when pumping.

TIRE LINERS

Tire liners are specially made strips of a tough, flexible material placed inside the tire body. Liners are installed between the tire and inner tube and may help prevent thorns, glass, and other sharp objects from reaching the inner tube (figures 2.31). Liners should be installed centered on the tire

FIGURE 2.31

Tire liner placed inside tire body

midline. Liners will not prevent pinch flats and do not protect from sharp objects penetrating the sidewall area of the tire.

TEMPORARY TIRE REPAIR WITH TIRE BOOT

If the tire has been ripped and the casing damaged, it may not hold an inner tube. It is possible, in some cases, to make a temporary repair with a Park Tool TB-2 Emergency Tire Boot. A booted tire should not be considered a permanent repair. The tire should be replaced as soon as possible.

Begin repair by locating rip in tire. Compare rip to size of tire boot. Tire boot must completely overlap the rip to be effective. Clean inside the tire adjacent to the rip. When necessary, cut patch to fit inside the tire casing. Cut boot as large as possible but not so large it will stick out beyond tire bead. Align the patch making sure the edges do not extend beyond the tire bed to the tire beads. Center the patch to the rip and press it inside of the tire casing (figure 2.32).

It is possible to make a temporary boot using other material. Use a strong material that is resistant to tearing. Paper currency should not be considered acceptable tire boot material.

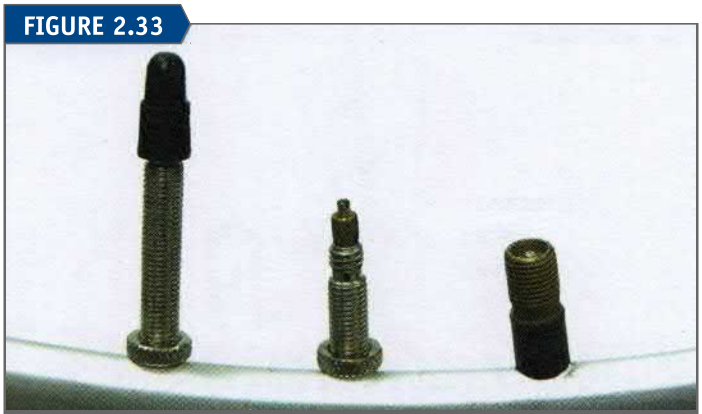
FIGURE 2.32

Place TB-2 Emergency Tire Boot over cut in tire and replace tire as soon as possible

INNER TUBE VALVES

There are two common types of valve stems on bicycles: Schrader and Presta ("French" type) (figure 2.33). The Schrader or American-type valve is common on cars and motorcycles. It is also found on many bicycles. The valve stem is approximately 8 mm (5/16 inch) in diameter and has an internal spring plunger (valve core) to assist in shutting the valve.

FIGURE 2.33



From left to right: a long stem Presta valve with cap, a standard length Presta valve without cap, and a Schrader valve without cap

To deflate the Schrader valve tube, it is necessary to stick a small hex wrench or other object into the valve in order to press on the stem and release the air. Upon release of the stem, the valve spring shuts. Schrader-compatible pump fittings press on the internal stem with a small peg inside the pump head, which allows the tube to be filled.

The Schrader valve core can be removed from the tube if necessary. The valve core may be loose and cause a slow leak, or it may become jammed with dirt and not open and close properly. Removing the valve core also permits sealant to be injected inside. Use a valve core tool such as the Park Tool VC-1 Valve Core Remover to remove or tighten the core (figure 2.34).

FIGURE 2.34

Schrader valve core removed for cleaning and inspection with Park Tool VC-1

The rim's valve hole should match the valve of the tube. If a rim has been made with the smaller valve hole for Presta valves, it can be drilled and enlarged to the 8 mm size by using an 11/32 inch (8.5 mm) hand drill. After drilling, use a small round file to remove any sharp edges. Rims that are less than 15 mm outside width should not be drilled. It is also possible to use the smaller Presta valve in a rim intended for the larger Schrader by using an adapter sleeve.

The Presta or French-type valve is common on mid- and higher-priced road bikes and on higher-priced mountain bikes. Presta stems are thinner than Schrader valves (6 mm diameter, nominally 1/4 inch). At the top of the Presta stem is a small valve locknut, which must be unthreaded before air can enter the tube (figure 2.35). To deflate the inner tube, unthread the locknut and depress the valve stem. To inflate the tube, unthread the locknut and inflate using a Presta-compatible pump.

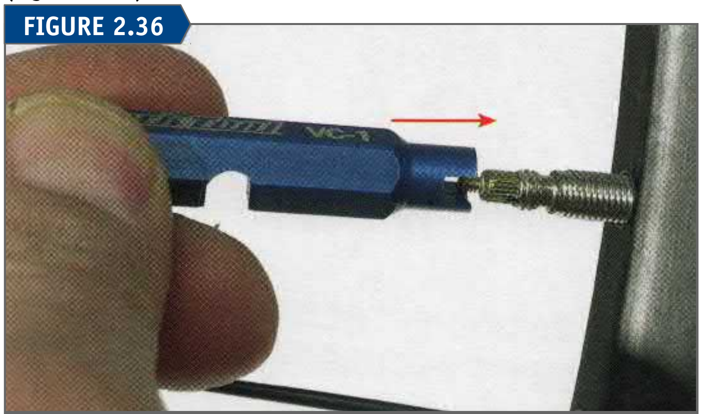
FIGURE 2.35

Component parts of the Presta valve: (A) valve cap, (B) valve locknut, (C) valve stem lockring, (D) valve adaptor for Schrader rim

Some brands of Presta tubes use a valve shaft that is fully threaded. These come with an extra locking nut or ring. Loosen the ring by hand and remove it before installing the tube. Install and fully inflate the tube. Then install the lockring and snug only by hand. When deflating the tube, loosen and remove the nut first. When a tire is fully inflated and is then deflated, the valve moves back into the tire casing. The valve may be ripped from the tube if the locknut is left locked too tightly to the rim.

Some models and brands of Presta inner tubes use a removable valve core. Inspect the end of the valve for two wrench flats. Use a valve core tool such as the Park Tool VC-1 or a small adjustable wrench to secure or remove the core (figure 2.36).

FIGURE 2.36



A removable Presta valve and the VC-1

Presta-compatible pump heads do not have a small peg inside the pump head. Also, the seal of a Presta pump head is smaller than the pump head of the Schrader pump. To inflate a Presta tube, unthread the valve stem locknut and tap lightly to release the valve seal. The seal tends to stick over time and tapping the stem breaks it free, which makes it easier to inflate. Press the Presta-compatible pump head onto the stem and inflate the tube. Some pump heads may have a lever-operated cam to help seal the gap between the pump head and the valve.

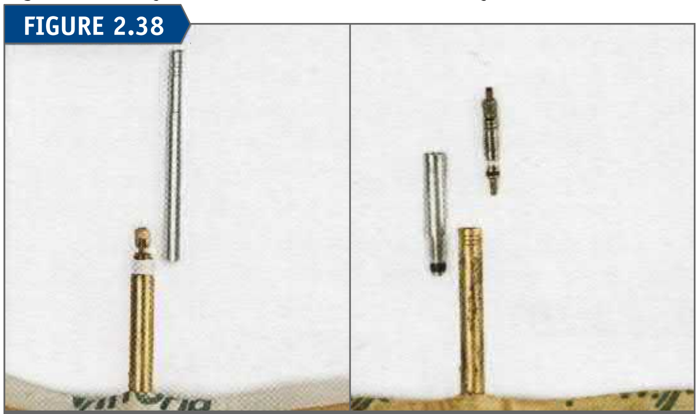
There is no performance difference between the two kinds of valves. The Schrader valve, however, is wider and requires a larger rubber base to bond it to the tube. Consequently, very narrow tubes use the Presta valve. A Presta-to-Schrader adapter is available, which allows Schrader pump heads to be used on Presta valves (figure 2.37).

FIGURE 2.37

A Presta-to-Schrader valve adaptor

Inner tube valve stems are available in different lengths. Rims with a very tall cross section require longer valve stems (60 mm or 80 mm). There are valve extenders available that screw onto the Presta valve and allow the tube to be inflated (figure 2.38). If the inner tube uses a removable valve core, use an extension that screws into the valve's inner threads. There are also designs that are simply a tube to lengthen the stem but do not permit the Presta valve locking nut to be secured. If the locking nut cannot be closed, the valve may leak. Extenders that do not allow the valve nut to be tightened may allow the tube to leak slowly.

FIGURE 2.38



Left: simple valve extender with lock nut loose
Right: removable valve core with double-threaded extender

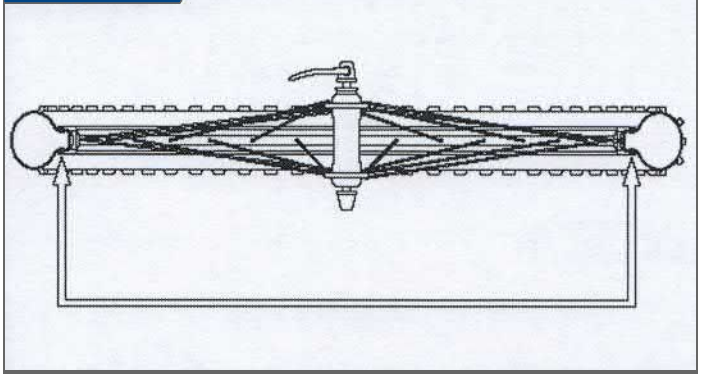
TIRE & TUBE SIZING

Tires are made with a steel wire or fabric cord, called the "bead," which is molded into each edge of the tire. The bead forms a circle. The diameter of this circle determines the tire fit to the rim. The tire bead is made to fit into the rim bead seat, which is the area below the outer rim edge (figure 2.39).

Do not attempt to mix tires and wheels with different bead seat diameters. Although the bead seat diameter determines the tire and wheel fit, there is little consistency between manufacturers in how tires are labeled or identified. Different countries at times have used different nomenclature marking systems. This can cause confusion when selecting a tire for a wheel and frustration when installing a tire.

An antiquated but still common system uses "inch" designations, such as 26-inch, 27-inch, or 29-inch. The inch size does not directly refer to the bead seat measurement. It is a simply code, and it refers to the approximate outside

FIGURE 2.39



Bead seat diameter of the rim and tire

diameter of an inflated tire. For example, there are several 26-inch tires that use different bead seat diameters. A 26 x 1⅜ inch tire, for example, will not interchange with the common MTB 26 x 1.5 inch tire. There are three even more obscure tire standards also referred to as 26-inch diameter, but none are interchangeable. As a rule, tires marked with fraction sizes, such as ½, ¾, etc., do not interchange with tires marked in decimal sizing, such as 0.5, 0.75, etc.

Another common system is the older French system of sizing. The numbers are reference numbers and are not accurate measurements of anything. Road bicycles commonly use a 700c tire that has a bead diameter of 622 mm. The "700c" does not refer to bead diameter. The "c" is part of the code system. There are also 700a and 700b tires and wheels, but none interchange with the more common 700c. Additionally, the 650b tires and wheels will not interchange with the 650c tires.

The ETRTO (European Tire and Rim Technical Organization) system, which is the same as the ISO system (International Standards Organization) is now becoming more common. The ISO or ETRTO system uses two number designations for the tire and rim sizing. The larger number is always the bead seat diameter. Rims and tires with the same number are made to fit one another. For example, tires marked 622 will fit rims marked 622, because the bead seat diameter is 622 millimeters for both. Look for this sizing system on the tire. Rims may also have ISO sizing on the label (figure 2.40).

The rim marking may also provide a two number system. The smaller number is the width in millimeters between rim sidewalls. Generally, a wider rim will accept a wider tire. A narrow tire on a relatively wide rim will mean the tire profile shape will be less rounded. A wide tire on a narrow rim will result in less support for the tire in cornering, which can cause the tire to laterally roll or twist. Additionally, rim caliper brakes will have very little room to clear the tire with this combination. As a loose rule, the ISO tire width should be between one and a half to two times ISO rim widths. A rim width 25 mm between the sidewalls should use an ISO tire width of about 37–50.

FIGURE 2.40

ISO (ETRTO) sizing numbers on tire label along with French sizing

The inner tube should match the tire size diameter closely. Tires that are close in bead diameter may use the same inner tube. For example, an inner tube for an ISO 630 tire (27-inch) will also fit an ISO 622 (700c) tire. The inner tube should also match the tire width, but, because inner tubes are elastic, one inner tube may fit a range of tire widths. If the inner tube is too narrow for the tire width, it will become very thin when inflated inside the tire body. This will cause it to be more susceptible to punctures and failures. If the tube is too wide for the tire, it will be difficult or impossible to properly fit inside the tire casing and seat in the rim. Part of the tube may stick out of the tire and blow out when the tire is fully inflated. Refer to Table 2.1 for common sizes for the tire and wheel bead-seating systems.

TABLE 2.1 *Tire Sizing*

COMMON SIZING NAME	ETRTO/ISO BEAD SEAT DIAMETER	COMMON USES
29-inch	622	MTB using the 29-inch tires. Rim is same diameter as 622 below.
27-inch	630	Older road bikes and less expensive road bikes
700c	622	Road bikes, hybrid bikes
26 x 1⅜ inch S6	597	Older Schwinn S-6 sizing
26 x 1⅜ inch	590	Department store three-speeds, English three-speeds
650b or 27.5 inch	584	MTB and some touring "randonneur" bikes
26 x 1–3.7 inch	559	MTB using 26-inch sizing
26 x 1½ inch or 650c	571	Smaller road bikes or special triathlete bikes
24 x 1–1.75 inch	507	Juvenile MTB
20 x 1–1½ inch	451	BMX racing and recumbent (fractional inch widths)
20 x 1–2.2 inch	406	Juvenile bikes, BMX, freestyle bikes, recumbents
16 x 1⅜ inch	346	Front small wheel recumbent
16 x 1–2.2 inch	305	Some recumbents and juvenile bikes

INSTALLATION OF TIRE & TUBE ON WHEEL

Tires are sized to match the rim. However, even within the same rim and tire sizing standard, certain tire/rim manufacturer combinations are more easily mounted by hand than others. Companies may not hold the same tolerances, and the result may be that some combinations will be tight and may be difficult to mount by hand. These combinations require tire levers for installation. Never use a screwdriver, knife, or other sharp tool to mount the tire.

Procedure for tire installation:

a. Note any directional arrows of the tire manufacturer. Directional arrows printed on the sidewalls indicate rotation of wheel. Not all tires have direction orientation.
b. Inflate tube enough for tube to hold its shape.
c. Install tube inside tire. Install with tube valve adjacent to air pressure recommendations written on tire sidewall (figure 2.41).

FIGURE 2.41

Place tube into tire before mounting tire to rim

d. Lean rim vertically against your legs with the valve hole facing up.
e. Lower tire and valve into rim valve hole and align valve so it is pointing straight toward hub. A crooked valve can lead to a flat tire later (figure 2.42).
f. Install one bead at a time, beginning with the one adjacent to your legs. Center of rim is slightly smaller in diameter, so work head toward center to make it easier to get on rim.

FIGURE 2.42

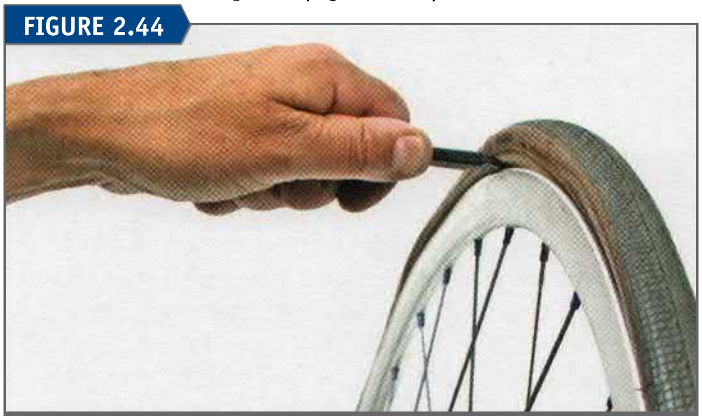
This crooked valve will eventually be cut by the rim valve hole

FIGURE 2.43

Push tire bead up and over rim sidewalls

g. Work tire bead onto rim with hands. If tire head will not seat using hands, use a tire lever as a last resort. Use caution when using tire levers to avoid pinching inner tube. Use tire lever in same orientation as removal method.
h. Work tube over rim sidewall and into rim cavity.
i. Install second bead onto rim (figure 2.43). Use care if using a tire lever. Do not lift lever beyond 90-degrees from the wheel plane (figure 2.44).

FIGURE 2.44



Use levers if necessary to lift bead over edge of rim

j. Inspect both sides of tire for bead seating and for any sign of the inner tube sticking out. If the tube is visible under the tire bead, remove the tire and reinstall.
k. Inflate to low pressure and inspect the bead again on both sides. Look for a small molding line above the bead. This line should run consistently above the rim (figure 2.45).
l. Inflate to full pressure and check with a pressure gauge. It may be necessary to press downward above the valve in order to engage the pump head. For fully threaded valve shafts, reinstall any locking nut only lightly finger tight.

FIGURE 2.45

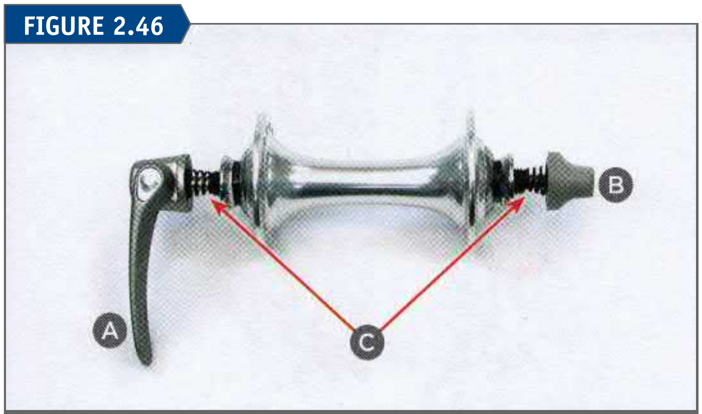
This bead seat line is bulging upwards from improper tire seating. Deflate immediately and reseat tire.

WHEEL INSTALLATION

The wheels must be properly mounted to the bicycle frame. Misalignment can result in problems with shifting, brake pad alignment, and bike handling. If the wheel is not securely mounted in the dropouts, it may come out and possibly injure the rider. Wheels may be held to the bike with a quick-release system, axle nuts, or a “through-axle” system.

The quick-release shaft is fitted with two conically shaped springs. The small end of the spring faces the axle, and the large end faces outward away from the hub. These springs

FIGURE 2.46



Common quick-release hub with (A) Lever, (B) Adjusting nut, (C) Centering springs

make the wheel easier to install. If one or both springs become twisted or damaged they can be removed. The springs serve no purpose once the wheel is tight on the bike (figure 2.46).

The quick-release skewer uses a cam device to hold the wheel securely to the frame dropouts. It is important that the skewer be fully and consistently tightened before each ride. This is also important for the pressure applied to the hub bearings. For most brands of skewers, hold lever parallel to the hub axle, which is halfway through its swing from fully open to fully closed (figures 2.47, 2.48, and 2.49). Tighten adjusting nut snug against the dropout. Check results by moving the lever. Lever should meet resistance to closing halfway through the swing. Lubricate the cam mechanism if it appears sticky or dry.

FIGURE 2.47

Quick-release lever in fully open position

FIGURE 2.48

Adjust nut for lever resistance half way through swing

FIGURE 2.49

Closed skewer lever should be parallel to center plane of bike

FIGURE 2.50

(A) Lever not fully closed; (B) Position for lever in fully closed position

The cam mechanism is designed to lock when the lever is parallel to the center plane of the bike. Inspect section of lever adjacent to the cam. If the lever arm is not fully closed, the wheel is not properly secured (figure 2.50). Double-check the skewer adjusting nut and the pressure on the lever.

The ends of the axle of the quick-release hub must sit inside the dropouts in order for the quick-release to secure tightly against the frame or fork. If the axle is too long for the bike's dropout spacing, it will not permit the wheel to be properly secure. If you have borrowed a wheel, check that the axle ends sit inside the dropout face.

Quick-release skewers come in two basic designs, the "open cam" and the "closed cam" (figure 2.51). In the open cam, the cam mechanism and pressure points are visible and exposed to dirt and grime. Setting lever resistance at halfway through swing may be too tight for some models. However, these

FIGURE 2.51

Open cam style seen on the top, and closed cam seen on the bottom skewers should still close with force. The open cam model should be lubricated to work effectively. Consult specific manufacturer for recommended pressure of closing. The closed cams should also be lubricated, but the working parts are better shielded from dirt and grime.

Procedure for wheel installation in open-dropout fork or frame:

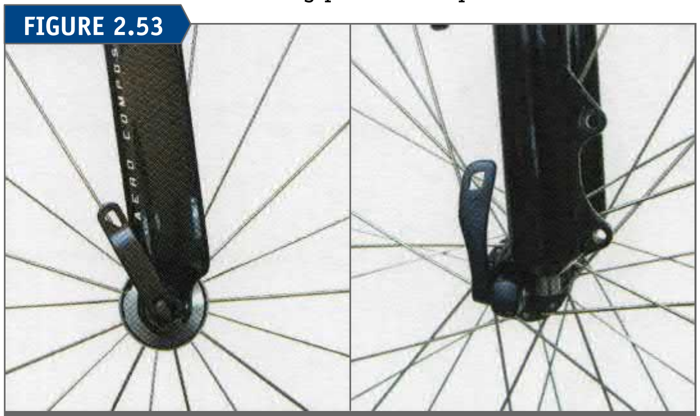
a. Open brake quick-release mechanism for rim caliper brakes only.
b. Move wheel quick-release skewer to open position.
c. Install between dropouts with quick-release skewer lever on non-drive side.
   Front: Guide rim or disc rotor between brake pads. Pull hub up fully into dropout.
   Rear: Check that rear derailleur is in most outboard position. Pull rear derailleur back to open chain (figure 2.52). Place cogs between upper and lower sections of chain and engage chain on smallest cog. Guide rim or disc rotor between brake pads. Guide axle up and fully into dropouts. Pull up and/or back depending upon dropout style. It may be necessary to flex dropouts open to get wheel in.

FIGURE 2.52

Pivot derailleur back to clear wheel and cogs

d. Adjust closing tension of quick-release skewer and close the lever.
   Front: Wheel should be centered between fork blades. If necessary, open skewer, move wheel either left or right until wheel appears centered, then close skewer. The quick-release skewer cam and adjusting nut must be fully engaged on the dropout surfaces.
e. Determine final closing position of quick-release lever.

FIGURE 2.53



Place lever just in front of fork blade when possible

FIGURE 2.54

Skewer orientation must allow lever to be fully closed, even with wide fork ends

f. **Front:** Rotate lever and adjusting nut so lever is just in front of fork when firmly and fully closed (figures 2.53 and 2.54). However, with some dropout designs or suspension forks, it will be necessary to use an alternate position if lever will not fully close.
   Rear: Orient skewer so lever will end up between the seat stay and chain stay, unless this prevents lever from fully closing (figure 2.55). This position provides leverage of the stays for closing and opening.

FIGURE 2.55

Align lever between chain and seat stays

g. Close rim caliper brake quick-release mechanism (if any).
h. Inspect brake pad alignment and centering by closing and opening pads with brake lever. Spin wheel and check pad alignment to rim (disc). If brake pads are not centered, see Chapter 11, Caliper Disc Brakes, or Chapter 12, Caliper Rim Brakes. If wheel fails to adequately center in frame, either the frame or wheel may be misaligned.

View centering of wheel between chain stays and seat stays. Open skewer and adjust as necessary to center wheel in frame. If rim brake pads are not centered to wheel, see Chapter 12, Caliper Rim Brakes. If further attempts to align the wheel fail to adequately center it in frame, either the frame or wheel may be misaligned. Seek professional help.

If it is difficult to maneuver the wheel into the dropouts, install the front wheel when the bike is standing on the ground. By placing the bike on the ground, the axle will seat fully up in the dropouts.

FRONT WHEELS WITH DISC BRAKES

Bikes using disc brake calipers and rotors follow the basic process as described above. The rotor should be placed between the pads of the caliper as it is installed. Use care not to displace the brake pads when installing the wheel (figure 2.56).

Front wheels using a disc brake must always be fully and properly secured. The caliper disc brake applies a load to the disc rotor, which applies a pulling force on the hub in the dropout. This force tends to pull on the wheel in a direction to remove it from the fork. If the wheel is poorly mounted, it may result in the wheel coming out of the fork during use.

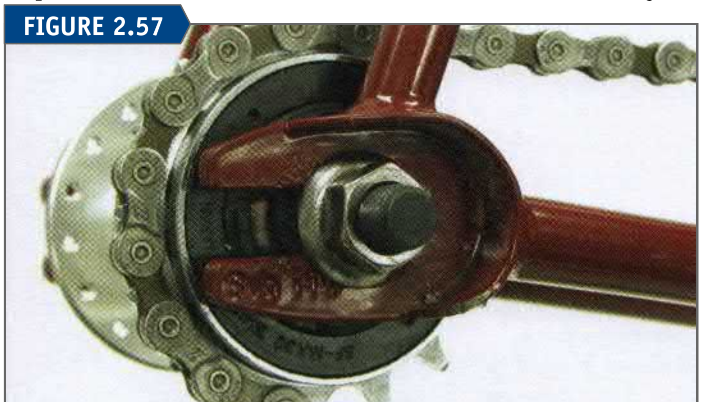
FIGURE 2.56

Guide rotor between caliper disc brake pads

SOLID AXLE TYPES

For non-quick-release wheels with axle nuts, washers go on the outside of the dropouts (figure 2.57). Secure axle nuts fully and then double-check alignment. Front wheels may use a special washer that acts as a wheel retention redundancy.

FIGURE 2.57



Solid axle and horizontal dropout

THRU-AXLE SYSTEMS

The thru-axle system uses a hub design that allows the axle to be pulled from the hub. This allows the wheel to be installed into a frame or fork design with ends that are completely enclosed, providing a very rigid and secure interface (figure 2.58).

The axle and frame will locate the wheel in the frame. There is no room to move the wheel to center it in the bike as with open dropout systems. These systems may use a pinch bolt

FIGURE 2.58

20 mm thru-axle fork and hub

FIGURE 2.59

The maxle quick-release system

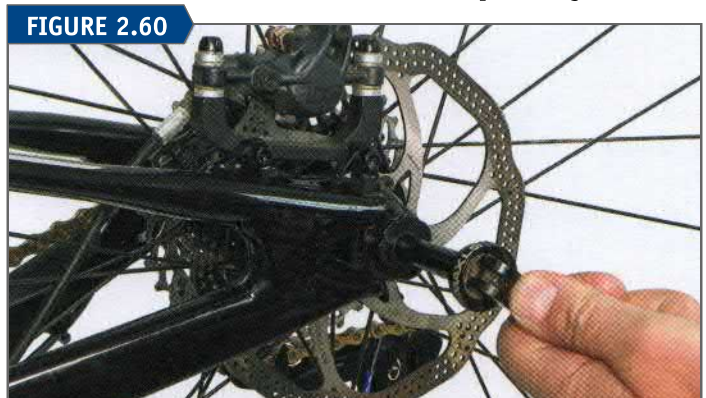
system to secure the axle, or a quick-release type system (maxle) that requires no tools (figure 2.59).

Quick-release thru-axle systems are similar to conventional systems in that they use a cam system. The axle has threading on one side and is fit through the dropout and through the hub. A lever system rotates the axle and threads, snugging it in the dropout. The axle is then held secure by the cam. The cam (or in some brands a double cam) is adjusted so there is resistance approximately halfway through the swing from open to closed.

There are two standards for front fork thru-axles. There is a 15 mm diameter with 100 mm spacing, and a 20 mm diameter with 110 mm spacing.

Thru-axle systems are also made for the rear hub. These use a 12 mm diameter axle, and can come in widths of 135, 142, 150, 157, and 160 mm. There are both simple straight axles

FIGURE 2.60



Maxle system in a rear thru-axle bike

that secure by threading and a pinch slot in the dropout, and maxle systems that use a quick-release lever (figure 2.60).

There are also hubs popularized by DT Swiss® that use a thru-axle design for open dropout bikes. The rear thru-axle is 10 mm diameter to fit into rear open dropouts. The front thru-axle is 9 mm to fit into open dropout forks. The axles come out of the hub completely, like any thru-axle hub. This system is designed to stiffen the hub when it is mounted in the frame or fork. However, these hubs will work in frames that traditional quick-release hubs fit. The lever at the end of the skewer acts as a wrench to loosen or tighten the wheel in place (figure 2.61). The lever does not operate as a cam, like the traditional quick-release lever. Turn the lever counter-clockwise to loosen and clockwise to tighten. Pull back on the lever to disengage the lever from the skewer to position the lever end as necessary after tightening.

FIGURE 2.61

Open dropout with a 10 mm thru-axle hub system

TUBELESS SYSTEMS

Tubeless tire systems are similar to those used on cars and motorcycles. The tire is sealed airtight to the rim bead without an internal inner tube. The rim inner perimeter must also be airtight. Tubeless tires can increase the contact area of the tire to the ground because they can be ridden at low relative air pressure, which can improve the ride feel and handling of MTB bikes and cyclocross bikes. The tubeless system is also available in a road bike version. The road bike tubeless system can reduce rolling resistance because there is no movement between an inner tube and tire.

A common cause of flat tires (especially in off-road riding) is a “rim pinch.” The inner tube is pinched when the tire strikes a rock or other object. Tubeless tire systems have no inner tube to pinch when used at low pressures and are not susceptible to this common flat.

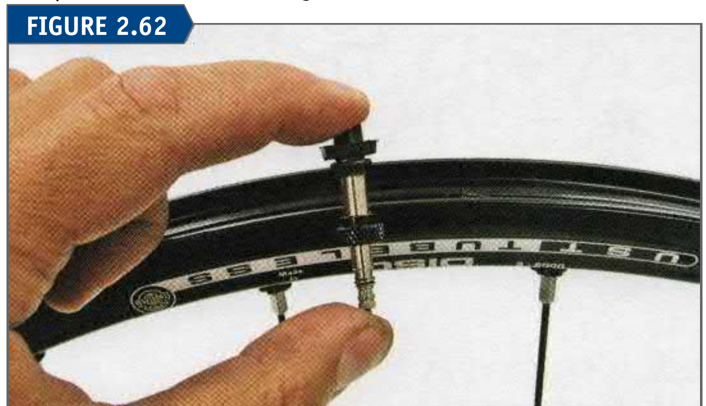
Tubeless tires are still prone to punctures from nails, glass, thorns, etc. Additionally, the system is liable to leak if the tire head or rim seat has become damaged or disengages. Hard lateral impacts to the tire can result in a “burp” in the system. This is where the head is momentarily pushed away and disengages from the rim sidewall, allowing air to escape. This reduces air pressure and weakens the tire bead to rim strength, making the wheel and tire susceptible to more burps until the tire is reinflated.

The Universal System Tubeless (UST) is a rim and tire design standard for bicycle tubeless systems. A UST tire will have a special butyl liner to hold air without an inner tube, and will have a specially shaped tire bead. The UST rims will have either no nipple holes in the rim tire bed, or these holes will be completely sealed. The UST rim bead seat is designed to accept and hold the beads of the UST tires. UST tires can be used on a UST rim without tire sealants.

To remove tubeless tires, begin by fully deflating the tire. Push only one tire bead into the center well of the rim all around the wheel to free it from the rim. On some tire/rim combinations, it is possible to pull the bead off the rim without tire levers once it is sitting on the center part of the rim, which has a smaller circumference than the bead seats. If tire levers are necessary, then take care to use only plastic levers. Pull the loose bead over the rim edge. Push the second bead from the tire seat and then pull the whole tire from the rim.

Tubeless systems may use either a special Presta or Schrader valve secured into the rim and held in place by a nut (figure 2.62). The valve is an airtight fit to the rim.

FIGURE 2.62



Tubeless valve system

Procedure for tubeless tire installation:

a. Check that valve is fully seated inside of the rim and valve nut is secure. Clean the tire bead and rim seat as needed.
b. Insert one bead over the rim wall and into the center of the rim. The first bead must be fully installed before inserting the second bead over the rim.
c. Special tubeless tire seating compounds can be useful to help bead seat properly and seal to the rim. Soapy water on the bead of the tire can also help (figure 2.63).
d. Inflation is best done with an air compressor. This provides large amounts of air to quickly force the bead to the rim, creating a seal. If no compressor is available,

FIGURE 2.63

Soapy water can help the bead seat into the rim quickly pump to form a seal. It's helpful to have a friend assist by holding the tire centered to the rim during inflation.

e. Over inflate the tire if the bead is not fully seated. Bead will often seat with a popping sound. Inspect for bead leaks using soapy water at the bead and look for any bubbles. Deflate and reseat as necessary.
f. Allow tire to sit for some hours and check that there are no slow leaks. Set tire to desired riding pressure.

The un-inflated tubeless tire relies on high air volume to push the tire bead to rim and create a seal. This is why an air compressor is so useful when installing the tire. If it does not seem possible to seat the bead well enough to inflate the tire, attempt to use a long strap to help seat the tire. Place the strap around the circumference of the tire. Tighten the strap to help hold the bead to the rim and inflate the tire (figure 2.64). This helps the bead hold to the rim while tire is inflated.

FIGURE 2.64

Use a strap to apply even pressure on tires that are difficult to inflate

The tubeless system is best patched by removing it from the rim. The inner surface of the tire is butyl rubber and similar to an inner tube. Locate the hole and clean an area inside the tire body. Use a self-vulcanizing patch with similar procedure as described for the inner tube repair. If tire sealant was run inside the tire, the patch will not work well. If necessary, install an inner tube inside the tubeless tire until a new tubeless tire can be mounted.

Liquid sealants for tubeless tires are available from various manufacturers and are intended to seal small holes in the tire. These are best applied to the tire before mounting. All tubeless systems are susceptible to air loss, more than conventional inner tube systems. All tubeless tire manufactures assume that tires are checked for pressure before each use.

Procedure for tubeless tire sealant installation:

a. Install one tire bead on the wheel.
b. Hang the wheel vertically with valve at either the three or the nine o'clock position (figure 2.65). If the bike is mounted in a repair stand, the handlebar ends can be used as a hanger.
c. Pour sealant into the tire at the six o'clock position. Consult the sealant manufacturer's instructions for amount of sealant to pour.
d. Leave the tire and wheel hanging. Carefully engage the second bead while working from the bottom upward on both sides (figure 2.66).

FIGURE 2.65

Hang wheel with tire in place

FIGURE 2.66

Work bead onto rim

e. Remove the wheel from the hanger and inflate tire and seat bead.
f. Inflate wheel to full a pressure and inspect seating. Spin wheel to distribute fluid.

There are both tire and rim manufacturers that state not to use any sealants inside their product. The rim material may corrode or the tire lining may be damaged. Consult rim and tire manufacturers for their statements.

TUBELESS CONVERSION SYSTEMS

Manufacturers offer conversion kits for using a traditional inner tube compatible rim with "tubeless ready" tires. There will be mixed results with these systems depending upon the rim and the application of the kit. For the best results from a tubeless tire system, use both tires and wheels designated as UST.

The conversion kits available on the market share commonalities. There will be a strong, heavy duty sealing tape to install into the rim. There will be a valve core that tightens into the rim and which must seal into the tape. Sealing liquids are installed to plug small leaks in the rim-to-tire interface and in the tire casing itself. Conversion systems are susceptible to air loss through several points in the system, including seepage of air through the sidewalls.

Procedure for tubeless tire conversion:

a. Remove old tire, tube, and the rim strip. Inspect inside wheel for dents in the rim bead or other anomalies. Also inspect for burrs in the aluminum bed or nipple eyelets, and make sure the rim has a smooth finish.
b. Clean inside the rim wheel well using acetone, alcohol, or similar solvent that will not leave an oily film.

FIGURE 2.67

Install rim sealing tape directly over valve hole

c. Install conversion rim sealing tape in rim bed, pulling tape snugly as the tape unrolls to cover the entire bed inside the wheel circumference (figure 2.67). Overlap tape, covering valve hole. Work with care to cover rim evenly with no loose area of tape. Press down on tape to ensure a good bond to the rim. Tape must seal the inner perimeter airtight.
d. Use a pointed sharp object to make a hole in the tape at the rim valve hole. Carefully puncture a hole. Do not tear or shred the tape at the valve hole.
e. Install tubeless tire valve and align in rim (figure 2.68). Secure with nut fully tightened by hand. Do not use pliers to tighten nut.

FIGURE 2.68

Secure tubeless valve through rim sealing tape

f. Install tire and sealant as described above in "Procedure for tubeless tire sealant installation."
g. Inflate tire immediately. Begin with low pressure and inspect tire seating. Continue to fully inflate tire.
h. Spin wheel to spread sealant inside tire. Next, place wheel horizontally on a bench and spin to work sealant into tire-bead interface. Flip wheel to other side and repeat spinning. Check tire in a few hours and repeat spinning to spread sealant.

Because these tubeless conversion kits are commonly used on non-UST rims, it can sometimes be difficult to get a tire successfully mounted. The bead seat of the rim may be too deep to push upward on the tire bead. If a tire will not seat, it can be helpful to remove the tire and build up the rim tape inside the rim. Install extra tape directly over the conversion kit sealing tape. Use one or two rounds of an electrician's tape or a duct tape. Reinstall tire and attempt to inflate.

FIGURE 2.69

Inject sealant after tire bead was seated

When the tire valve is removable core, it can be very practical to inject tire sealants through the valve (figure 2.69). This requires use of a large syringe or similar tool. These can often be purchased at veterinarian supply stores, farm supply stores, and pet stores. Install and inflate tire without sealant. Hang wheel from hook to prevent dislodging of tire bead. Remove valve core. Fill syringe with quantity of fluid recommended by sealant manufactures. Reinstall valve core and inflate tire. Spin wheel to spread and disperse sealant.

It can be very helpful in getting the bead to seat and hold to use a mixture of dish soap and water. Even using straight liquid soap without dilution will help block air and permit the bead to catch the rim. After the bead holds and the tire inflates, bubbles will show any potential weak points in the tire to rim seating.

It is not uncommon for "tubeless ready" or non-UST tire casings to be porous enough to allow air to escape directly through the sidewalls. This considered "normal" by some manufacturers as long as it does not escape at an unacceptable rate. This seepage can be seen when soapy water is applied to the sidewalls. Bubbles will appear from this air seepage along the sidewall (figure 2.70). The design of non-UST systems is that the tire sealant will eventually seal this area. Other than using a different model of tire, there is no other solution. Hold the wheel horizontal and spin to spread the fluid inside the sidewall areas.

FIGURE 2.70

Bubbles showing air seepage through tire sidewalls

TUBULAR TIRES

A tubular tire uses casing that is sewn around an enclosed inner tube. The complete tire unit is then glued to a special "tubular" rim. Tubular tire systems are available in various sizes including both road and off-road cyclocross and MTB racing versions. The gluing process is very important to the performance and safety of the wheels. A poorly bonded tire may roll off of the rim during use and cause the rider to fall.

The tubular rim does not have the sidewalls that act as the bead seat of the clincher rim. Tubular rims have a concave radius surface to accept the tubular tire. Tubular tires do not interchange with clincher rim systems.

Like any bonding or gluing process, surface preparation is important. The tubular rim surface should be cleaned with a strong solvent, such as acetone, that does not leave an oily film. Use proper hand protection and work with good air ventilation. If using a typical 25 g tube of adhesive glue, it will take one tube per wheel for rims without a previous base coat.

Because the tire can be difficult to stretch on to the rim, it is best to begin by mounting the unglued tire on the clean rim. Inflate the tire fully to allow it to stretch for several hours. If no clean tubular rim is available for stretching, use a clincher wheel of ETRTO 622 (700c).

Caution:

The tubular tire system, even when mounted properly, is still susceptible to failure during use. Every precaution should be taken when bonding the tubular to the rim. At this time there are no industry standards for tubular mounting.

Procedure for tubular tire mounting:

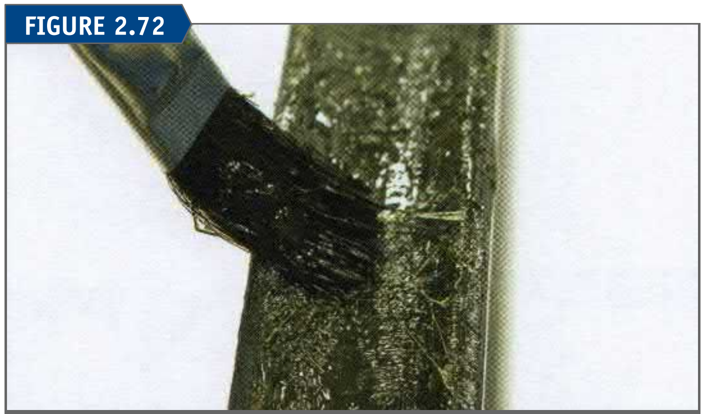
a. Clean the rim tire seat using a solvent such as acetone.
b. Inflate the tire fully. This will roll the base outward and make it easier to apply the base coat.
c. Using a brush, apply a thin coat to the tire's base strip. Cover the strip side to side with an even coat. Allow this coat to completely dry. This will make handling the tire less messy when mounting (figure 2.71).

FIGURE 2.71

Inflate tire and apply a single base coat

d. Apply a thin coat to the rim surface. Allow this coat to completely dry. Ideally allow this to dry for 12 hours. The solvent from the glue needs to evaporate. For new rims with no base coat, apply at least three to four base coats allowing 10–12 hours between coats (figure 2.72).

FIGURE 2.72



Base coat rim with thin even coats

e. Apply one last coat to the rim before mounting. Do not allow this coat to dry. Mount the tire immediately after finishing this last coat.
f. Deflate the tire, but leave enough air inside to hold the tire body shape to aid installation.
g. Place the rim vertically on a clean surface. Do not mount on grass, carpet, etc. Any contamination of the rim glue will weaken the bond.
h. Place and align the valve inside the rim valve hole. Using one hand, press down firmly on tire at stem. Grab the tire body with other hand and pull with force to the side, laying the tire in the glue bed. Work the hand at the valve in the opposite directing pulling with force and stretching the tire as you work the base tape into the rim glue bed. Continue to apply pressure as you work down to the bottom of the wheel (figure 2.73).

FIGURE 2.73

Stretch tire as it is mounted

FIGURE 2.74

Push tire up onto rim

i. The last section of tire is the most difficult to mount. Use thumbs to push tire up and onto rim (figure 2.74).

j. Mount wheel in bike or in truing stand and spin wheel. Inspect top tread of tire relative to rim. Grab sections of tire that appear to wobble, and push and twist the tire straight (figure 2.75). Better quality tires will align, while lesser quality tires may not have been initially made straight and may not run perfectly true.

FIGURE 2.75

Roll tire on rim to center and true

k. Inflate the tire fully to press it into rim bed. Allow tire to sit at least 24 hours before use. Tubular glues are typically contact cements that require drying. Strength will improve with drying time.

It is possible to mount tubular tires on rims that have a previous bed of glue. Safe mounting will always require at least one coat of fresh glue, but additional thin base coats may be required if the base coat is thin or provides inconsistent cover.

Old glue bases or dirty glue bases should be cleaned off the rim. For aluminum or carbon fiber rims, it is possible to use heavy-bodied paint removers. Use a biodegradable remover when possible and follow stripper directions. Follow cleaning with stripper wash and then a soap and water wash.

It is impractical to fully inspect the mounting of a tubular without partially removing it. Roll the tire back away from the rim to inspect the glue at the rim/tire interface (figure 2.76). If popping and cracking is heard, it is an indication the bond is old or there was an inadequate amount of glue in the bond. The tire would be suspect and liable to roll off the rim. Re-glue tires failing this test.

FIGURE 2.76

A poorly bonded tire with inadequate glue at interface of rim and tire

There is no on-the-ride repair for a flat tubular; it must be changed for a spare. It may be necessary to use a tire lever to work under the tire and free it from the rim. Work the lever back and forth to free the tire from the glue bond. Use care not to contaminate the glue surface of the rim with dirt. Install the spare, center it as best possible to the rim and inflate fully. **Note:** The tire bond to the rim is compromised for the spare tubular, so ride with caution. Avoid excessive speed especially in tight corners where there can be a lateral load. Properly re-glue the tire as soon as possible.

CHAPTER 3

REAR SPROCKETS

The rear sprockets are the gears mounted to the drive wheel of the bike, usually the rear wheel. Also referred to as cogs, the sprocket teeth mesh with the chain and drive the wheel and the bike forward. The sprockets will wear with use and must be replaced eventually. Sprockets are also removed in order to service the axle bearings.

The clutch or ratchet systems used on derailleur and some single-speed bikes allow the rider to coast. The sprockets spin relative to the hub when the rider stops pedaling but lock and drive the rear wheel when the pedals and chain are turned forward. Bearings fitted in the sprocket system allow the gears to turn freely. It is common and normal to have a slight amount of play between the inner and outer parts of the sprocket bearing system. Additionally, when the wheel turns during coasting, the rear sprockets may appear to wobble slightly side to side. This is also common and not usually a problem because when the bike is pedaled, the inner and outer parts lock together as they drive to eliminate the wobble.

Rear sprockets on multi-speed bikes are attached to the hub in one of two ways. Bikes may use a "freehub," which is a ratchet system mounted to the body of the hub (figure 3.1). This cylindrical mechanism acts as a clutch that ratchets for coasting and locks for driving the bike when pedaling. The freehub body has a series of splines on the outer shell. "Cassette" sprockets, also called the "cassette stack," mate to these splines. The pattern, spacing, size, and width of the freehub and cassette splines may vary between component manufacturers, making some brands and models non-interchangeable.

FIGURE 3.1

Cassette sprockets on the left with freehub body on the right

FIGURE 3.2

Lockring holding cassette sprockets secure to freehub body

Sprockets secure to the freehub body with a lockring (figure 3.2). When the sprockets are removed, the ratcheting freehub remains on the hub body. Most modern derailleur bicycles use the freehub system. The cassette system is used by some single-speeds as well as 6-, 7-, 8-, 9-, 10-, and 11-speed rear sprocket systems. The spacing between cogs tends to get narrower with more and more sprockets added to the cassette system. Freehubs designed for more cogs can accept cassettes with few cogs if the appropriate spacers are used. However, you cannot add more cassette cogs than the freehub was designed to accept.

An alternative system to the cassette and freehub is the "freewheel." Freewheels thread on and off a large machined thread on the hub (figure 3.3). The modern thread standard for freewheels is 1.37 in. x 24 tpi. The sprockets with the ratcheting mechanism can be removed from the hub, cleaned, and reinstalled as a unit. Freewheels are available with single or multiple cogs up to nine speeds.

FIGURE 3.3

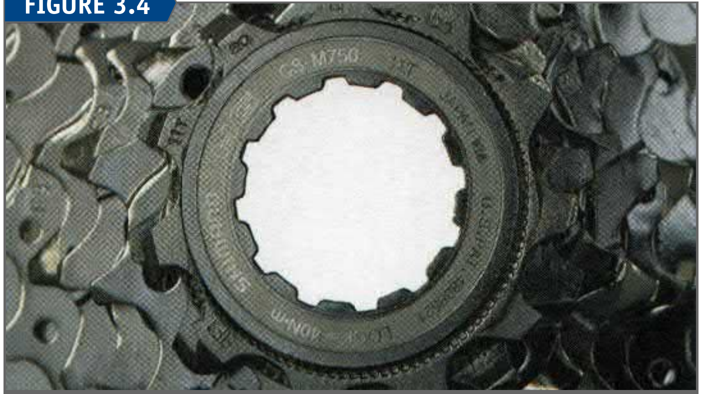
Rear hub threaded for freewheel

CASSETTE SPROCKET REMOVAL & INSTALLATION

Cassette cogs are held on the freehub by a lockring sitting outward from the smallest sprocket. Pressure from the lockring prevents the sprockets from moving side to side on the freehub and also helps prevent the sprockets from damaging the freehub body by rotation. These rings are often marked with the word "LOCK" and an arrow on the lockring indicating direction to turn for locking.

There are two non-interchangeable lockring tool standards. Cassette systems by Shimano®, SRAM®,

FIGURE 3.4



Cassette lockring for Shimano® and similar brands

FIGURE 3.5

Park Tool FR-5 cassette lockring remover

Chris King®, Sun Race®, American Classic®, and others require a lockring tool with 12 splines. The tool fitting is approximately 23.5 mm diameter (figure 3.4). Use the Park Tool FR-5 (figure 3.5). Another option is the Park Tool FR-5G, with built-in guide pin. The pin helps keep the tool from twisting in the lockring.

Campagnolo® cassettes also require a lockring tool with 12 splines. However, the tool fitting is approximately 22.8 mm in diameter (figure 3.6). Use the Park Tool BBT-5/FR-11 (figure 3.7). Although the both the FR-5 and BBT-5/FR-11 lockring removers look similar, the two are not interchangeable.

Cassette cogs are separated on the freehub by spacers. Cassette manufacturers may design spacers into the cogs, or the spacers can be pinned between cogs. The spacer may also simply be loose. Generally the spacers are the same within a cassette system, and if the order of spacers is mixed, it will

FIGURE 3.6

Campagnolo® cassette lockring

FIGURE 3.7

Park Tool BBT-5/FR-11 cassette lockring tool for Campagnolo® lockrings

not affect the cog spacing. However, always note orientation of spacers when taking off a cassette. Note any spacers behind the cassette. These are used as corrective spacing by some manufacturers or to convert the freehub to use fewer cogs then it was designed for.

Procedure for cassette sprocket removal:

a. Mount bike in repair stand and remove rear wheel.
b. Remove quick-release skewer, or axle nut of solid axle.
c. Inspect cassette and select correct type of cassette lockring remover.
d. Engage remover onto splines of lockring.
e. Install quick-release skewer (or axle nut) and install skewer nut on outside of remover. **Note:** For FR-5G, the guide pin takes the place of the skewer. Install the FR-5G into the axle without skewer.
f. Snug skewer nut against remover (figure 3.8). Skewer acts as a holding device for remover.

FIGURE 3.8

Use skewer and nut to hold tool firmly to lockring

FIGURE 3.9

Loosen lockring while holding cassette sprockets

g. Hold sprockets from rotating in the counter-clockwise direction with chain whip tool. Turn remover counter-clockwise with a large adjustable wrench, the hex end of another Park Tool Sprocket Removing Chain Whip Tool SR-1, or the Park Tool Freewheel Wrench FRW-1 (figure 3.9). It should require some force to remove the lockring. Expect to hear a clicking sound from the teeth on the lockring.
h. Turn remover only one full revolution counter-clockwise. Loosen and remove skewer before continuing to remove lockring.
i. Continue to hold sprockets and turn remover counter-clockwise until lockring is unthreaded from freehub body.

j. Remove lockring and sprockets. Note orientation of spacers behind sprockets. Spacers should be replaced in same order as removed.

The chain-whip tool is not required to install the cassette sprockets and lockring. The cassette ratcheting mechanism will hold the freehub body and keep the sprockets from rotating in the direction the lockring tightens. Hold wheel firmly as cassette lockring is tightened. For corrosion protection, grease or anti-seize may be smeared on the freehub body.

Procedure for cassette sprocket installation:

a. Inspect splines of freehub body. Look for a wide space between splines.
b. Inspect internal splines of sprockets. Look for a wide spline to mate with wide space on freehub body (figure 3.10).

FIGURE 3.10

Align the wide spline inside sprocket with wide space on freehub body.

c. Align splines and engage all sprockets and spacers.
d. Grease threads of lockring and thread lockring into freehub body.
e. Insert cassette lockring tool into splines of lockring. Install quick-release skewer and thread skewer nut on outside of lockring tool.
f. Snug skewer nut against remover. Skewer acts as a holding device for remover.
g. Turn cassette lockring tool clockwise until lockring is fully tight (figure 3.11).

The SRAM® XX1 system is an 11 cassette system. For the XX1, SRAM® uses a proprietary freehub body and cassette design (figure 3.12). The cassette will not fit on the freehub bodies that use the traditional lockring at the end of the freehub. The sprockets are not individually removable from the cassette stack. The cassette uses the Park Tool FR-5 remover on the lockring. The lockring is nearly the width of the cassette and engages splines' threads on the freehub adjacent to the spokes.

FIGURE 3.11

Tighten lockring clockwise

FIGURE 3.12

SRAM® XX1 cassette with special freehub body

Begin installation of the SRAM® XX1 by first greasing the threads. Slide the cassette over the freehub body and engage the splines. The splines are symmetrical and any orientation will work. Use the FR-5 to thread the system lockring to the freehub. Secure fully as any other type of cassette stack.

Removal of the SRAM® XX1 is the same as other systems. Use a chain whip to hold the cassette stack and keep it from from turning. Engage the FR-5 into the lockring and turn counter-clockwise until the threads are disengaged. Pull cassette from freehub.

FREEWHEEL SPROCKET REMOVAL & INSTALLATION

Freewheels are made of two assemblies. The outer body with the cogs will rotate freely counter-clockwise to allow for coasting. The inner body contains the threads that secure to the hub. The inner body should have either recessed notches or splines in the body to fit the removal tool, usually recessed inside the smallest sprocket. There have been numerous brands and models of freewheels through the years, and some may not have any tool available.

Tech Note:

Some brands use fittings that are now obsolete or are simply unusable. These freewheels must be destroyed to be removed from the wheel. The freewheel cone is removed clockwise. The bearings, pawls, and outer freewheel body are removed, and the inner body is grabbed in a vise and turned counter-clockwise for removal. A new freewheel is then installed.

To remove freewheels, begin by determining type or brand of freewheel and the removal tool required. The removal tool must fit the part correctly, or both may become damaged. To determine the type or brand of freewheel, remove the wheel from the bike and look at the flat surfaces of freewheel near the axle for a brand name. See Table 3.1 for the matching freewheel tool.

Procedure for freewheel removal:

a. Mount bike in a repair stand and remove rear wheel.
b. Remove quick-release skewer or drive side axle nut.
c. Inspect freewheel center and select correct type of remover.

TABLE 3.1 *Freewheel Removal Tools*

FREEWHEEL BRAND	FREEWHEEL FITTING	APPROPRIATE TOOL	TOOL & DESCRIPTION
Shimano®, Sun Race®, and Sachs®			Park Tool FR-1 12 splines 23 mm approx. diameter
Suntour® two-notched			Park Tool FR-2 2 notches 25 mm across
Suntour® four-notched			Park Tool FR-3 4 notches 24 mm across
Atom®, Regina®, some “Schwinn® approved”			Park Tool PR-4 20 splines 21.6 mm approx. diameter
Single speed, BMX			Park Tool FR-6 4 notches 40 mm across
Falcon®			Park Tool FR-7 12 splines 23 mm approx. diameter (slightly larger than FR-1)
Compact single speed (30 mm thread, “flip-flop hub”)			Park Tool FR-8 4 notches 32 mm across

d. Engage remover onto splined notches of freewheel.
e. Install quick-release skewer. The skewer nut should be on the outside of the remover.
f. Snug skewer nut or axle nut against the remover. Nut acts as a holding device for the remover.

FIGURE 3.13

Turn tool counter-clockwise to remove freewheel from hub

g. Turn the remover counter-clockwise using a large adjustable wrench (figure 3.13). Park Tool removers will also fit the hex end of the Park Tool SR-1 Sprocket Chain Whip Tool or the Park Tool FRW-1 Freewheel Removal Wrench. It will require some force to remove the freewheel. Another option is to mount remover tool flats in the jaws of a vise and turn the rim counter-clockwise.
h. Turn the remover only one full revolution counter-clockwise. Loosen and remove skewer or axle nut before continuing to remove freewheel.
i. Turn remover counter-clockwise until freewheel is unthreaded from hub. Lift the freewheel from the hub.

Procedure for freewheel installation:

a. Apply grease or anti-seize heavily inside mounting threads of freewheel (figure 3.14). Lack of thread lubrication may seize freewheel to the hub.
b. Lay wheel on bench and hold flat. Hold freewheel sprockets parallel to wheel and lower freewheel onto threads.

FIGURE 3.14

Heavily grease threads of freewheel

FIGURE 3.15

Example of off-centered freewheel from possible cross threading

c. Axle should be centered in hole of freewheel. If axle appears off-center, freewheel is cross-threaded on hub threads (figure 3.15). Remove and realign.
d. Begin threading freewheel clockwise by hand until freewheel feels fully threaded.
e. Use chain whip tool to fully seat freewheel clockwise against hub, so that derailleur adjustments will be correct when the wheel is installed in the bike. It is also possible to install the wheel in the bike and use the pedals to fully seat the freewheel. The freewheel must be seated to accurately adjust rear derailleur settings.
f. If either a new freewheel or new wheel is installed, check rear derailleur limit screw settings and indexing. See Chapter 9, Derailleur Systems.

Some freewheel models allow the removal of individual sprockets. Sprockets can be held to the freewheel body with a lockring, or the first cog may act as the lockring. However, individual replacement sprockets for freewheels are not available, so there is no need to remove the sprockets from the freewheel body. The cogs can be cleaned while in place on the freewheel body.

SINGLE-SPEED REMOVAL

Single-speed rear hubs may use either the cassette system or a screw-on freewheel, depending upon the make and model. For threaded freewheels use the same procedures as multiple cog freewheel removal and installation.

Cassette system single-speeds may come with a lockring similar to multiple speed cassettes. Use the Park Tool FR-5 and the same procedures as multiple speed cassette systems.

There may also be a notched lockring or a lockring with flats retaining the cog. If the lockring has flats, measure across the flats and use the appropriate size wrench or a large adjustable wrench. Notched lockrings are removed and tightened with the Park Tool HCW-17 Lockring Tool (figure 3.16).

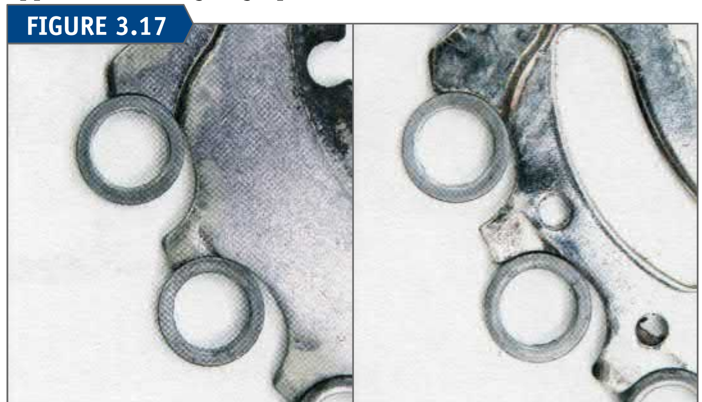
FIGURE 3.16

Single speed cassette system with notched lockring

SPROCKET INSPECTION & CLEANING

The teeth of the cassette or freewheel are cut to fit chain with a ½ inch pitch. Rear sprockets eventually wear out. As the chain is ridden it loads only the back side of the sprocket teeth. Material is eventually ground away, changing the shape and widening the space between the teeth (figure 3.17). The chain rollers will then not properly engage the teeth and, on derailleur bikes, the chain will skip over the cog when load is applied, such as going up a hill.

FIGURE 3.17



Left: chain rollers sitting in a worn sprocket showing poor engagement
Right: chain rollers showing good engagement on a new sprocket

FIGURE 3.18

Inspect for a smooth and shiny surface indicating a worn cog

FIGURE 3.19

This sprocket shows signs of original stamping marks indicating very little usage

Visually inspect the sprockets from behind where the chain engages each sprocket. Look at various sprockets and notice any that are shiny and smooth compared to the rest (figure 3.18 and figure 3.19). This indicates a relatively worn cog. The best test for a worn cog is to ride it with a new or unworn chain. If the cog does not skip under load, it is not worn out.

Cyclists tend to use two or three favorite rear sprockets more than the others. These, naturally, will wear out first. Commonly, these are the 15- to 18-tooth sprockets. If individual sprocket replacements are available, replace these worn cogs. Otherwise, all rear cassette sprockets are typically replaced together. When a new cassette or freewheel is installed, a new chain should be installed.

Single-speed bikes will also wear at the rear sprocket. The chain will not skip under load like a derailleur bike, but it will begin to make excessive noise and become less efficient as the teeth become hooked.

Rear sprockets and front chainrings require cleaning if the entire drivetrain is to be maintained. Use care not to get solvent into the bearings of the freewheel/freehub or the bearings of the bottom bracket. Freehub mechanisms and freewheel bodies use ball bearings running on bearing surfaces as well as small springs and pawls. These component parts are not typically "overhauled" by complete disassembly. The unit may be removed from the hub, flushed, and scrubbed clean in solvent. The solvent will then be blown out with compressed air or allowed to evaporate. Lubrication is then dripped into the mechanism. Grease is not recommended for freehubs or freewheel internals because it may cause the small springs and pawls to stick. If the freewheel/freehub spins roughly after cleaning, the bearing surfaces are worn out and the unit should be replaced. There are no internal parts available for freehubs or freewheels from manufacturers. See page 47, Freehub Removal & Installation.

Rear sprockets can be cleaned while still mounted to the wheel. Begin by scraping between sprockets with the comb part of the Park Tool GearClean® Brush (figure 3.20) or a thin screwdriver to remove dirt and debris. Hold wheel so sprockets are tilted downward underneath the wheel, then use a dry stiff bristle brush between sprockets. Dip brush in solvent and scrub sprockets while holding sprockets facing downward. This helps to keep solvent out of bearings. Use a rag to wipe

FIGURE 3.20

Cleaning debris between sprockets with the "comb" of the GSC-1

solvent off sprockets, rim, and tire. Grab two corners of rag and pull taut. Use this section to "floss" between sprockets.

Freehubs can be removed for internal cleaning. This process is described in Chapter 4, Hubs. Although the freehub can be pulled, it is not designed be taken apart down to the bearings and ratcheting pawls. Worn freehubs are replaced, not overhauled.

FIXED GEAR SPROCKETS

A fixed gear is a single-speed sprocket that is locked to the hub shell. When the rear wheel is turning the cog must turn, and consequently, the chain and cranks must turn. Fixed gear drivetrains are used for Velodrome racing (track bikes) and some street bikes. It is possible to modulate speed by changing leg speed, but for street use this is not a substitute for a caliper braking system with a hand lever.

Fixed gear cog threading is the same pitch and diameter of common threaded freewheels and will fit hubs threaded for freewheels. However, fixed cogs are intended for hubs designed with a lockring (figure 3.21). The lockring of a fixed gear hub is slightly smaller than the cog and is left hand threaded. Because of the left hand thread of the lockring, it would be self-tightening if the rear cog were to begin loosening. Lockrings only need to be snug; do not overtighten.

Fixed gear cogs come in 1⁄8 inch and 3⁄32 inch widths (nominally 3 mm and 2.4 mm, respectively) and must match the chain roller width. To install the fixed cog, grease threads of both the cog and lockring. Thread cog onto hub and tighten with chain whip. Install lockring and snug. Chain length and tension is determined in the same way as a single-speed bike.

FIGURE 3.21

Lockring and single speed fixed gear cog

CHAPTER 4

HUBS

Hubs are the mechanisms at the center of the wheels that allow the rim, spokes, and tires to rotate in the frame. The hub consists of an axle, a bearing system, and a hub shell to hold the spokes. Hub bearings will require servicing for wear from use, and from exposure to dirt. If a hub was initially adjusted improperly, it will greatly accelerate wear on the hub bearings.

The hub axle is fixed to the front or rear forks, while the hub shell rotates with the tire and spokes. On derailleur bicycles, multiple rear sprockets are affixed to the rear hub with a clutch mechanism that allows the rider to either coast or to drive the wheel forward. On disc brake bikes, the hub will also hold the disc rotor used for braking. Hubs can also be designed to hold an internal gear system. For internal gear hub systems see Chapter 10, Internal Gear Systems.

Hubs vary in width according to the intended use and bike design. Hub width is measured from left to right locknut faces (figure 4.1). This is referred to as the “over-locknut” width. The inside width of the frame or fork should match the over-locknut width of the hub by 1–2 mm. The fork or frame will not be harmed when hubs differ from their width by this small amount.

Usually, front hubs designed for open dropout forks are 100 mm wide. Rear hubs have been made in many different widths through the years. As more sprockets were added to the hub, the wider the over-locknut width needed to be. As mountain bike tires became wider, it was also necessary to increase the hub width. See Table 4.1 for some of the hub over-locknut standards and their typical uses.

FIGURE 4.1

Measuring over-locknut width of a rear hub

TABLE 4.1 *Common Hub Standards*

COMMON HUB USE	OVER-LOCKNUT WIDTH
Open dropout forks	100 mm
15 mm thru-axle forks	100 mm
20 mm thru-axle forks	110 mm
Rear hub, older track bike, some rear coaster brake hubs	110 mm
Older 5-speed bikes, current track bike standard	120 mm
6- and 7-speed road bikes	126 mm
8-, 9-, 10-, and 11-speed modern road bikes	130 mm
Common MTB, internal gear hubs, and road disc brake hubs; 12 mm thru-axle	135 mm
Tandem open dropout	140 mm
MTB 12 mm thru-ax1e	142, 150, 157, and 160 mm
Tandem open dropout	160 mm
“Fat tire” standard	170 and 185 mm

It is possible to manipulate some rear hubs and change from one over-locknut width to another. If the hub uses a straight threaded axle, a new axle of a different length can be installed and spacers adjusted accordingly. The majority of modern hubs are cartridge bearing types with special flanged axles and do not allow for changes to hub over-locknut widths.

On “thru-axle” hubs, the axle is removed fully from the bike to get the wheel out. The hub width is measured from end to end of the hub as it inserts in the frame or fork (figure 4.2). There is no axle locknut for the over-locknut measurement. Front forks are 100 mm wide for the 15 mm diameter thru-axle hubs. The 20 mm front forks accept the 110 mm wide thru-axle hubs.

FIGURE 4.2

Thru-axle fork with hub in the 15 mm axle standard

FIGURE 4.3

Closed dropout and a 12 mm rear thru-axle hub

Rear hubs are also designed for thru-axles and use a closed dropout (figure 4.3). The common axle diameter is 12 mm. There are several width standards for rear thru-axle bikes listed in Table 4.1. There is no interchangeability between the standards.

HUB BEARING SERVICE: ADJUSTABLE CUP-AND-CONE TYPE

The procedures below are written primarily for cup-and-cone hubs on standard 10 mm and 9 mm threaded axles, such as most Shimano® hubs. The procedures here are also applicable to other adjustable cup-and-cone type hubs. However, some hub models from both Campagnolo® and

Shimano® have significant differences in procedures. For full service on these models, such as the Shimano® Dura-Ace® or Campagnolo® Record® hubs, contact the manufacturer or see the Repair Help section of www.parktool.com.

Adjustable-type hubs use cone-shaped races threaded onto an axle. The hub shell holds cup-shaped races. Ball bearings are trapped between the cones and cups. Rear hubs must allow for the sprockets and tend to be more complex than front hubs. The modern freehub or cassette hub uses a separate clutch mechanism to hold the cassette cogs. The freehub body may be removed from the hub shell in a separate operation but is normally left in place for axle bearing service.

Ball bearing and bearing surfaces are covered with grease to minimize wear. The parts are shielded from dirt by covers and seals. Exposure to the elements will increase wear on the bearing surfaces and shorten ball bearing and bearing surface life. Water is capable of penetrating most hub seals and will carry dirt inside. Hubs should see occasional service to prevent wear and to maximize life.

Hub cones have narrow wrench flats that require a special, thin spanner called a cone wrench (figure 4.4). Cones are made with wrench flats ranging from 13–28 mm. For front hubs, the cone wrench sizes tend to be 13 mm, 14 mm, and occasionally 15 mm. In rear hubs, 15 mm and 17 mm are the most common wrench sizes. If the locknut is a simple hex nut, use a combination wrench or even an adjustable wrench. Hex locknuts are commonly 17 mm or 16 mm. However, some locknuts will accept only a cone wrench.

FIGURE 4.4

Cone wrenches are required to service the narrow flats of hub cones

Freehub bodies are lubricated internally with a light lubricant. Soaking entire rear hub in a solvent with freehub attached will remove this lubrication. Avoid getting solvent into the freehub body during hub disassembly and cleaning. Simply wipe the freehub clean of old grease with rags. Most freehubs can be removed from the hub body in an optional procedure for cleaning. See page 47, Freehub Removal & Installation.

DISASSEMBLY

During any disassembly, it is a good idea to take notes or even take pictures of the parts orientation. Note especially any differences between left and right side parts. For example, an axle may be asymmetrical with more threading on one side than the other. Make a note of the axle protrusion past the locknut face on the right side. The parts arrangement of a typical Shimano® hub is seen below (figure 4.5).

FIGURE 4.5

Parts of a common Shimano® rear hub: (A) Hub shell, (B) Ball bearings, (C) Axle, (D) Locknuts, (E) Cones, (F) Washers, (G) Rubber seal

Procedure for hub disassembly:

a. For rear hubs, begin by removing rear sprockets (See Chapter 3, Rear Sprockets).
b. Remove the quick-release skewer. For solid axle type hubs, remove axle nuts. If the hub has a disc brake rotor, it should be removed to avoid contamination by grease.
c. Inspect axle ends. Measure and note the amount of axle protruding past locknut. For quick-release hubs, counting the number of threads is an adequate measurement (figure 4.6).
d. Begin dismantling hub from the left side. If available, mount hub in an axle vise. Mount right side of hub down with left side facing upward.
e. Remove rubber cover or seal from left side, if any.

FIGURE 4.6

Count the number of threads past locknut face for a reference of axle protrusion

FIGURE 4.7

Loosen any left side locknut

f. Hold cone using cone wrench and loosen locknut counter-clockwise. On hubs with oversized axles, inspect axle end for a hex fitting. This is a locking cap locknut. Use a 5 mm hex to loosen left side locknut while holding cone (figure 4.7).
g. Remove locknut and washers. To make reassembly easier, place parts on a string, piece of wire, or zip tie as an organization aid, in the same orientation as they came off hub (figure 4.8).

FIGURE 4.8

Hold parts together in order with zip tie or string

h. Remove cone by turning counter-clockwise and place on your organization zip tie in same orientation as it came off the axle.
i. Place one of your hands below right side of hub and lift wheel slowly. Be prepared to catch loose bearings that fall from hub. Place wheel on bench.
j. If inspecting for a bent axle, remove right side locknut and cones. Note that left side and right side cones, washers, and locknuts may be different. Do not confuse left and right side parts. Use a zip tie or some other method to keep track of parts. Also note axle threading may be asymmetrical. The side with more axle spacers gets more axle thread.
k. Count the number of bearings on each side and then use a pencil magnet to remove bearings from hub shell. Measure ball bearing size. Hub bearing size may be ¼ inch, 3⁄16 inch, or 5⁄32 inch depending upon model.
l. Leave dust caps in place. Dust caps tend to be fragile and any attempt at removal may result in damage. Use a small brush or a rag used over a small screwdriver to clean inside and under dust caps.

FIGURE 4.9

Adjustable cup-and-cone thru-axle front hub

m. Clean and dry all parts. Wipe freehub mechanism using damp rag. Do not soak freehub in solvent unless it is to be removed.

Shimano® uses the cup-and-cone design for thru-axle hubs. These are simply a variation on the same adjustable hub systems. Inspect for a locknut and cone opposite the rotor side. Both cone and locknut will have wrench flats. Use cone wrenches to remove the locknut and disassemble the cone (figure 4.9). These hubs are adjusted for no bearing play in or out of the bike.

PARTS INSPECTION

Inspect hub cups and cones for pitting or damage. Use a ballpoint pen to trace the bearing path. Roughness and wear will be felt as the small ball of the pen passes over pits (figure 4.10). Cones are often available as a replacement part. Inspect ball bearings for brightness. If balls are dull-looking, they should be replaced. If the cup is damaged, it typically cannot be replaced, and the entire hub must be replaced. To inspect the axle, roll it on a flat surface and watch for a gap along the axle-to-flat surface area appearing as axle rolls. Bent axles cannot be straightened and should be replaced.

FIGURE 4.10

Look and feel for pits along ball path of cone

ASSEMBLY

Refer to any notes or photos you made from the disassembly procedure. For example, the axle thread length may vary between left and right side. Do not take apart the cone, spacer, and locknut zip tie until ready to install.

Procedure for hub assembly:

a. Grease axle threads.
b. Grease heavily inside hub shell cups. Place ball bearings in both cups and cover with more grease. Make sure balls are seated flat in cup. The balls should be covered in grease.
c. If all parts were removed from axle, install right side parts. Use care to install in the same orientation as they came off. Note rear axle threads may be asymmetrical. Refer to earlier notes.
d. Adjust right side cone and locknut to return right side axle protrusion to the original measurement past locknut face, as noted in disassembly. Tighten right side locknut fully against cone.
e. Install axle through right side of hub.
f. Install left side axle parts, using care to install in the same orientation as they came off. Do not set axle

protrusion on this side and do not tighten locknut at this time.

g. For quick-release type hubs, snug the cone down until it contacts the ball bearings, then turn back counter-clockwise ¼ turn (90 degrees). This will purposely make the bearing adjustment too loose. Hold the cone with the cone wrench without turning it any farther and, while holding the cone ¼ turn from snug, fully tighten the locknut. There should be axle play at this early setting. Proceed to "Hub Adjustment: Cup-and-Cone."

It is important to check that the threaded axle of a quick-release hub does not protrude past the face of the dropout (figure 4.11). The quick-release skewer must press on the dropout, not the axle end. If the quick-release skewer presses on the end of the hub axle, check the alignment of the axle between the left and right locknuts or shorten the axle by grinding or filing the ends slightly, if necessary.

FIGURE 4.11

Any axle protruding past dropout will not permit quick-release skewer to fully lock wheel

HUB ADJUSTMENT

The cone races moving relative to the cups along the axle perform bearing adjustment. The locknut then locks the cones in place. If the adjustment is overly tight there will be too much pressure on the balls and bearing surfaces, and the system will quickly wear out. A rear hub bearing that is too tight can also result in freehub drag. If the adjustment is too loose, it will cause play in the wheel and this can also prematurely wear out the hub. Proper bearing adjustment is a precise and sometimes time-consuming job. Several attempts at adjustment should be expected before an acceptable adjustment is found.

It is normal to have play between the internal thread of the cone and the external threads of the axle. A hub cone will wiggle on the axle thread until the cone locknut is tightened down against the cone. Because of this normal thread play, you must first tighten the locknut against the cone when checking bearing adjustments.

The goal for adjustable bearings is to have the bearings rotate as freely as possible without any knocking or play. When beginning a bearing adjustment, start with it loose and then proceed to tighten the adjustment in small increments until the play disappears. This ensures the adjustment is as loose as possible but is without play. In most cases, try to make small changes, in increments of 1⁄32 of a complete

FIGURE 4.12

Make only small incremental adjustments to hub bearings

rotation (figure 4.12). Assuming you have the common 32-hole rim, imagine rotating a cone wrench only the angle of spoke to spoke while making adjustments.

The common quick-release hubs have hollow axles that allow for the quick-release skewer shaft. These axles flex slightly when the quick-release lever is closed and pressure is applied to the dropouts, effectively shortening the axle and tightening the bearing adjustment. Hub bearing adjustments must account for this slight change in effective axle length. For adjustable-type hubs there should be a slight amount of play in the axle when the wheel is out of the bike. This play should disappear when the hub and wheel are clamped tightly in the frame. The exception to this is for thru-axle hubs and for some hub models with large, oversized axle systems.

Adjust hub bearings when the wheel is out of the bike. However, to test the adjustment, it is necessary to install the wheel and close the skewer fully tight.

To test the bearing adjustment of the cup-and-cone hub, grab the wheel while it is mounted in the frame and pull it firmly side to side. Rotate wheel to a different position and test again, feeling for a knocking sensation (figure 4.13). If no play is felt, remove the wheel. Grab the axle (not the skewer) and rock it up and down to check for play. If the axle has play when the wheel is outside the bike but no play inside the bike, the hub is adequately adjusted. If there

FIGURE 4.13

Grab wheel and pull side to side laterally to check for knocking of bearing play is no play in the axle when the wheel is outside the bike, the adjustment is too tight, even if the axle seems to turn smoothly when out of the bike. Loosen cone only slightly and retest adjustment in the bike.

Procedure for hub adjustment:

a. If the wheel is mounted in the bike, pull rim side to side to check for bearing play. If no play is present, it is necessary to remove and again check for play out of the bike.
b. Remove wheel from bike. Test bearing adjustment by pulling up and down on axle and feeling for play or knocking. If there was no play in hub when mounted in the bike, but there is play present when hub is outside the bike, the adjustment is adequate. If there is no play in the axle when the hub is outside the bike, the adjustment is too tight. If the hub is too tight and requires adjustment, remove quick-release skewer and springs. Remove any rubber boot covering cones and locknuts on side being adjusted.
c. Secure the right side axle in an axle vise, if available.
d. Hold the left side cone with a cone wrench and loosen the locknut.
e. Loosen cone counter-clockwise a small amount (1⁄32 turn). Hold cone and secure locknut. If hub feels very tight outside of bike, loosen ¼ turn in order to create play.
f. Reinstall skewer and install wheel into frame/fork. Secure quick-release fully.
g. Test bearing adjustment by pulling side-to-side, checking for knocking. Play will resonate through frame or fork.
h. If play is felt, remove wheel and remove skewer. Repeat steps “c” to “g”, proceeding with small adjustments, until no play is felt when the wheel is installed.
i. Reinstall any seals or rubber boots removed during disassembly and install wheel in bike. The wheel must be installed with the same quick-release pressure used when checking bearing play.

If an adjustment cannot be found to allow smooth rotation of the axle, the bearing surfaces may be worn out. If play does not disappear until bearing adjustment is very tight, a locknut may not be tight against cone, which will allow movement. It may also be that the bearing cups inside hub shell have come loose. It may be possible to use a retaining compound behind the cup to re-secure it. However, hub or wheel replacement is the best option.

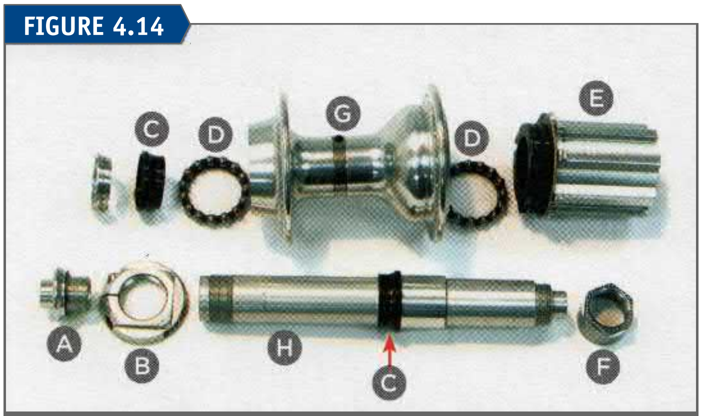
OVERSIZED AXLE SERVICE: CAMPAGNOLO® AND SHIMANO®

Both Campagnolo® and Shimano® use “oversized” axle designs for select models (figure 4.14). The oversized axle provides a stronger and stiffer connection between front or rear dropouts.

There are many service features shared between Campagnolo® and Shimano® oversized hubs. Each uses an oversized aluminum axle with end caps reduced to 10 mm. Campagnolo® oversized hubs use unthreaded cones and are similar in concept to threadless headsets. These are locked in place by a sliding compression ring and a lockring with a pinch bolt.

Shimano® uses threaded end caps as the locknut which are removed with hex wrenches. Cones are threaded and are held by the locknut (figure 4.15).

FIGURE 4.14



Component parts of the Campagnolo® Record® hub: (A) Axle end cap, (B) Left side lockring, (C) Cones, (D) Ball Bearings, (E) Freehub, (F) Right side axle nut (G) Hub shell (H) Axle

FIGURE 4.15

Threaded cone of Shimano® Dura-Ace 9000 rear hub

Shimano® and Campagnolo® use the cup-and-cone design. The oversized axles do not significantly flex when installed on the bike and the quick-release skewer is closed. The adjustment can be done out of the bike and will be effectively the same as when in the frame.

For service procedures of the Campagnolo® and Shimano® oversized axles, contact the manufacturer or see the Repair Help section of www.parktool.com.

HUB ADJUSTMENT: SOLID AXLE CUP-AND-CONE

Non-quick-release hub systems use axle nuts and washers on the outside of the dropouts to hold the wheel in place (figure 4.16). Adjustment of solid axle hub bearings is similar to the hollow axle quick-release type, but there is no need to allow

FIGURE 4.16

Solid or non-quick-release axle on derailleur type bike for axle flex. Remove the wheel from the bike. The adjustment for solid axle hubs does not change when mounted in the bike. It can be useful to mount a "fixed wrench" to act as a lever on the right side when adjusting. This allows you to tighten or loosen relative to the fixed cone. If no play is present, create play by loosening bearing adjustment. Proceed to adjust tighter in small increments until play is gone. The goal is to find the loosest adjustment that has no play.

FREEHUB REMOVAL & INSTALLATION

Freehubs contain a ratcheting mechanism to allow freewheeling. Depending upon the brand and model, the freehub may contain internal parts that eventually wear out. There are no serviceable parts inside most freehubs. The freehub may be removed on many models for cleaning and re-lubrication. If this service did not help or solve the freehub problem, the freehub should be replaced as a complete unit.

The axle bearing dust caps on many freehubs can be easily damaged if removed. Work around dust caps to avoid damage as replacement caps are difficult to obtain.

Procedure for freehub removal and installation:

a. Remove skewer and cassette.
b. Remove axle.
c. Inspect inside freehub body for a bolt fitting. If no fitting is apparent on right side, inspect through left side.
d. Insert hex wrench and turn counter-clockwise. Wrench sizes may vary from 10–15 mm (figure 4.17). 10 mm is the most common.
e. Remove freehub. Inspect for any washers or spacers behind freehub and remove.

FIGURE 4.17

Loosen and remove freehub bolt

FIGURE 4.18

Remove seal (if present) behind freehub body

f. Use a seal pick to remove any dust seal that may be behind the freehub body (figure 4.18).
g. Flush freehub with solvent. Scrub the bearing cup clean.
h. Blow-dry freehub, rotating freehub to remove solvent from internals. If no compressor is available, allow freehub to dry until no solvent is left inside.
i. Drip lubricant inside the freehub body from the backside and front side. Install dust seal.
j. Grease freehub installation bolt.
k. Install washers or spacers as necessary.
l. Install freehub onto hub body.
m. Install and secure freehub bolt.
n. Assemble axle assembly into hub and adjust.

CARTRIDGE BEARING HUBS

Cartridge-type hubs typically use non-serviceable industrial or rolling element bearings. These are simply used until the bearing surfaces are worn or damaged, and then the entire cartridge bearing is replaced. Ball bearings are trapped between inner and outer rotating races (figure 4.19). There should be no play between the inner and outer races of the cartridge. With use, play will develop between these two races and the entire cartridge unit will require replacement.

FIGURE 4.19

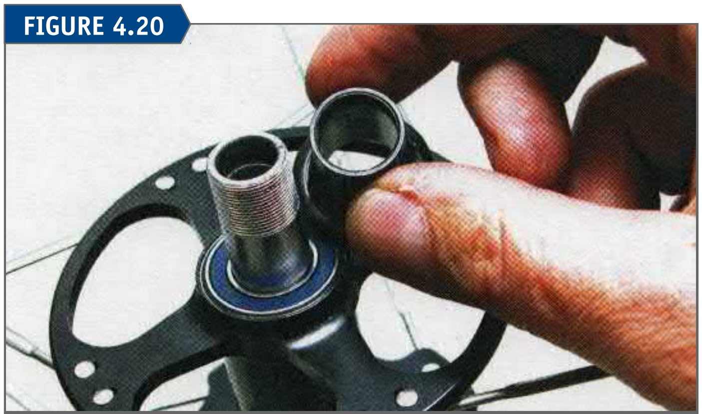
Cutaway of cartridge bearing showing inner races and ball bearings

Most cartridge hubs are not serviceable in the sense that they are overhauled and adjusted. The bearing units use rubber covers. The bearing, however, is not fully "sealed" and is susceptible to dirt and water. The bearing is removed as a unit and a new one is pressed in. Some hub models require specialty tools and service of these hubs is best left to professional mechanics.

Cartridge hub designs typically press the outer race of the cartridge bearing into the hub shell. Removal of the bearing from the hub shell may involve impact or pressing of the bearings. It is likely that the impact will damage the bearing. If a bearing is being removed, it is assumed it will be replaced with a new bearing.

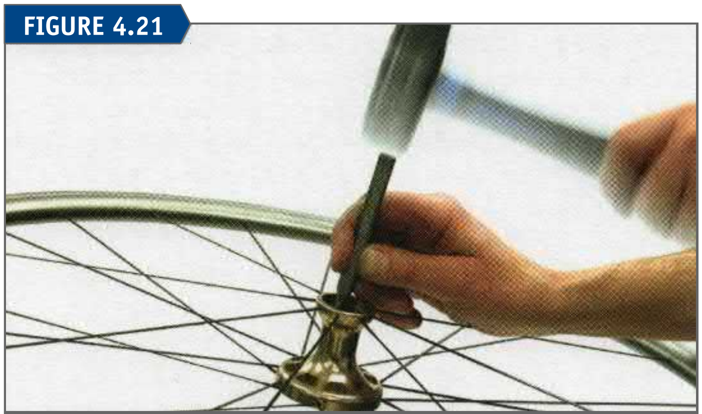
The hub axle may be threaded or non-threaded. The axle holds the inner race of the cartridge bearing secure. Threaded axles typically use a "sleeve nut" system. The nut will be tightened until it touches the bearing, then should be backed away ¼ turn. A locknut then secures the sleeve nut. This prevents the sleeve nut from pressing on the inner bearing race. The inner and outer cartridge races align vertically for smooth operation. If the inner race is pushed inward, the bearing tends to wear out quickly (figure 4.20).

FIGURE 4.20



Threaded sleeve nut holding axle to cartridge bearing

FIGURE 4.21



Removing pressed races

Bearings of the threaded axle system are commonly removed by impact. A punch is placed through the hub, and the bearing is struck first on one side and then the other. This tapping "walks" the bearing out of the hub shell (figure 4.21).

Non-threaded axles are typically made with a collar (figure 4.22). These axles use end-caps and come either in threaded or push-on fit. Look for wrench flats either on the cap or inside the axle. After end-caps are removed, the axle is struck with a mallet and acts as the punch to drive out the bearing.

The installation of cartridge bearings typically involves an interference fit. The bearing will be slightly larger than the hub shell. Hub manufacturers provide pressing and impact tools. It is possible to use steel sockets that match the diameter of the bearing race at the interference fit (figure

FIGURE 4.22

Non-threaded axle with a cartridge bearing

4.23). For example, if the interference fit is on the outer race of the bearing, the diameter of the driving tool must match the diameter of the outer race of the bearing.

There are many brands and models of cartridge bearing hubs. The Mavic hub is used here as a representative of the type. However, service procedures will vary. For information on other brands and types contact the hub manufacturer or see the Repair Help section of www.parktool.com.

FIGURE 4.23

Driving in a cartridge bearing with a socket

MAVIC® HUB (LEVEL 1 TYPE)

There are several versions of the Mavic® hub system, and exact procedures may vary with each model. Mavic® cartridge bearings are pressed into the hub shell. The axle must be removed to drive the bearings out with a punch. Bearing service tools are available from a Mavic® retailer. It is possible to substitute punches and sockets of the correct outside diameter. Service of the rear hub is typically more complex due to the freehub. The service procedures below for the "Level One" hubs using the "Force Transfer System Light."

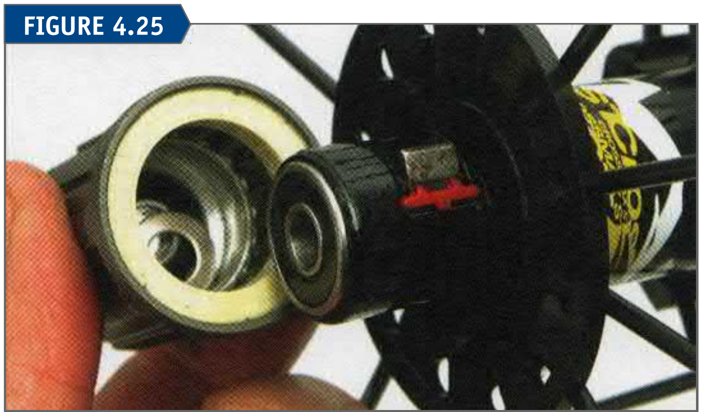
Procedure for rear hub service:

a. Remove skewer, cassette cogs, and rotor, if applicable.
b. Remove left side end cap by pulling on it.
c. Insert 5 mm hex wrench in right side of axle. Insert 10 mm hex wrench in left side of axle. Turn either side counter-clockwise to loosen and remove axle from hub (figure 4.24).
d. Pull freehub body from hub shell. Note any washer under freehub (figure 4.25).
e. There is a seal on hub shell beneath freehub that may be left in place. Use care to not cut or damage seal if removing it.

FIGURE 4.24

Remove axle from hub with hex wrenches

FIGURE 4.25



Remove freehub body from hub shell

f. It is not necessary to removal pawls from hub shell. If pawls are removed, work carefully and pull pawls away from body. Use care not to lose pawl springs or parts.
g. First remove right side and then left side cartridge bearing using drift punch. Tap side to side gradually to remove (figure 4.26).

FIGURE 4.26

Drive bearings from hub shell

FIGURE 4.27

Remove right side cap by holding freehub body and turning cap counter-clockwise

h. To replace bearing in freehub, remove threaded right side cap counter-clockwise. Use cassette cogs and chain whip to hold freehub body while removing cap (figure 4.27). Cassette lockring is not required.
i. Drive bearing from freehub.
j. Install drive-side bearing using driver tool (figure 4.28). Center bearing to hole and tap into place to fully seat.
k. Install opposite bearing using driver tool. Center bearing to hole and tap into place.

FIGURE 4.28

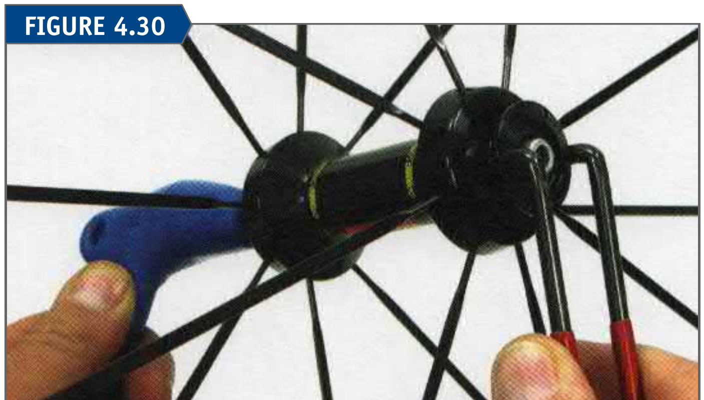
Drive bearing fully into hub shell

l. Install bearing in freehub using driving tool and reinstall threaded cap.
m. Install seal if removed. Lubricate seal, pawls, and inside freehub with mineral oil or light chain lubricant.
n. Install right side axle into freehub. Place washer on axle inside freehub body.
o. Engage freehub body onto hub. Squeeze pawls inward while turning freehub counter-clockwise.
p. Install axle through left side and thread into right side axle.
q. Hold right side axle using a 5 mm hex wrench and tighten left side axle with 10 mm hex wrench.
r. Install left side axle end cap by pushing on axle end.
s. Install cassette stack and rotor, if applicable. Install wheel in bike.
t. Hub adjustment is done on left side at lockring. Use a pin spanner such as the Mavic® tool or Park Tool SPA-2.

FIGURE 4.29

Adjusting bearing play at lockring

FIGURE 4.30



Removing the axle from a front hub

u. Grab rim and pull side to side. If play exists, turn adjusting nut clockwise in small increments until gone (figure 4.29).

The front hub of the Mavic® Level One series wheels have two bearings pressed into the hub shell. Look for 5 mm hex fitting in the axle and hold the opposite side bearing adjusting nut with a pin spanner (figure 4.30). Loosen and remove adjustable cap. Bearings are tapped out and new ones pressed in as with the rear hub. Tightening the one bearing adjustment lockring on the bike as with rear hub makes the adjustment complete.

Tech Note:

For more information on other hub models visit www.parktool.com/blog/repair-help

CHAPTER 5

WHEEL TRUING

Bicycle wheels act as the "ball bearings" between the frame and the ground. The wheels allow the bike to roll forward as we pedal. Straight, round wheels add to the bike's performance. Some adjustment to the wheel runout (trueness) is possible by making adjustments to spoke tension. Non-serviceable bladed spoke wheels or large carbon disc wheels have no truing adjustment or repair options like traditional wire spoke wheels.

The bicycle wheel is composed of a hoop or rim that is suspended by spokes around the hub. Each spoke is under tension and pulls on a limited section of rim. Spokes coming from the right side hub flange pull the rim both toward the hub and to the right side. Spokes coming from the left side hub flange pull the rim toward the hub and to the left side. Spokes are oriented at the rim in a left-right-left-right pattern to counter the pull from each side or flange. Having spokes tight with relatively even tension makes the wheel spin straight. Changes to spoke tension will change the amount of pull on the rim where the spoke attaches and affect its position or "true." The process of changing spoke tension to correct rim runout is called "truing." Professional mechanics will use tools such as truing stands, centering gauges (dishing tools), spoke wrenches, spoke tension meters, and their experience to adjust spoke tension and produce a durable and strong wheel (figure 5.1).

Wheels are under constant stress when used, and occasional truing will keep the rim running straight. Spoke tension is adjusted by tightening or loosening a threaded nut, called the "nipple," at the end of the spoke. The nipples are turned with a spoke wrench (figure 5.2). Although a common phrase among mechanics is to "tighten the spokes," it is the nipples that are turned, not the spokes. Turning the nipples changes tension on the spoke, much like any nut or bolt.

Wheels not only help us go, they also help us slow. Caliper rim brakes such as linear pull, cantilever, side pull, and dual pivot brakes use the rim sidewall as the braking surface. Brake pad adjustment is difficult and often futile with an out-of-true or wobbly wheel.

FIGURE 5.1

Equipment used by professional mechanics

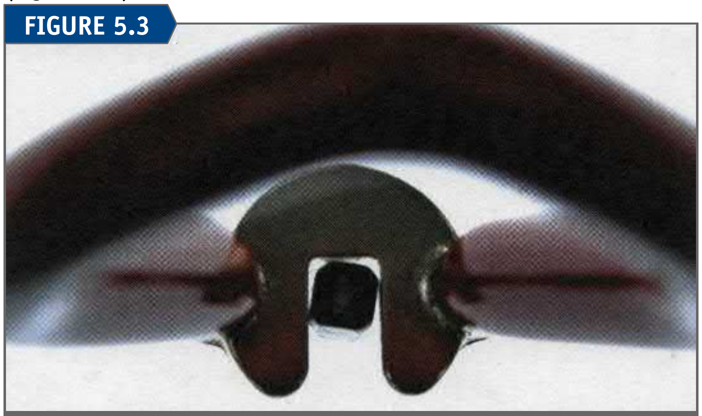
FIGURE 5.2

Spoke wrenches for various-sized spoke nipples

WHEEL TRUING OVERVIEW

When truing, it is especially important to use a correctly sized wrench. Spoke nipples are typically made of brass or aluminum, both of which are relatively soft materials. Nipples may be square shaped and come in different sizes. A wrench that is even slightly too large easily damages the nipple by rounding the corners (figure 5.3). Use a caliper to measure across the nipple flats and purchase the correct-sized wrench. There is no correlation between spoke diameter and nipple size. See Table 5.1, Spoke Wrench Fit. If you own spoke wrenches of different sizes, use the smallest that will fit, even if it seems to slow down putting the wrench on the nipple (figure 5.4).

FIGURE 5.3



Spoke wrenches that are too large will round nipple corners

TABLE 5.1 *Spoke Wrench Fit*

NIPPLE TYPE	SIZE	PARK TOOL WRENCH
Square	3.23 mm	SW-0 or SW-20 (black)
Square	3.3 mm	SW-1 (green)
Square	3.45 mm	SW-2 or SW-22 (red)
Square	3.95 mm	SW-3 (blue)
Square	4.4 mm	SW-14
Square internal	3.23 mm	SW-15 or SW-16
Hex-headed internal	3/16 inch (4.7 mm)	SW-16.3
Hex-headed internal	5 mm	SW-15 or SW-17
Hex-headed internal	5.5 mm	SW-15 or SW-18
Hex-headed internal	6 mm	SW-19
Six-splined round (Mavic®)	5.7 mm OD	SW-13
Seven-splined round (Mavic®)	6.4 mm OD	SW-12
Six-splined round as grommet for square nipples (Mavic®)	9 mm OD	SW-12 or SW-13
Six-splined round (DT Swiss® Tricon)	4 mm	SW-5 (gray)

FIGURE 5.4

A proper fitting wrench will protect the nipple

There are some styles of nipples made with a special pattern or size. In some cases the wrench may be available only from the nipple manufacturer.

There are also some styles of nipples that fit internally, inside the rim. It is necessary to remove the tire and rim strip to access the head of the nipple in order to fit a tool to the nipple for adjustment (figure 5.5). The nipple head may be a 3.2 mm square shape, or a hex shape in $\frac{3}{16}$ inch (4.7 mm), 5 mm, 5.5 mm, or 6 mm.

FIGURE 5.5

Truing a rim with internal nipples

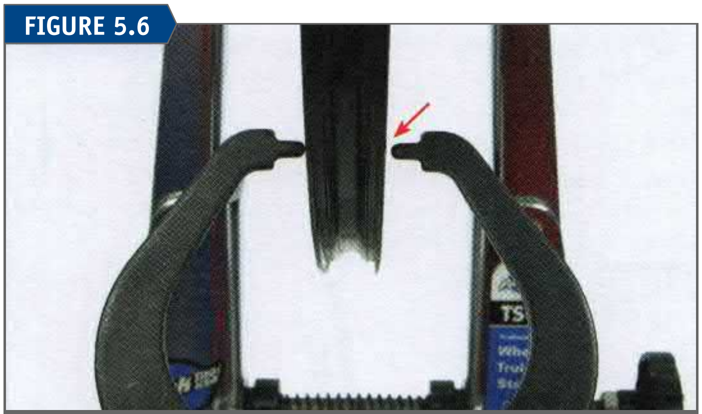
Park Tool produces numerous spoke wrench options. If you intend to purchase one wrench, it is best to measure across the nipple flats. If it is a round nipple with splines, count the number of splines as well as measure the outside diameter. See Table 5.1 for sizing detail.

There are four basic aspects of wheel truing: lateral true, radial true, rim centering over the hub (dish), and spoke tension. A properly trued wheel will have all four aspects adjusted evenly for best performance.

LATERAL TRUE

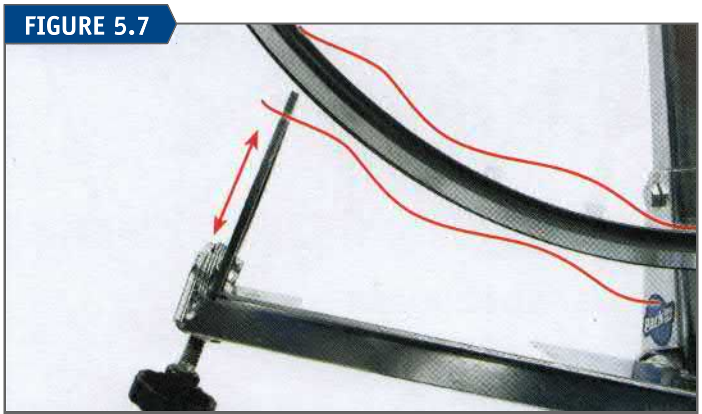
Also called “rim runout,” this is the side-to-side wobble of the rim as the wheel spins (figure 5.6). This aspect is the most critical for rim brake caliper settings. Too much runout will make it difficult to set the rim brake pads without the pads rubbing the rim. Extreme runout problems result in the tire hitting the frame or fork.

FIGURE 5.6



Gap between rim and one caliper indicates deviation from lateral true

FIGURE 5.7



Radial error in the movement of the rim as it spins

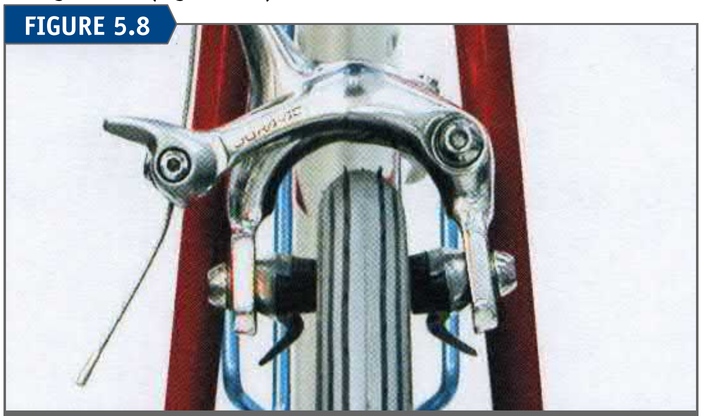
RADIAL TRUE

This is the amount of vertical runout or hop (figure 5.7). If the wheel becomes out-of-round, it moves or hops up and down with each revolution. In severe cases this will affect brake pad placement and can be felt by the rider as a bump every wheel revolution.

RIM CENTERING (DISH)

This is the centering of the rim in the middle of the front fork or rear frame. If the rim is offset left or right within the forks or dropouts, it may be difficult to adjust the brakes. Severe cases of poor centering can also cause handling problems because the front and rear wheel won’t track in a straight line (figure 5.8).

FIGURE 5.8



Centering error seen in the frame by this rear wheel sitting too far to the right side

TENSION

This is simply the tightness of the spokes. Spokes are tensioned just like other fasteners. Spoke tension is best measured using a tool called a spoke tension meter (tensiometer) such as the Park Tool TM-1, which flexes the spoke using a calibrated spring (figure 5.9). With experience, spoke tension can be roughly estimated by squeezing pairs of spokes and feeling the deflection.

FIGURE 5.9

Spoke tension measurement with a tensiometer

TRUING PROCEDURES

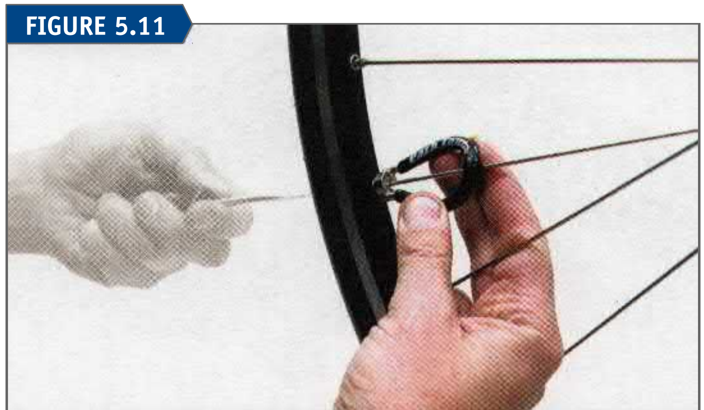
It is useful to use a steady pointer as a reference, such as one found on a truing stand, when sighting rim movement and deviations as the rim turns. Park Tool truing stands allow easier and faster work when truing. The truing stand uses a caliper indicator as a reference to gauge the rim runout. If no truing stand is available, it is possible to use anything that will hold the wheel as steady as a truing stand. The bicycle frame or fork itself may also be used. Use the brake pads if there are rim brakes, or use a zip tie to create an indicator as a reference gauge. Secure and snug a zip tie at rim height on each side of the seat stay or fork blade. Cut zip tie to a length able to touch the rim (figure 5.10).

FIGURE 5.10

Use zip ties for reference indicator if truing stand is not available

When truing, it is critical to get the spoke wrench fully engaged on the nipple before turning. A wrench that is only partially engaged may damage the nipple and make further truing difficult. When truing a wheel, the wrench and nipples may be viewed and adjusted upside down. This happens if the wrench and nipple are viewed and adjusted below the axle center. The wrench will appear to the mechanic as turning to the left when tightening the nipple. Do not allow this to

FIGURE 5.11



Visualize turning the wrench as if a screw driver is turning the nipple

confuse you. Keep in mind that the nipple is rotating around the fixed spoke. Imagine a screwdriver at the nipple end and turn it clockwise or counter-clockwise as required (figure 5.11).

There are some models of wheels where the nipple is located at the hub flange. These wheels true the same as conventional wheels. Tightening a spoke will draw the rim towards the hub flange side where it connects. The threading of the spokes and nipples is still a right-hand thread, and nipples tighten clockwise as seen from the orientation of the nipple.

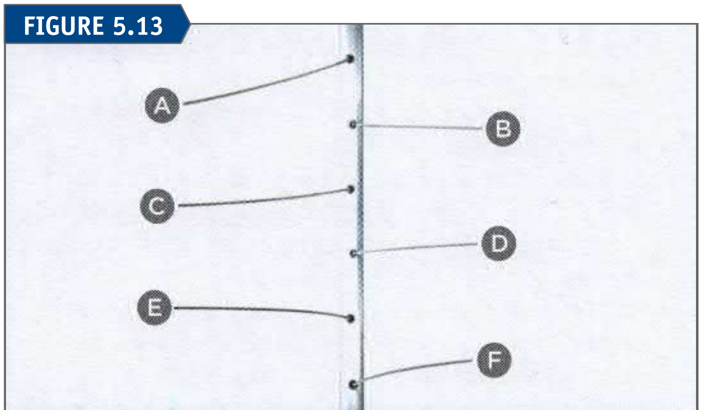
Bladed or flat spokes add to the complexity of truing. If a bladed spoke is not held while the nipple is turned, the blade may twist until the flat section is at an angle to front of the bike. Use needle nose pliers, a small adjustable wrench, or a bladed spoke tool such as the Park Tool BSH-1 Bladed Spoke Holder (figure 5.12) to prevent the spoke from twisting.

FIGURE 5.12

Use of the Park Tool BSH-1 to prevent bladed spoke twists

The image below is a "mechanic's eye" view of the rim (figure 5.13). The spoke nipples labeled A, C, and E are on the left side of the rim and come from the left side hub flange. Spoke nipples B, D, and F are on the right and come from the right side hub flange. Left side spokes pull the rim toward the left. Their pulling is offset by the pull of spokes on the right. Each nipple affects a relatively wide area of the rim. For example, spoke C pulls mainly at the nipple hole of the rim, but this spoke also affects the rim up to and even past A and F. Turning nipple C to increase spoke tension will move that section of rim to the left. Turning nipple D to increase tension will move that section of rim to the right. Loosening nipple C will also move the rim to the right because of the constant pull of D and B. While is possible to manipulate several spokes to correct the same rim error, a person new to truing should

FIGURE 5.13



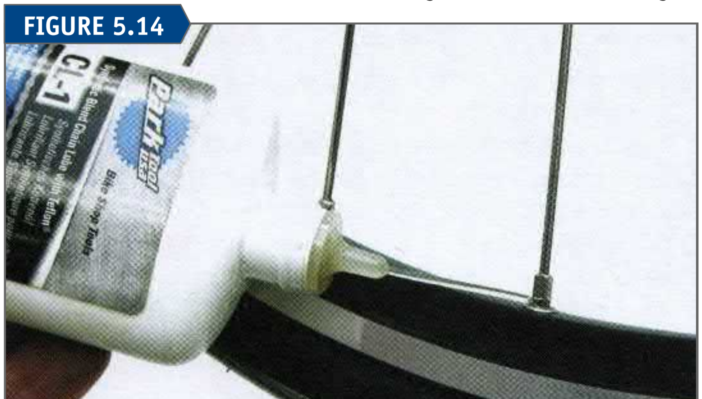
Spoke tension will determine wheel trueness

consider making one type of adjustment at a time. After some experience, the mechanic can use both tightening and loosening of different spokes in same correction.

As spokes are connected from the hub to the rim, they create a pattern, called the "lacing pattern." The common pattern results in a weave effect as spokes from the same flange radiate outward at a tangent. Spokes radiate clockwise, and a second set radiates counter-clockwise. The spokes are joined at the rim with an alternating pattern of left-right-left right. However a tangential pattern lacing is not the only option. Spokes can be joined at the rim in a pattern of two right side spokes, then one left, then two right, etc. Each spoke still pulls on a small section of rim.

Before making any adjustments to spoke tension, use a light lubricant and oil the threads of the spokes and the hole where the nipple exits the rim (figure 5.14). This will reduce the effort of turning the nipple to tension the spoke. Clean any lubricant from the rim and rim braking surfaces after truing.

FIGURE 5.14



Use a drop of lubrication on the spoke threads and where nipple exits rim

Lateral Truing

Lateral or side-to-side truing is the most commonly required truing procedure. Lateral runout shows up relatively well when viewed from the side, such as at the rim caliper brake pads. Tightening or loosening spokes at a section of rim can change lateral movements of the rim. Inexperienced mechanics should generally tighten nipples when correcting deviations. Tightening the spoke tension will typically produce more rim movement while making these corrections.

Wheel rims do not need to spin perfectly straight with zero lateral runout in order to be completely serviceable. Most wheels will be adequately true if they wobble laterally less than 1/16 inch (1 mm) and if the rim does not strike the brake pads. More experienced mechanics may get the lateral tolerance down to 0.5 mm or less. While achieving very low runout is enjoyable for some people, it does not necessarily help the performance of the bike.

Procedure for lateral truing:

a. If a truing stand is available, remove wheel from bike. Alternatively, mount the wheel in the bike and attach zip ties on each side of the rim at the seat stays or fork blades. If the wheel requires extensive truing, remove the tire.
b. Place wheel in truing stand. Move indicators close to rim.
c. Spin wheel and inspect for left-right deviations.
d. Adjust indicator of truing stand (or zip tie end) so that it lightly touches the rim in one area. Work off of either left or right side.
e. Stop wheel where rim and one indicator are closest or touch. This area is the largest lateral deviation of the rim runout and should be corrected first. If the area of lateral error appears to be large, select only one spoke at the middle of the deviation for the first correction.
f. Rotate rim back and forth past indicator and find center of rim deviation. It is easier to see the runout as it moves toward an indicator or rubbing it, rather than as a deviation that moves away from an indicator (figure 5.15). Use either a left side or a right side indicator.

FIGURE 5.15

Isolate rim lateral deviation

g. If rim deviation moves toward the left side, find the right flange nipple at the rim closest to center of deviation. If rim deviation moves toward the right side, find the left flange nipple closest to center of deviation. Tightening this spoke will move rim deviation in this section of rim.
h. Tighten the selected spoke nipple ¼ to ½ turn. A ¼ turn is a 90-degree turn of the nipple, while a ½ turn is a 180-degree turn. Spin the wheel and check deviation again. It is often necessary to repeat the process at one area. Do not tighten more than ½ turn at a time. It is better to proceed in small increments and to check progress between each nipple tightening by spinning the wheel.
i. Locate another side-to-side deviation using indicator. Repeat process of finding center of deviation and correcting deviation by finding and turning nipple from spoke of opposite flange.

j. After making three corrections on one side of the rim, switch to other side indicator or zip tie. This will help maintain previous wheel centering.
k. Continue making corrections. To check tolerance, adjust indicator so it just barely rubs the rim in one area. Spin wheel slowly from this point and inspect for the largest gap between indicator and rim. This area is the worst left-to-right lateral deviation. If this gap appears less than 1 mm (approximately the thickness of a dime), wheel is adequately trued laterally. In some cases, it will be necessary to continue truing for tighter tolerances.
l. If only lateral true is being adjusted, clean the rim's braking surface with a solvent such as rubbing alcohol or window cleaner. If frame-mounted zip ties were used as indicator, cut and remove these from frame.

Radial Truing

The wheel rim may appear to move in and out toward the center as it rotates around the hub. This can also be viewed as an up-and-down movement. This radial aspect of the wheel can be affected by spoke tension. Sections of rim moving away from the hub are called "high spots." Sections of rim moving toward the hub are called "low spots." Sections of rim can be moved toward the hub by tightening spokes from both flanges at areas of high spots. Loosening spokes from both flanges will tend to move a section of rim slightly outward at low spots. In correcting radial runout, it is necessary to correct both high spots and low spots. It is typically best to work using pairs of spokes, one from the left side and one from the right side. By working with adjacent left-right spokes there is less of a tendency for the wheel to become laterally out of true. It is necessary, however, to always double check the lateral true after making radial corrections.

Procedure for radial truing:

a. Remove tire from wheel.
b. Mount wheel in a truing stand or mount wheel in bike frame and attach zip tie indicator to frame. Attach tie close to outer edge of rim.
c. Bring indicator (zip tie) close to outside edge of rim.
d. Spin rim and bring indicator (zip tie) slowly closer to rim until there is a very light rub. This point is the largest high spot or radial deviation away from the hub.
e. Stop rim at light rub. Move rim back and forth through rub and locate center of deviation. This section of rim needs to move closer to hub (figure 5.16).

FIGURE 5.16

Isolate radial runout and select a left-right pair of spokes to correct problem

f. Tighten the two spokes in the middle of the deviation. Tighten one left side and one right side spoke, each the same amount, beginning with ½ turn.
g. Move the rim back and forth through the selected area. Repeat tightening if necessary.
h. Spin the wheel and move the calipers (zip tie) slightly closer to the rim to find next deviation. Correct the rub by tightening a left-right pair of spokes at the center of the rub.
i. After making three radial corrections, stop and double-check lateral true. Correct the lateral true as needed before proceeding with further radial adjustments.
j. After making several radial corrections to high spots, the rim may show only areas moving toward the hub or low spots. It will be necessary to loosen the low spot areas. Spin the rim and move caliper (zip tie) to create a light continuous scrape. The areas not scraping are low spots and need to move away from the hub to be corrected. Isolate the center of the worst low spot.
k. Loosen two spokes on either side of the center of the low spot. Spokes should be adjacent left-side and right-side pairs.
l. Repeat procedure on other low spots. Occasionally check and correct lateral true.
m. Check for acceptable radial tolerance. Adjust indicator so it just barely rubs the rim in one area. Spin wheel slowly from this point and inspect for the largest gap between indicator and rim. This area is the largest radial deviation. Wheel is adequately trued for round when the deviation from the highest to lowest is less than 1 mm (1⁄16 inch).
n. Check and correct lateral true as needed.
o. If no other truing is to be done, clean the rim's braking surface with a solvent such as rubbing alcohol or window cleaner. Cut zip ties from frame. Reinstall tire and reinstall wheel in the bike.

If the wheel rim has been damaged and deformed from impact, such as during riding or even during shipping, it may not be possible to correct the rim to a tight tolerance. If the rim shows an inward movement in one section toward the hub and the spokes in that area are already loose, the rim has been bent. This type of damage is not repairable. Replacement of rim or wheel is recommended. Contact a professional mechanic.

Wheel Centering (Dishing)

The rim should be centered in the frame, front fork blades, or the rear stays. Use a ruler and measure from the left and right stay or fork blade to the rim. If the distances are equal and the rim looks centered, it is centered. If there is a greater distance from one stay or blade compared to the other, the wheel is off-center, or "misdished."

The rim can be moved over to the frame center by adjusting spoke tension. Remember, spokes from the left flange pull the rim toward the left, while spokes from the right flange pull the rim toward the right. Tightening all left side spokes evenly will move the rim to the left. Tightening all right side spokes evenly moves the rim right. Alternatively, loosen all left side spokes to move the rim right. Loosen all right side spokes to move the rim left.

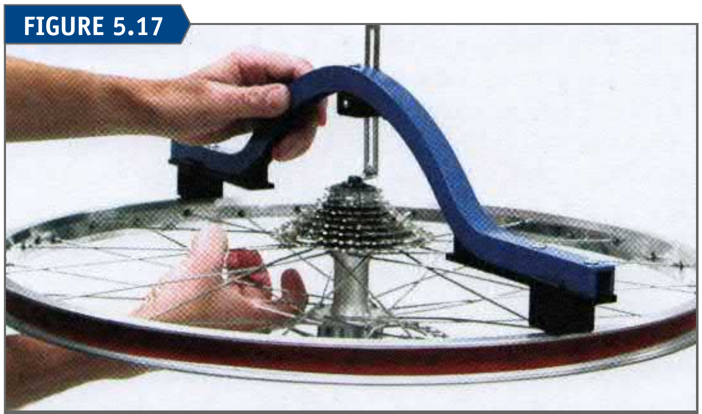
The most accurate method to check rim centering over a hub is with a centering gauge called a dishing tool, such as the Park Tool WAG-4 Wheel Alignment Gauge or WAG-5 Portable Wheel Dishing Gauge. The Park Tool WAG-4 comes with two sliding blocks on the feet. These blocks allow the tool to measure off the wheel rim even when a tire is still mounted.

Procedure for wheel centering with a dishing tool:

a. Note which side of the wheel is being checked. In this example, we will assume the right side is being checked first and use this as a reference for the left side.

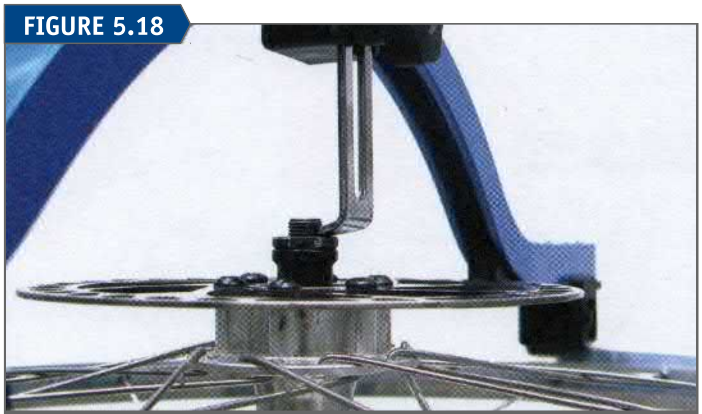
b. Place feet of dishing tool on rim and lower the sliding indicator until the end rests on the face of the right side locknut (figure 5.17). Do not rest indicator on end of axle. The rim must be centered relative to the locknut faces when mounted in the frame, not the axle ends.

FIGURE 5.17



Dishing gauge set to reference right side of wheel

FIGURE 5.18

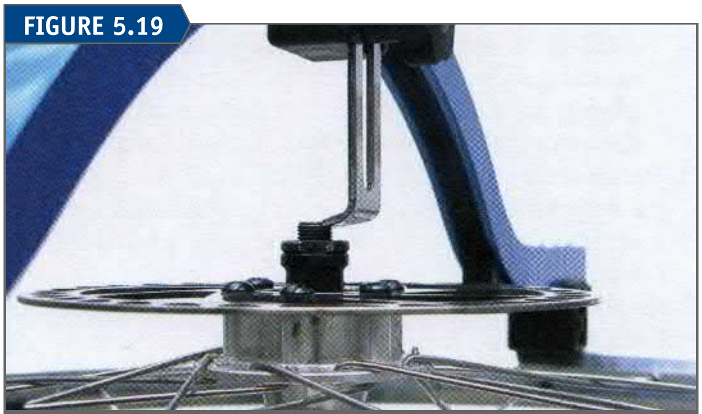


Three-point contact of tool feet and indicator showing a correctly dished wheel

c. Turn wheel over to check left side. Place feet of dishing tool on rim. Note indicator relative to locknut face. There are three possible results:

1. Both feet of dishing tool rest on the rim and the indicator pointer lightly contacts the left locknut face or is within 1 mm of it. This rim is adequately centered to the locknuts. No correction of centering is required (figure 5.18).
2. Both feet of the dishing tool rest on the rim, but there is a significant gap between the indicator and locknut face (figure 5.19). This indicates that the rim is off-center towards the left side. If the gap is greater than 1 mm, the rim should be re-centered. In this example, the rim should be moved to the right. However, it is less confusing to view any dishing error at the rim rather than the hub. If after checking the wheel there is a gap as described above, reset the indicator using the left side as the first reference, and then compare this to the right side. You will find there is now a gap between the rim and one of the dishing tool feet, while the indicator rests on the locknut face. This method makes it more obvious that the rim should be moved towards the feet of the tool. When viewing a gap between the locknut face and dishing tool indicator, the rim is actually pulled away from that locknut face in order to correct the error.
3. The indicator is unable to contact the locknut face while both feet are resting on the rim. When the indicator does contact the locknut, only one foot rests on the rim, leaving a gap between the rim and opposite foot (figure 5.20). This indicates the rim is off-center towards the right side. Adjust spoke tension to move rim to the left to close the gap between dishing foot and rim.

FIGURE 5.19



Dishing gauge indicator showing rim is off-center

d. Correct centering error by tightening spokes connected to the flange on the same side in which there was a gap between the rim and dishing tool foot. Tighten each spoke on that side only ¼ turn. **Note:** A rim is off-center of the bicycle mid plane by only half the distance between the indicator and the locknut face. For example, if the indicator is 3 mm from locknut face, the rim is off-center by 1.5 mm from the mid plane of the bike.

e. Double-check and correct lateral true as necessary. The dishing tool's design assumes the rim is laterally true.

FIGURE 5.20

Dishing gauge indicating wheel is off-center

f. Use the dishing tool and check wheel again, starting with step "a" above. Keep in mind that rim position has changed relative to the locknut face of the original reference side. Repeat corrections if necessary. When gap between rim and dishing tool is less than 1 mm, wheel is adequately centered.
g. If no other truing is to be done, clean the rim's braking surface with a solvent such as rubbing alcohol or window cleaner.

When making corrections to dish, keep in mind that you will also make changes to overall tension. Making corrections by tightening one side will increase overall tension of both sides, while loosening one side will decrease overall tension of both sides.

Spoke Tension

Consider that spokes are really just long thin bolts with nipples as the nuts. These are no different than other fasteners. Like any threaded fastener, there is an acceptable range of tightness, which is called tension. Spoke tension is the amount of force pulling on the spoke. Although spoke tension increases as the nipple is turned and tightened, it is not useful to measure the torque of the nut (nipple) because there are more direct ways to measure spoke tension.

As the wheels rotate while you ride, the spokes that are on the bottom, next to the ground, will momentarily lose their tension level then regain tension as they rotate past this low point. This change of tension in each revolution is called a "stress cycle." Wheels with a relatively low overall spoke tension actually endure a greater swing in tension compared to wheels with greater overall tension. Stress cycles, the loosening and retightening of tension, fatigue the metal and lead to spoke breakage. Wheels with low overall spoke tension will continue to loosen even more as the bike is ridden. This results in shortened spoke life, more spoke failure, and a wheel that requires continuous truing.

While low overall spoke tension results in problems, too much tension can also cause issues. Spokes with too much tension can deform or crack the rim near the nipple holes (figure 5.21). Too much tension can also lead to failure of the hub flange. Spoke nipple wrench flats can become deformed and rounded by forcing the nipple to turn when the spoke tension is too high. However, the spoke itself can typically take more stress than rim, nipple, or hub flange.

FIGURE 5.21

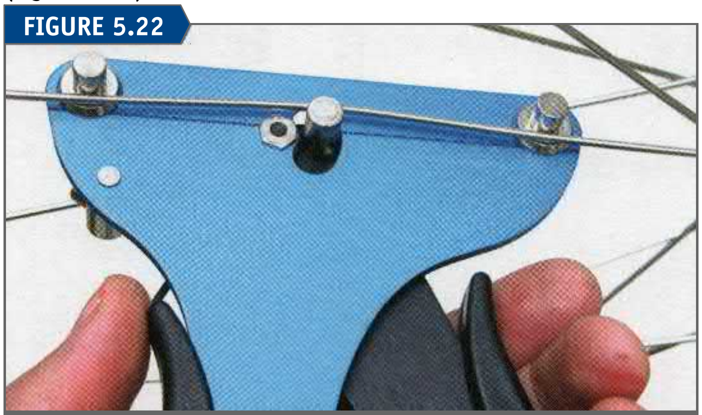
Crack in rim from excessive spoke tension

When adding or subtracting tension, work slowly and in relatively small increments. For example, to add tension to a low-tension wheel, begin with a spoke next to the tire valve hole and add only ¼ turn to each spoke. After adding this tension, double-check the lateral trueness. It is common to make corrections to the other aspects of runout after adding overall tension. If more tension is desired, add another ¼ turn to each spoke and again check the other aspects of truing. Repeat the process until the desired tension is achieved.

It is common for the spokes to become twisted along their long axis as the nipples are turned. This called "spoke windup." To minimize the spoke twisting, lubricate the nipple. When truing, you can place a finger on the spoke as you turn the nipple. Significant windup can be left in the spoke. If you feel this twisting, make slightly more correction than you intend, then rotate the nipple back to help relieve the windup. It is common to still end up with some windup in the wheel. The safest method to relieve this torsional stress on the spoke is to simply ride the bike. You may hear an initial popping or pinging sound while the spokes untwist. In some cases, it will be necessary to true the wheel again laterally.

Spoke tension is best measured with a spoke tension meter (also called a tensiometer), such as the Park Tool TM-1 Tension Meter. It is possible, to some degree, to "feel" the tension by squeezing crossing or parallel spokes. The squeezing technique can, however, be deceiving and inconsistent. The stiffness of rims and thickness of spokes vary widely. A tension meter allows the user to determine both relative spoke tension between spokes and the tension force of each spoke. The TM-1 Spoke Tension Meter is a tool that includes a chart to determine the amount of pulling force, measured in kilograms force (abbreviated as "kgf"). The TM-1 is designed to read tension for many different types of spokes, including titanium, aluminum, and bladed shapes (figure 5.22).

FIGURE 5.22



Park Tool TM-1 Tension Meter flexing spoke to determine tension

Rim manufacturers specify tension recommendations from as low as 60 kgf to as high as 200 kgf. However, 100 kgf is a common tension recommendation. It is the rim, not the spoke type or diameter, that determines the limits of tension. Generally, the heavier and stronger the rim, the more tension it can handle. A light rim may weigh from 280 grams to 350 grams. A relatively heavy rim may weigh 450 grams or more. Additionally, rim eyelets may help distribute the load on the rim wall. A lack of eyelets on a light rim implies that less spoke tension should be used. There is a wide range of possible tension, and it is always best to consult the rim manufacturer for the most up-to-date specifications.

Manufacturers typically give specifications for the wheel with no tire pressure. Tire pressure will have the effect of lowering the tension slightly. Generally, do not try to account for this drop by adding more tension than recommended by the manufacturer. Parts makers list tension for the tight side of the wheel. For rear wheels, this will be the sprocket side or right side. For front wheels with a disc, the tighter side is the disc side. If the flanges are equally spaced from the hub center, then either side can be measured. This is the case for most front wheels made without a disc rotor mount.

The TM-1 Tension Meter includes a Conversion Table that is used to determine the pulling force on the spoke. The tool presses on a spoke to flex it. The pointer of the tool is used to determine a “deflection reading.” This reading is used along with the appropriate spoke column to give a reading of the pulling force on the spoke, the spoke tension.

To use the TM-1 Tension Meter it is necessary to know both the type of material in the spoke and the diameter of the spoke. Most spokes are steel and many are stainless steel. Stainless steel will usually be very weakly magnetic when tested. Aluminum spokes will have a different feel and look, as will titanium, and are not magnetic.

The tool includes a simple diameter gauge used for round spokes only. The smallest slot the spoke fits into determines the diameter. The diameter at the middle section of spoke will determine the appropriate column on the Conversion Table. If the spoke is butted at the ends, the tool is deflecting only the middle, so only consider the middle of the spoke for the Table. For a bladed spoke, it is necessary to use a measuring caliper to measure the spoke’s width and thickness.

Using the Conversion Table, find the column corresponding to the material and diameter of the spoke being measured. For bladed spokes measure the width and thickness of the spoke. Follow the column down to the row corresponding to the spoke’s deflection reading (as determined in step “d” below). The number at this intersection is the actual tension of the spoke in kilograms force (kgf). For bladed steel spokes that are not listed on the Conversion Table, use the on-line Conversion Table generator at www.parktool.com.

Procedure for tension measurement with TM-1 tensiometer:

a. Determine the material and spoke dimension near the middle of the spoke. Find the correct column on the Conversion Table included with the TM-1.

b. Squeeze the TM-1 at the handle grips. Place the spoke between the two fixed posts and the moveable post. With butted spokes, position the posts so they rest on the narrowest portion of each spoke. With aero/bladed spokes, position the posts so they rest against the wide, flat side of the spoke.

c. Gently release the handle. Releasing the tension rapidly will cause erratic reading results.

d. With the TM-1 engaged on the spoke, the pointer will be pointing to a number on the tool’s scale. This number is a deflection reading. Use this number on the Conversion Table and find where it meets the appropriate spoke column. This number is the tension of the measured spoke.

For the most accurate wheel average measurement, measure all spokes on one side, total the deflection readings, and divide by the number of readings taken. However, only measuring one-quarter of the wheel will give you a good idea of the overall tension. If you have a 32-spoke wheel, measure eight spokes and calculate their average tension.

Spoke tension will vary slightly from spoke to spoke even in a well-trued wheel. A wheel that has the same relative tension for all the spokes on a flange, however, will tend to stay true longer. The use of a spoke tension meter will help get the spokes closer to the same relative tension. Generally, attempt to get the spokes within 20 percent of one another. On wheels with dish (rear wheel or front disc wheels), the left and right side tensions will not be equal. This is normal and will not be a problem for the wheel.

As you use the TM-1 from spoke to spoke along the same hub flange, notice some spokes are tighter relative to others. You can use a marker to write the reading on the rim for reference. It is common to see a tight spoke adjacent to relatively loose spoke, both coming from the same flange. The tighter spoke is pulling more on the rim to keep it straight at the section of the rim relative to the lesser tension spoke. The idea of tension balancing is to loosen the tighter spoke a little, then tighten the neighboring spokes on the same flange a little to maintain lateral true. With practice it is possible to make the rim laterally true while keeping the spokes relatively close in tension. This procedure helps in producing a wheel that stays true and straight longer. It also helps maximize spoke life as the stress of riding is evenly shared between them.

Another technique to determine relative spoke tension is to pluck spokes like the strings of a musical instrument. You can also use a small hex wrench or a spoke to “thump” the spokes. Two spokes the same length and same tension should have the same pitch. Like any technique, there are tolerances. This technique does not tell you absolute pulling force in kgf, but it will point to spokes that are tensioned very differently.

BROKEN & DAMAGED SPOKE REPLACEMENT

A broken spoke will cause the wheel to come out of true. It may be possible to correct lateral true enough to keep riding until the spoke can be replaced. However, low spoke-count wheels (28 spokes or less) may develop substantial lateral runout from a single broken spoke. It may not be possible to correct the runout enough to safely finish a ride even by opening the rim brake calipers. Disc hub wheels will allow for more lateral error, but if the tire is striking the frame or fork, it should be trued as well as possible to prevent contact with the frame or the fork.

To repair a wheel with a broken spoke, begin by removing the tire. On rear wheels, also remove the rear sprockets. Remove the old spoke from the wheel and hub. The new spoke should be the correct length. If possible, measure the old spoke or remove a second spoke for measurement. Feed the new spoke through the hub in the same orientation as the original spoke. The spoke head should similarly face inward or outward

FIGURE 5.23

Bend spoke to lace into wheel

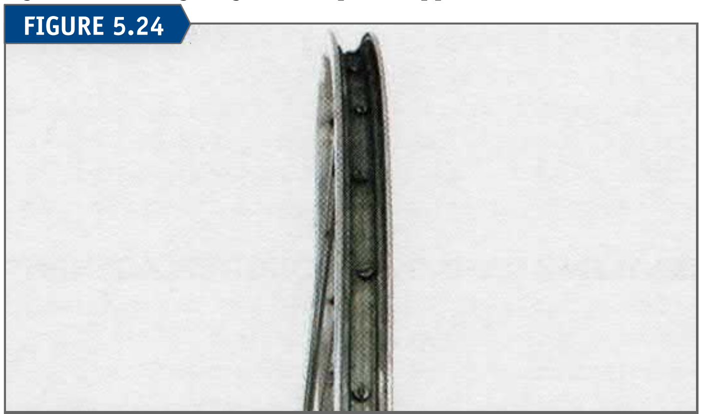
in the flange. It may be necessary to flex and bend the spoke, but avoid kinking it (figure 5.23). Inspect another spoke of the same flange and same orientation and follow the same pattern.

Replace the nipple as well as the spoke. If possible, use a spoke tension meter to measure spokes on the same side as the broken spoke and average the readings. Tighten the new spoke until it reaches the average. True the wheel with the procedures described above.

WHEEL WEAR, DAMAGE, & REPAIR

Rims may become damaged from impacts, such as hitting rocks, potholes, or curbs. Crashing or impacting the side of the rim in a fall can also cause irreparable damage. Truing may afford a limited repair for crashed wheels. Begin by checking relative tension in the damaged area. For example, if a wheel deviates in one section to the right, check left and right side spoke tension in that area. If the wheel runs right even though right side spokes appear loose and left side spokes appear tight, the rim metal is bent. This indicates the rim has been deformed beyond the point where spoke tension can repair it (figure 5.24).

FIGURE 5.24



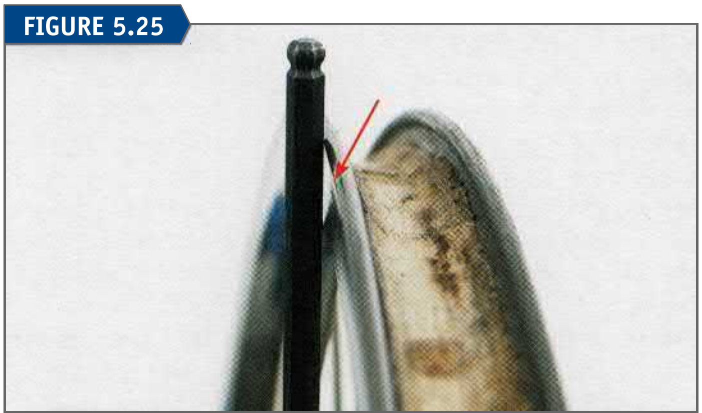
Wheel rim deformed beyond repair

Bicycle rims may be made from aluminum, carbon fiber, or steel. Steel and aluminum are metals that bend under extreme stresses and impacts. Carbon fiber may also fail, but typically will not become permanently deformed until it breaks. A deformed metal rim in theory may seem repairable by simply "bending it back". However, in practice this rarely works well. The metal hardens when bent and will harden again when re-bent back into shape.

Adjusting spoke tension on a wheel with a badly bent rim is unlikely to help, except possibly to get the rider home from a ride. Trying to bash the rim or attempting to re-bend the rim back in the problem area is a desperate repair measure. It's unlikely to help return the wheel to a useable condition. Wheel rims can be replaced, and a new rim is easily laced around the old hub. See a professional mechanic for this service or purchase a new wheel.

In bicycles with rim caliper brakes, brake pads grab and grind the rim walls, thinning the metal. The pressurized tire is held in place by the rim sidewalls, which become weakened over time. Thin sidewalls may fail during a ride, causing a tire blowout. Inspect visually, and feel the rim-braking surface for a dished, concave surface. If the rim appears worn, remove the tire and place a straight edge along the rim surface. Inspect for a gap between the straight edge and the rim. If the gap is larger than 0.2 mm (approximately the thickness of a business card), the rim should be replaced (figure 5.25). Modern rims often come with a machined groove as a wear indicator. Replace the rim when this groove disappears from rim wear.

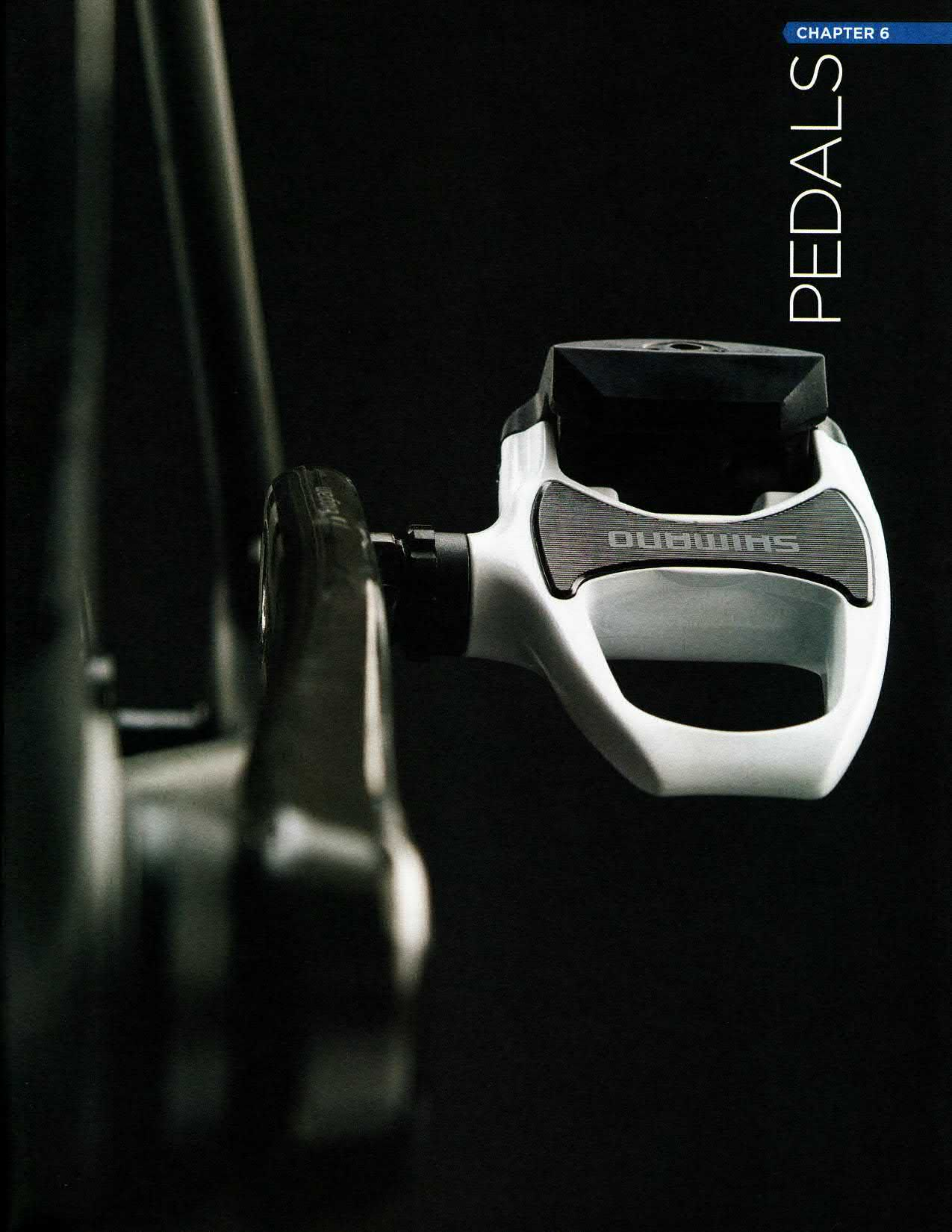
FIGURE 5.25



Rim showing unacceptable wear on braking surface

CHAPTER 6

PEDALS



Pedals are mechanisms attached to the ends of the cranks. Pedals come in a variety of designs for specialty uses. The "platform" pedal is a simple flat pedal and may be used with any recreational street shoe. Toe clips can be added to many of these pedals that act as cages to help retention the foot to the pedal. "Clipless" pedals require shoes fitted with special cleats. Clipless pedals use retention mechanisms that attach the shoe to the pedal. Lightly lubricate clipless pedals at cleat engagement pivot points. Occasionally check the security of all threaded fasteners on the pedal cage and body.

PEDAL REMOVAL

Pedals are removed from the cranks to service the axle bearings, pack the bike for shipment, or change pedals. Most pedals have narrow wrench flats on the pedal axles adjacent to the crank. The common wrench size is 15 mm. While pedal wrenches appear to be similar to cone wrenches, use a proper pedal wrench, not a cone wrench, for the narrow wrench flats on a pedal. A pedal requires much greater tightening torque than a cone wrench can deliver. Use of the wrong wrench may damage both pedal and wrench. Pedals may also use a hex fitting at the end of the spindle behind the cranks (figure 6.1). Use a long-handled hex wrench for removal and installation. When working on pedals, rotate the bike in a repair stand to find good leverage.

FIGURE 6.1

Pedal wrench fitting is at end of pedal spindle and is behind crank

The right side (drive side) pedal uses a right-hand thread. It removes counter-clockwise and installs clockwise. The left side (non-drive side) pedal uses a left-hand thread. It will remove clockwise and install counter-clockwise. This thread difference prevents the pedals from rotating loose. As the pedal turns during riding, the bearings on the pedal body reverse the direction of load on the spindle. Pedals are commonly marked with an "R" on the right side pedal and an "L" on the left side pedal. The left pedal may also have "hash marks" on the spindle to mark as different from the right. It is also possible to view the thread angle to determine which is the left threaded and right threaded pedal.

Procedure for pedal removal:

a. Mount bike in repair stand and shift chain to largest chainring. This helps protect against cuts from chainring teeth.
b. Rotate bike until right pedal is easily accessed. Reach over or through frame as necessary for best leverage.
c. Place wrench securely onto pedal wrench flats. For hex wrenches, fully secure wrench into back of pedal. Reposition wrench until crank and wrench form an angle of 90 degrees or less. Use opposite crank for extra leverage. Correct mechanical advantage is critical on pedals, which are often overly tight. When possible, grab opposite crank for second lever.
d. Turn pedal wrench counter-clockwise (as seen from outboard of pedaling looking inward) to remove right pedal. Use care not to cut hand on crank or chainring. Note that loosening both the right and left side pedal can be seen as pedaling forward while the wrench engages the pedal flats (figure 6.2).

FIGURE 6.2

Pedal in a forward direction to remove pedals from cranks

e. Remove pedal completely from crank. Inspect for any pedal washer on crank or pedal spindle.
f. Rotate bike as necessary until left pedal is easily accessed.
g. Engage pedal wrench onto left pedal and grab right crank for second lever. Position wrench and crank for good mechanical advantage.
h. Turn pedal wrench clockwise to remove left pedal or turn crank so the pedal is pedaling forward.
i. Remove left pedal completely from crank. Inspect for any pedal washer on crank or pedal spindle.

PEDAL INSTALLATION

The common pedal thread for aluminum cranks is 9⁄16 inch x 20 tpi. The pedal thread of the steel one-piece crank is ½ inch x 20 tpi. Pedal threads tend to be made of bearing-hard steel and are relatively difficult to damage. However, minor pedal thread damage may be repaired with a thread file.

Pedal threads can damage the aluminum threads of the crank if the threads are misaligned. Start initial threading with only your fingers to avoid forcing the pedal into the crank threads. Using a pedal wrench to start the thread will not allow the feel necessary to detect cross threading of the pedal.

Some cranks require the use of a "pedal washer". This is a thin washer to protect the crank. These are especially useful to prevent gouging carbon fiber cranks. The washer will have a low profile and is placed between the pedal and crank (figure 6.3).

Pedals are secured to a relatively high torque range, approximately 34 Nm (300 inch-pounds). As an example of effort on the wrench, assume the wrench is grabbed 8 inches (20 cm) from the pedal. It would require an effort of

FIGURE 6.3

Pedal washer for a carbon fiber crank

approximately 35 pounds (16 kg) force. Grease or anti-seize on the threads is recommended to prevent pedal thread corrosion and seizing to the crank arm.

Procedure for pedal installation:

a. Identify right and left pedals. Look for “L” or “R” marking on pedal axle or wrench flats. If no “L” or “R” marking is seen, use pedal thread direction to identify pedals. Left-threaded pedals (threads sloping upward to the left) fit the left crank. Right-threaded pedals (threads sloping upward to the right) fit the right crank.
b. Apply grease or anti-seize to threads of both pedals. Install pedal washer if appropriate.
c. Thread right side pedal into right crank using only your fingers to avoid cross threading.
d. Engage pedal wrench to flats (or inside hex fitting) and fully thread pedal into arm. For pedals with external wrench flats, hold wrench with one hand while holding pedal with other. Rotate the cranks and pedal assembly backward to install quickly.
e. Arrange pedal and crank for best mechanical advantage. Use opposite arm as second lever (figure 6.4). Tighten pedal fully.
f. Repeat for left pedal by threading pedal counter-clockwise to install.
g. Fully secure left pedal. For pedals with external wrench flats, hold wrench with one hand while holding pedal with other. Rotate the cranks and pedal assembly backward to install quickly.

FIGURE 6.4

Good mechanical advantage for securing pedals

DAMAGE TO CRANK PEDAL THREADS

If the crank threads are damaged, the pedal may be difficult to install. To repair thread, use an appropriate sized tap, either 9⁄16 in. x 20 tpi or ½ in. x 20 tpi, and chase the threads in the crank. Begin the tap from the backside of the crank to use the undamaged threads for best alignment.

If a pedal has come loose and fallen out, the outer thread of the crank hole may be mangled and damaged. Use a pedal tap to align thread. However, a tap will not restore metal that has been removed or torn away. If the threads are questionable, install and tighten the pedal. If the pedal pulls up properly at full torque, it will be useable.

If the pedal threads in the crank are damaged beyond a tap repair, they may be repairable using a thread insert system. Solid aluminum cranks may be repaired by being drilled or tapped to a large thread. A special bushing is then installed with an internal 9⁄16 inch thread. This repair is best left to professional mechanics. If the arm is carbon fiber or is a hollow aluminum design, this repair may not be possible. Because cranks are available individually as a replacement part, replacement of the arm is often the less expensive option.

PEDAL BEARING SERVICE

The bearing systems in pedals are similar to other rotational bearings on the bike. The axle is attached to the crank and rotates inside the pedal body. Bearing service is possible on some brands and models, but others are simply thrown away when bearings become excessively worn.

The procedure for bearing service varies between pedal brands and is reviewed at www.parktool.com/blog/repair-help.

CRANKSETS

Cranks are levers that connect the pedals to the bottom bracket spindle. The cranks are fitted with toothed sprockets called chainrings that drive the chain. Cranks may be removed to replace cranks or chainrings, service the bottom bracket bearings, or to clean the chainrings. Crank systems have become more complex in recent years. To know the service options you will need to know the type of crank and type of bottom bracket bearing system installed in the bicycle.

CRANK TYPES

Common modern crank designs include “three-piece” and “two-piece” crank systems. The parts of the three-piece crankset are the left arm, the right arm, and the axle spindle (figure 7.1). The spindle is held in position by bearings in the frame. Both cranks must be removed to service or replace the bearings of a three-piece system. Both left and right cranks will have crank bolts in the arms.

FIGURE 7.1

Three-piece crank components: right crank with chainrings, left crank and the spindle

Two-piece crank designs include systems such as the Shimano® Hollowtech® II, Campagnolo® Ultra-Torque® and Power Torque™, SRAM® GXP®, Race Face® X-Type™, FSA® MegaExo®, and other similar systems. The spindle is permanently fixed on one crank, making it effectively one piece of the system. The second piece is simply the other crank. The spindle is passed through the bearings in the frame and the opposite crank is bolted to the spindle (figure 7.2). The bearings are not part of the crank or spindle. Two-piece cranks will have a crank bolt on one arm and no crank removal bolt on the opposite crank.

FIGURE 7.2

Two-piece crank components: left and right crank, one with an integrated spindle.

An older design called the “one-piece” crank was used once used on USA made Schwinn bikes. It is still seen on BMX bikes and some inexpensive bikes. A single S-shaped forged arm is fitted in a large unthreaded shell. Service of the one-piece crank is reviewed at www.parktool.com/repair-help.

In the two-piece and three-piece crank systems there are different standards for the spindle-to-crank interface. Many of the newer cranks use proprietary designs and do not interchange between brands or even different models of the same brand. It may be necessary to remove the crank bolt or cap to inspect inside the arm to confirm the type of interface.

The tapered square spindle interface is usually found on less expensive bikes, older bikes, and “classic” bikes (figure 7.3). It is a three-piece crank system, with the spindle end formed as a square stud made with a slight taper. The spindle fits a corresponding square tapered hole in the crank. There are two standards for spindle tapers. The JIS standard is used on Shimano® cranks, and many Asian-made cranks. The ISO standard is used by Miche® and Campagnolo® square spindle cranks. These two standards should not be mixed when choosing spindles or cranks.

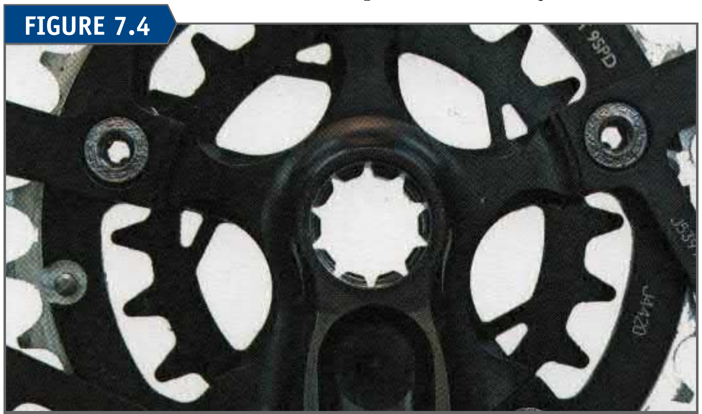
FIGURE 7.3

Square crank hole with square spindle inside

“ISIS Drive” is a three-piece crank system using a round spindle with splines at the crank spindle interface (figure 7.4). The term ISIS Drive does not refer to a particular brand but to a design standard. Several manufacturers offer cranks in the ISIS Drive standard, and all ISIS Drive cranks and spindles interchange. This system uses a 21 mm diameter spindle with 10-splines.

Octalink® is a three-piece crank system used in some Shimano® cranks. It is a round spindle nominally 21 mm

FIGURE 7.4



ISIS Drive crank with 10 splines

in diameter but with an eight-splined pattern (figure 7.5). There are two standards in the Shimano® Octalink® system. The original standard is called Octalink® V1, and was used on models BB-7700, 6500, 5500, M950, and M952. The Octalink® V2 fits the BB-ES70/71 and BB-ES50/51. The V2 system uses a thicker and longer spline (approximately 9 mm), while the V1 spline is relatively narrower and shorter (approximately 5 mm). The V1 and V2 Octalink® standards do not interchange between spindles or cranks. The ISIS Drive and Shimano® Octalink® systems are not interchangeable for cranks or spindles.

FIGURE 7.5

Shimano® Octalink® crank and spindle interface at the left arm

FIGURE 7.6

The SRAM® Power Spline™ system and Park Tool CWP-7 Crank Puller

The Power Spline™ crank system is three-piece proprietary design by SRAM® that uses a round spindle crank interface with 12 splines (figure 7.6). A similar system is Power Drive™ by FSA®. Both systems use a sight taper to the splined spindles but the two systems do not interchange. Both brands can be removed with the Park Tool CWP-7 or CCP-22 crank puller.

CRANK REMOVAL & INSTALLATION

This section will review crank removal and installation for some common crank brands. There are also proprietary systems that are variations on these designs. When in doubt contact the crank manufacturer for removal procedures. Bearing service is performed after cranks are removed and is covered on page 79.

The removal procedure for a two-piece crank varies with the manufacturer. However, some brands and models share design concepts and are removed and installed with similar procedures. In a two-piece system, one crank has the spindle permanently mounted. The opposite arm must be removed first, and then the remaining crank is pulled from the bike.

SELF-EXTRACTING CRANK SYSTEMS

Both the two-piece and the three-piece cranks may be fitted with "self-extracting" or "one-key" release systems. The crank puller is effectively built into the crank (figure 7.7). A threaded cap with a hole in the center takes the place of the crank dust cap and is threaded over the crank bolt to act as bolt-retaining ring. To remove this crank, leave the crank cap in place. Turn the crank bolt counter-clockwise. The crank bolt backs against the crank cap and will then pull the arm from the spindle.

FIGURE 7.7

Self-extracting crank with hex wrench in place for removal

If the retaining ring has been removed, it should be reinstalled and retightened. Retaining ring threading varies with manufacturer. If the ring was 22 mm diameter thread, you may substitute a crank puller tool such as the Park Tool CWP-7. Retaining rings made in larger thread diameters have no other separate crank puller tool option available. Use the manufacturer's retaining ring for crank removal.

Self-extracting systems rely on the cap being secure and tight in the crank. The cap should be occasionally checked for tightness (figure 7.8). The thread is normally a right-hand thread. If the cap is a left-hand thread, it is typically marked accordingly and must be tightened counter-clockwise.

FIGURE 7.8

Check security of self-extracting retaining ring using a Park Tool SPA-2

Self-extracting systems require extra care when installing the crank to the spindle. The self-extracting system makes it difficult to see how the arm is fitting onto the splines of the spindle. Cranks and spindles must align and mate properly as the crank is pressed onto the spindle. A forced mismatch can damage the crank. Splined cranks without the self-extracting cap system allow easy viewing of the crank to spline fit. If there is concern about mating the spindle to the arm, remove the self-extracting cap, install the crank, and reinstall the retaining ring.

To install the self-extracting crank system, inspect both the crank fitting and spindle for the pattern of “tooth” and “groove.” The tooth of the spindle must mate with the groove (space) in the crank fitting (figure 7.9). With crank pointing straight down to the six o’clock position, rotate spindle so it matches appropriately with the crank fitting. Use appropriate size hex wrench to rotate crank bolt clockwise. Thread carefully as you maintain alignment. Secure crank bolt fully. Mount second crank pointing the opposite direction with the same procedure and tighten fully.

FIGURE 7.9

“Tooth” (A) of spindle must align with “groove” (B) at crank interface

THREE-PIECE CRANKS: OCTALINK®, ISIS DRIVE, SQUARE SPINDLE, POWER SPLINE™, AND POWER DRIVE™

Three-piece cranks are held in place by force from well-torqued crank bolts or nuts. To remove the crank, these bolts or nuts must first be removed. The hex wrench size for crank bolts can vary from 6 mm, 8 mm, or 10 mm. If a hex headed bolt or nut is used, it may be a 14 mm, 15 mm, or 16 mm depending upon the brand.

Cranks without a self-extracting system require a crank puller to extract the arm from the spindle after the crank bolt is removed. Cranks are commonly made with an internal thread fitting to match the crank puller. The puller uses a 22 mm x 1 mm external thread to secure to the crank. The puller then uses a threaded stud to push against the spindle end. The spindle and arm are pulled apart when the puller stud presses with force against the spindle.

The crank puller must be compatible with the spindle type. The puller stud that pushes on the spindle must be slightly larger than the threaded hole in the spindle end. ISIS Drive and Octalink® systems use a larger bolt (12 mm or 14 mm), so these cranks use a puller stud tip with a diameter of approximately 16 mm. Square spindle, Power Drive™, and Power Spline™ systems use an 8 mm bolt thread and the puller end will be approximately 11 mm diameter.

Park Tool offers different puller options depending upon the spindle. ISIS Drive and Octalink® cranks use the CCP-44 or CWP-7 crank pullers. Square taper cranks, Power Drive™, and Spline Drive™ use the CCP-22 or the CWP-7 with the smaller pressing foot.

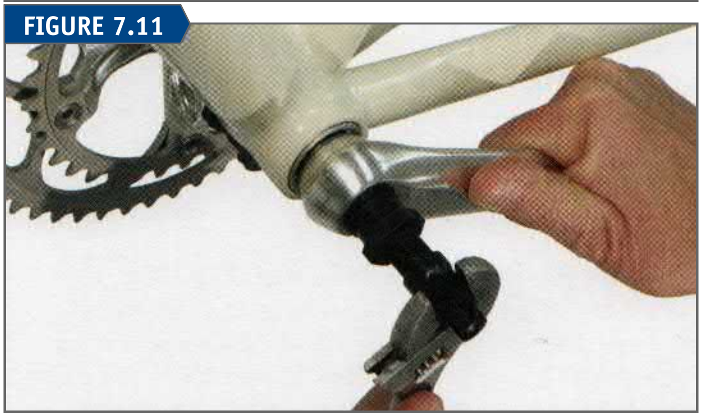
Procedure for crank removal:

a. Shift chain to largest chainring. This helps protects hands from chainring teeth.
b. Remove crank bolt or nut. Remove any washers inside the crank that were below bolt/nut.
c. Inspect crank bolt and select correct tool. Cranks with M8 crank bolts use the CCP-22 or CWP-7 with small tip. The larger M12 and M14 bolts use the CCP-44 or CWP-7 with larger tip.
d. Turn stud of puller until it sits recessed in the hex fitting of the tool. This permits full engagement of 22 mm thread into arm.
e. Thread crank puller into arm (figure 7.10). The 22 mm thread fitting must be fully threaded into arm before pulling arm. Failure to fully engage the tool’s threads in the crank arm may result in damage to the arm.

FIGURE 7.10

Thread and tighten puller securely into fitting before extracting crank

FIGURE 7.11



Remove crank from spindle by turning internal driver of crank puller

f. Turn stud clockwise (figure 7.11). When stud meets spindle, resistance will be felt. Continue threading stud into puller until crank is removed.
g. Unthread crank puller tool from crank and repeat process on other crank.

Three-piece cranks use a bolt or nut that acts as the pressing tool and forces the arms tight to the spindle end. The bolt or nut must be tight enough to keep the arm from loosening but not so tight that the arm becomes split or damaged. The bolt may need 25 to 38 Nm (300 to 450 inch-pounds) depending upon brand. Whenever possible, use a torque wrench for this installation. If a crank bolt comes loose and the arm falls off, the cause is likely to be a lack of torque during installation.

Square tapered spindles are made with a slight slope or taper. This shape creates a wedge as it is driven into the square hole of the crank. Generally this fit is not lubricated. Adequate torque is typically enough to keep arms from creaking. If a crank creaks even at full torque, remove and grease the pressed surfaces.

Splined type spindle systems such as ISIS Drive and Octalink® lack the taper of the square spindles. The splines should be well greased before installation.

Procedure for crank installation:

a. Grease or anti-seize under head and threads of bolts/nuts.
b. For square tapered spindle, leave spindle clean of grease. Grease (or anti-seize) the splines of spline type spindles.
c. Install right crank onto right side of spindle. Thread in bolt to spindle. Self-extracting models align tooth and groove of spindle and crank when installing.
d. Tighten bolt fully to manufacturer's specifications. Refer to Appendix C for recommended torques.
e. Align left arm so it points directly opposite the right arm. Self-extracting models align tooth and groove of spindle and crank when installing. Thread bolt into spindle and tighten bolt fully.
f. Grease threads of dust cap (if any), and install snugly.

TWO-PIECE COMPRESSION SLOTTED CRANKS: SHIMANO® AND FSA®

Shimano® cranks and some models of FSA® cranks use a left crank with a compression slot that is secured by pinch bolts. These systems do not use a conventional crank puller. A threaded cap is used to bring the arm against the bearings. The cap acts as a bearing adjustment only and does not hold the arm in place.

Procedure for crank removal:

a. Loosen fully any pinch bolts on left side crank (figure 7.12).
b. Remove the left side crank cap counter-clockwise. Shimano® cranks use an eight-pointed socket fitting. Use the Park Tool BBT-9 or BBT-10 (figure 7.13). FSA® crank caps use a 8 mm hex wrench.

FIGURE 7.12

Loosen pinch bolts of compression slotted crank

FIGURE 7.13

Remove crank cap after pinch bolts are loose

FIGURE 7.14

Lift stop plate to pull off Shimano® left cranks

c. For Shimano® Hollowtech® II, inspect for a "stop plate" inside the left arm slot (figure 7.14). Use a thin screwdriver or cone wrench to lift this plate upward. The stop plate acts as a safety redundancy to prevent left arm removal. FSA® has no stop plate.
d. Pull arm off spindle by hand. In some cases it may require light tapping with a soft mallet to remove arm if spindle-arm interface is dirty or sticky.
e. Pull crank to the right and remove it from the bike. It may be necessary to use a mallet to tap the spindle on the left side.

The left arms of these crank systems are used to adjust the bottom bracket bearings. The left arm slides along the spindle and is retained and located by tightening an end cap on the crank, much like a threadless headset cap adjusts threadless headset bearings. The bolts in the arm are tightened to keep the arm from falling off and to maintain the bearing adjustment.

Procedure for crank installation:

a. Grease spindle surface and install drive side crank and spindle from the right side and through both bearings (figure 7.15). If necessary use a mallet to fully install arm.
b. Grease threads of arm pinch bolts.
c. Place drive side crank in the six o'clock position. Hold left side arm in twelve o'clock position and press arm onto spindle using hand pressure. Lift stop plate of Shimano® crank over pinch bolt. Make sure stop plate is engaged over pinch bolt threads after crank is installed.
d. Grease threads of crank cap and secure gently. For Shimano® use the BBT-10 or BBT-9. For FSA® use an 8 mm

FIGURE 7.15

If necessary, choke up on mallet handle and tap arm fully into bottom bracket

FIGURE 7.16

Tighten by alternating sides until both bolts are pulled fully tight

hex wrench. Cap pushes arm to bearing. Recommended cap torque is only a very light 0.5 Nm (4 inch-pounds). Crank should not push into bearing with force. Overtightening will cause bearings to drag and wear.

e. Tighten each compression bolt slightly in turn as you move between bolts repeatedly to ensure both are fully and evenly tight (figure 7.16).

TWO-PIECE CRANKS USING WAVE WASHER: FSA® MEGAEXO® AND SRAM® GXP® PF

The FSA® MegaExo® and the SRAM® GXP® PF (BB86) use a "wave washer" to maintain a bearing adjustment. The crank arm uses a self-extracting system and is tightened fully to a dead stop against the end of the splines. The wave washer is a thin piece of spring steel with deformities that fits between

FIGURE 7.17

Wave washer between arm and bearing

the arm and the bearing. The wave washer flexes between the crank and bearing and prevents lateral motion of the spindle by pressing against the bearings and crank.

Procedure for crank removal:

a. Loosen crank bolt in left arm. Do not remove arm-retaining ring. Allow crank bolt to pull arm from spindle.
b. Note orientation of any spacers, seals, or wave washers (FSA®) before removing (figure 7.17).
c. Pull arm from right side to remove. Tap spindle end with mallet if necessary to aid removal.
d. Note orientation of any spacers, seals, or wave washers from right side crank before removing (SRAM®).

Procedure for crank installation:

a. Grease spindle where it inserts into bearings.
b. Grease splines of spindle and grease internal threads of crank.
c. Install any seals, spacers, and wave washers (SRAM®) as appropriate on crank. Install crank and spindle through bottom bracket.
d. Install any spacers, seals, and wave washers (FSA®) on left side.
e. Install and tighten left arm (figure 7.18).

FIGURE 7.18

Tighten arm full against stop of splined spindle

TWO-PIECE SELF-EXTRACTING CRANKS: TRUVATIV®, SRAM® GXP®

The SRAM® and Truvativ® Giga X Pipe (GXP®) drive side bearing has a rubber lip that compresses as the arms are pressed. As the left arm is tightened onto the spindle, it compresses into the lip to apply pressure to the bearings. There is no wave washer or compression slot to adjust against the bearings. These crank systems rely on pressure from the arm on the rubber lip to remove bearing play.

Procedure for crank removal:

a. Inspect both sides of crank for self-extracting crank bolt. A retaining ring will cover self-extracting bolt. Turn bolt in center of retaining ring counter-clockwise to pull one crank from the spindle.
b. Pull the remaining crank and spindle from the frame. If necessary, use a soft mallet with care to remove the crank and spindle from the bike.

Procedure for crank installation:

a. Grease the splines and surface of the spindle.
b. Insert crank and spindle through the right side bearing and out left side.

FIGURE 7.19

Secure GXP® arm

FIGURE 7.20

Hold frame with one hand and pull crank side-to-side checking for play

c. Install left arm onto spindle end. Tighten to a torque of 48 Nm (figure 7.19).
d. Check for play by pulling laterally on cranks. If there is play, tighten arm slightly (1/16 to 1/8 turn) and check again for play (figure 7.20). Repeat if necessary.

TWO-PIECE PRE-LOAD ADJUSTER NUT CRANKS: TRUVATIV®, SRAM® BB30 I-A, AND FSA® AFTERBURNER™

The BB30 I-A crank series from SRAM® and the FSA® Afterburner™ use a 30 mm diameter spindle for use in the BB30 bottom bracket bearing systems.

Procedure for crank removal:

a. Use a hex wrench to remove bolt in the left arm. Common hex size is 10 mm for these models. Note that opposite cap is marked "do not remove." This side was used to assemble crank to spindle and should not be removed.
b. Loosen bolt until arm is free from spindle.
c. Pull crank from bike. Tap spindle with mallet if necessary to help remove arm.

Bearing adjustment is made after the arm is mounted and fully secured. The left arm has a threaded bearing adjustment ring that turns against the bottom bracket bearing face to remove play and to stop the arms from moving side to side. It is only necessary to snug the ring against the bearing face. Do not force the ring into the bearings.

Procedure for crank installation:

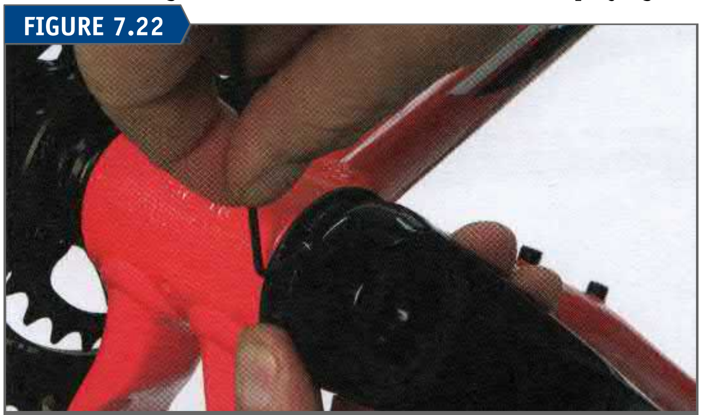
a. Loosen setscrew on bearing adjustment ring. Turn ring clockwise until fully threaded against crank (figure 7.21).
b. Insert crank spindle through bearings.

FIGURE 7.21

Reset the adjusting ring against the arm before installing crank

c. Install opposite crank and tighten crank bolt fully.
d. Turn threaded bearing adjustment ring away from left crank arm and toward bearings. Turn by hand only until ring contacts bearings. Don't overtighten adjustment ring.
e. Secure setscrew on adjustment ring (figure 7.22 and figure 7.23).
f. Check arms for lateral play. Use adjustment ring if play is present, tightening against the bearing only 1/16 to 1/8 turn. Retighten setscrew and check for lateral play again.

FIGURE 7.22



SRAM® adjusting ring system with locking setscrew

FIGURE 7.23

FSA® Afterburner™ crank with adjusting ring and setscrew

CAMPAGNOLO® AND FULCRUM® ULTRA-TORQUE® CRANKS

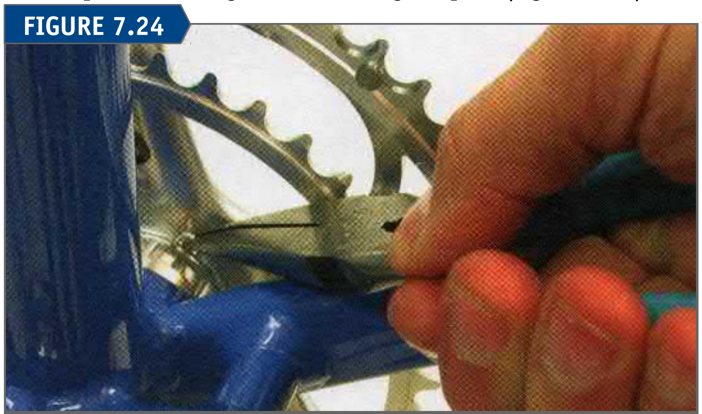
Both left and right cranks of the Campagnolo® and Fulcrum® Ultra-Torque® are fitted with one-half each of the spindle system. Each end of the spindle is machined in a gear shape to mate with the opposite arm. The spindle end teeth engage in the middle of the bottom bracket shell. A bearing is pressed tight to the spindle of each arm. The cups act as a retainer for the bearings on the cranks.

Bearing removal and replacement for the Ultra-Torque® system requires special tooling. See below for bearing service.

Procedure for crank removal:

a. Use needle nose pliers to remove the bearing-retaining clip from the right side bearing adaptor (figure 7.24).

FIGURE 7.24



Remove bearing-retaining clip from adaptor

FIGURE 7.25

Remove crank bolt with 10mm hex key

b. Use a long 10 mm hex wrench to loosen and remove the crank bolt from the center of the spindle (figure 7.25).
c. Pull each arm from the bottom bracket.
d. Remove the wavy washer from left bearing adaptor.

Bearing service for the Ultra-Torque® system is covered on page 83. Bearing adjustments for this system are part of crank installation from the pressure of the wave washer in the left side bearing adaptor. The wave washer is a round thin piece of spring steel that has a series of undulating bends. The wave washer is partially compressed and acts as a spring between the arm and bearing and prevents lateral movement of the crank spindle.

Procedure for crank installation:

a. Install wave washer into left bearing adaptor, or place wave washer on left arm.
b. Install right arm through right adaptor. Align left arm opposite of right arm and install through left bearing adaptor (figure 7.26).
c. Apply grease or anti-seize to threads of crank bolt and install through right side axle center.
d. Secure bolt fully.
e. Install bearing retaining clip to right adaptor.

FIGURE 7.26

Install arm and wave washer into left side into left side adaptor

CAMPAGNOLO® POWER TORQUE™ CRANKS

The Campagnolo® Power Torque™ system uses a spindle permanently fixed to the right arm. The crank bolt presses the left arm secure to the splines of the spindle. The Power Torque™ left arm has no threads or fittings designed in the system for crank removal. Gear pullers, such as the Park Tool combination CBP-3 and CBP-5 must be used to remove the left arm. The bearing puller from the CBP-3 must be used in conjunction with the CBP-5 to service the Power Torque™ crank. The carbon fiber arms are a different shape compared to aluminum arms and require a slightly different removal procedure. Bearing service of the Power Torque™ system is covered on page 84.

Procedure for crank removal:

a. Remove the spring clip from the drive-side bearing adaptor (figure 7.27). The crank cannot be removed with this clip in place.

FIGURE 7.27

Remove clip from drive side adaptor

b. Remove crank bolt using a 14 mm hex wrench. Inspect inside arm for any washer and remove.
c. Aluminum arms: Slide the plastic molded pad onto the crank. Install the extension plug into the spindle (figure 7.28). Carbon arms: Install fiberboard pad behind arm to minimize scratching and install extension plug (figure 7.29).
d. Engage the puller from the CBP-3 bearing puller set. Aluminum crank: caliper arms of puller fit over the

FIGURE 7.28

For aluminum arms install molded pad and extension plug

FIGURE 7.29

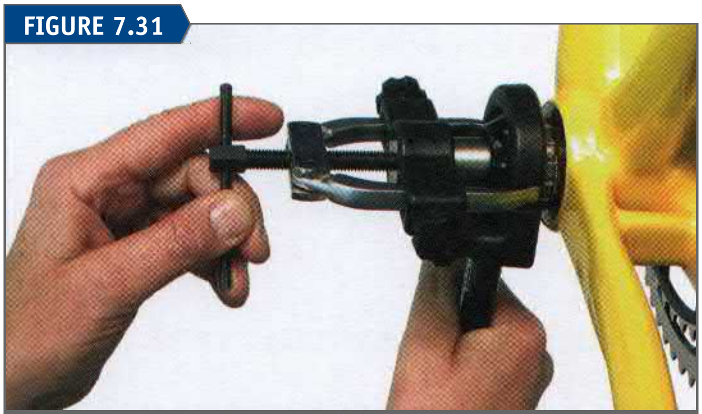

Fiberboard protection in place on carbon crank

molded pad. Align puller and use knobs to remove play from the puller fingers (figure 7.30). Ends of puller fingers should engage the recess behind the mold. There should be no play between fingers and puller body. Carbon crank: insert cardboard protection behind arm and engage puller fingers behind crank. Tighten puller finger knobs to remove play (figure 7.30).

e. Tighten handle of puller clockwise to pull arm from spindle (figure 7.31). Remove any seal and wave washer from left side.
f. Remove tool from crank. Pull crank to the drive side to remove it from the bike.

FIGURE 7.30

Engage caliper fingers and secure knobs to remove play

FIGURE 7.31

Turn handle clockwise to pull arm from spindle

Procedure for crank installation:

a. Install crank through right side bearing adaptor.
b. Install C-clip into pin-holes of right side bearing adaptor.
c. Install pre-load spring and seal cover over left side bearing.
d. Apply grease or anti-seize to splines inside of crank. Lubricate threads of crank bolt.
e. Align crank to point 180-degree opposite of drive side arm and install on spline of crank.
f. Install crank bolt and secure.

SPECIALIZED® S-WORKS® CRANKS

Specialized® Bicycle Corporation offers a proprietary crank system designed around the BB30 standard (figure 7.32). Special tools are required to remove the crank. The design of the S-Works® crank is similar in concept to Campagnolo® Ultra-Torque®.

FIGURE 7.32

Specialized® crankset and BB30 bottom bracket shell

Procedure for crank removal:

a. Remove dust-cover from right side crank with a 6 mm hex wrench.
b. Select the correct bit for the crank bolt. For carbon arms, use a T40 Torx® bit that is at least 50 mm long. Specialized® Bikes offers such a bit. For aluminum arms, use a 6 mm hex bit at least 50 mm long.
c. Insert bit from the right side and fully loosen crank bolt. Pull each arm from bike.

Procedure for crank installation:

a. Grease threads of crank bolt.
b. Insert left and right cranks into bike. Arrange so arms are 180 degrees apart.
c. Thread crank bolt into left arm and secure tight.
d. Install dust cover screw.

The S-Works® crank uses the BB30 bearing system. The bearing adjustment varies with the model of the S-Works®. Some models use a wave washer on the left arm. Other models use an adjustable convex and concave cone washer system lightly pressing against the bearings to remove lateral play. Inspect for three small setscrews at the left arm next to the bearing. Use a hex wrench to tighten each the same small amount. Check for lateral play, and continue to tighten each ¼ turn until lateral play is gone.

BOTTOM BRACKET SYSTEM TYPES

The term "bottom bracket" can refer to several parts of the bike. The bottom bracket shell of the frame, the bottom bracket bearings and the bottom bracket spindle (axle) are all part of the bottom bracket system.

The bottom bracket shell is part of the frame that houses the bottom bracket bearings and spindle. There are currently multiple bottom bracket shell designs, and the bearing system installed must be compatible with the shell design used. It is necessary to know the bottom bracket system to have the correct tools and parts for service. The model of crank does not necessarily determine the tools or procedures for the bearing service. In some cases you may need to disassemble the cranks to inspect the bottom bracket shell.

The two basic designs for bottom bracket shells are threaded shells and non-threaded shells. There are numerous standards for each.

THREADED STANDARDS

Threaded bottom bracket shells have an internal thread to accept the external thread of the bottom bracket bearing cup or adaptor (figure 7.33). Carbon fiber bikes with a threaded bottom bracket shell use a metal insert for the internal threading. The common bottom bracket shell-threading standard is 1.37 in. x 24 tpi. This is also referred to as "English," "BSC," or "BSA." A less common threading standard is 36 mm x 24 tpi and is referred to as "Italian." Older thread standards no longer in production include the "French," "Swiss," and "Witworth."

FIGURE 7.33

Left side (non-drive) of a threaded bottom bracket shell

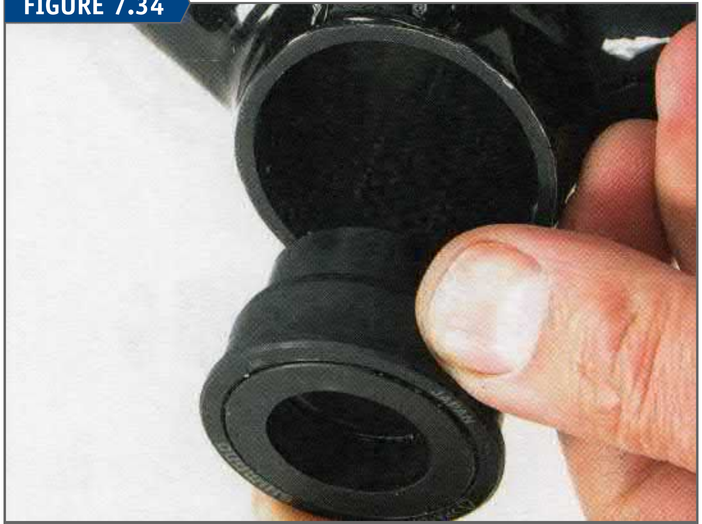
NON-THREADED STANDARDS

Non-threaded bottom bracket shells have a smooth inside bore that houses the bearing system. Non-threaded bottom bracket designs have several different possible configurations. In addition to matching the bottom bracket shell, the bearing system must be compatible with the crankset. Adaptors allow some interchangeability between standards in bottom bracket bearings and cranks.

BB86 and BB92

This system is named for the width of the shell, either 86 mm or 92 mm. The shell has a smooth bore with a nominal 41 mm inside diameter. The cartridge bearings themselves are held in an adaptor of plastic or aluminum and are pressed into the bottom bracket shell (figure 7.34). The system is designed for a crank spindle with approximately 24 mm diameter, such as the Shimano® Hollowtech® II, Race Face® X-Type™, FSA®, and others. The GXP® spindle from SRAM® uses different left and right bearing inside diameters (ID). The right side bearing has an ID of 24 mm; the left side has an ID of 22 mm.

FIGURE 7.34



BB86 frame shell shown with press fit bearing

BB90 and BB95

The Trek® Bicycle Company uses a variation of the BB86 system that incorporates the bearing holder into the bottom bracket shell of the frame, much like an integrated headset (IS). These cartridge bearings do not use an adaptor and simply drop into either side of the bottom bracket shell, slipping into the frame by hand (figure 7.35). The outer diameter of the bearings is 37 mm. Bearings are available

FIGURE 7.35

BB90 frame shell in a Trek® bottom bracket shell, shown with cartridge bearing for both 24 mm spindles and the SRAM® 24 mm and 22 mm stepped spindle design. Trek® refers to their system as BB90 (road) and BB95 (mountain).

BB30

The BB30 refers to the 30 mm diameter of the spindle commonly used on this standard. BB30 compatible bottom bracket shells have a smooth bore with 41.95 mm inside diameter. The shell width comes in both 68 mm (road) and 73 mm (mountain). A cartridge bearing with a 42 mm OD is pressed into each side of the frame shell. The bearing is pressed against an internal bearing-positioning stop such as a C-clip (figure 7.36). Adaptors are available to use two-piece non-BB30 cranks in the BB30 frame shells.

FIGURE 7.36

BB30 shell with C-clip bearing stops in place

PF30

The PF30 stands for "Press Fit 30." The frame shell has smooth bore with approximately 46 mm inside diameter (figure 7.37). The shell widths are 68 mm for road bikes and 73 mm for mountain bikes. The cartridge bearings are in a plastic or aluminum adaptor, which is then pressed in the shell. The PF30 bottom brackets accept the BB30 compatible cranks with the 30 mm diameter spindles. Adaptors are available to use non-BB30 cranks in the PF30 frame shells.

FIGURE 7.37

Left side (non-drive) of PF30 bottom bracket shell seen on full suspension frame

386EVO

The 386EVO standard is a variation on the PF30. The frame shell width of 86 mm and cranks in the 386EVO standard are correspondingly longer compared to the BB30 cranks. The inside diameter of the shell is 46 mm to accept the same bearing adaptors from the PF30 bearing systems. The spindles designed for 386EVO shells are 30 mm diameter. Adaptors are available to use the longer 386EVO cranks in the BB30, BB86, BB92, PF30, and threaded bottom bracket shell standards. Frames designed for the 386EVO must use the 386EVO crank.

BBright®

BBright® is a variation of the PF30 system and was developed by Cervelo® Bikes. The shell is 79 mm wide, with a 46 mm ID. Cervelo® offers cranks designed specifically for this system, although adaptors are available to use other cranks such as the 386EVO or the Shimano® Hollowtech® II crank in the BBright® standard.

Table 7.1 provides an overview of the various standards. There are adaptors available, however, that permit cranks of one standard to fit the bottom bracket shell of another standard. "Bore diameter" is the inside diameter of the bottom bracket shell. Threading standards are listed when applicable. Bearing ID applies only to cartridge bearings with removable spindles. The spindle diameter must match the inside of the cartridge bearings, but in some cases adaptors are available to reduce larger bearing IDs to fit small spindles. The shell width is measured from outside to outside of the bottom bracket shell faces. Crank spindle length must be compatible with the shell width.

TABLE 7.1 *Bottom Bracket Standards*

STANDARD NAME	BORE DIAMETER	THREADING STANDARD	BEARING ID	SHELL WIDTH OPTIONS
BSA/BSC/ English	34 mm	1.37 in. x 24 tpi	N/A	68, 73, 83, & 100 mm
Italian	35 mm	36 mm x 24 tpi	N/A	72 mm
BB30	42 mm	No threading	30 mm	68 & 73 mm
BB86	41 mm	No threading	~24 mm	86 mm
BB90	41 mm	No threading	~24 mm	90 mm
BB95	41 mm	No threading	~24 mm	95 mm
PF30	46 mm	No threading	30 mm (adaptors available)	68 & 73 mm
BBright®	46 mm	No threading	30 mm	79 mm
BB386EVO	46 mm	No threading	30 mm	86.5 mm

BOTTOM BRACKET BEARING SERVICE FOR NON-THREADED SHELLS

The cranks are attached to a spindle or axle, which is supported by the bottom bracket bearings. These bearings see a lot of load and wear from riding. Bottom bracket bearings are supported by the bottom bracket shell and are usually the lowest point of the bicycle. Any water that gets inside the frame tends to drain to the bottom bracket shell.

Service options and procedures will vary depending on the bearing system in the bike. It is often necessary to know the crank standard used on the bike because adaptors may be installed in the bottom bracket shell that allow mixing of shell and crank standards. The crank being used in the bike will determine the tools and procedure used.

BB30 BEARINGS

Bikes designed with the BB30 shell use two pressed cartridge bearings inside the frame. Like most cartridge type bearings, if the spindle is removed, the bearing seals can be safely lifted and the bearing cleaned and re-greased while still in place in the shell. When the bearings develop play and are worn out, they must be replaced. The old bearings are tapped out and recycled and new ones pressed back into place. To service the bearings use a tool such as the Park Tool BBT-30.3 Bottom Bracket Bearing Tool Set. It is the intent of bike manufacturers that if a bearing is removed from the system, it will be replaced with a new bearing. Removal is done by impact, and there may be slight damage to the bearing as it is removed. The procedures here are for bearings accepting a 30 mm diameter spindle. If there are adaptors installed in the bearings, you may need to use procedures for the crank standard being used.

Procedure for bearing removal:

a. Remove cranks from bike. Spindle will be removed from bottom bracket shell as part of crank removal.
b. For BB30 bearings, inspect inside bottom bracket shell and note bearing-stop clip. Orient foot of BBT-30.3 tool so it does not strike the any part of the clip.
c. Tilt the BBT-30.3 tool and guide the foot through one bearing, through the shell and engage foot into the opposite bearing (figure 7.38).

FIGURE 7.38

Engage foot of BBT-30.3 through bearing center and push foot to opposite bearing

d. Engage plastic guide bushing into bearing. The guide will keep tool and foot straight as it drives out bearing.
e. Use a hammer and strike the end of the remover to drive out bearing (figure 7.39). If necessary, rotate tool handle to strike different points on the bearing.
f. After one bearing is removed, pull tool back through remaining bearing. Place tool through open side of shell and engage plastic alignment bushing. Strike end of the remover and remove second bearing.

BB30 and PF30 cartridge bearings are a mild interference fit into the shell. The BB30 bearing outside diameter is 42 mm. The BB30 inside diameter is intended to be 41.96 mm. If the press fit is weak and the bearings slip into place by hand, use a retaining compound such as RC609 from Loctite® to supplement the fit. For removal of bearings pressed with the retaining compound, it may be necessary to apply mild heat such as from a hot air gun or a hair dryer.

FIGURE 7.39

Strike tool end to drive out bearing from shell

BB30 bearings use bearing stops inside bottom bracket shell, which are commonly snap rings. It is typically not necessary to remove the shell snap rings. If removal is necessary, use a small screwdriver to lift end of ring and pull out.

The BBT-30.3 tool set includes two bushings for the BB30 and PF30 standard. Bushing installation requires a headset press. Bushings help to center and align bearings during the pressing. A bearing must be pressed until it is recessed into the shell. Pressing with a flat plate will not push bearings to their proper bearing position.

Procedure for bearing installation:

a. Inspect inside shell for C-clips. Clips should be secure inside groove in bottom bracket shell.
b. Engage one bearing each on the bushings from the BBT-30.3 set. Bushing will keep bearing aligned during the press (figure 7.40).

FIGURE 7.40

Install headset press through shell and engage bushing and bearings

FIGURE 7.41

Press BB30 bearings with steady pressure from a headset press

c. Insert thread of headset press through bushings, bearings, and shell. Install second nut or stop plate of headset press, trapping bushing and bearings.
d. Turn headset press handle until plates contact bushing, bearings, and shell. Stop briefly and inspect alignment of bearings into shell (figure 7.41).
e. Continue to press bearings until both strike C-clips inside shell.
f. Remove headset press and bushings. Check inside shell for bearing contact at stops.
g. Install crank according to crank brand and model.

PF30 AND BBRIGHT® BEARINGS

The PF30 system and its variations are designed to accept the BB30 cranks with the 30 mm diameter spindles. It is basically a variation of the BB30 bearing system. The frame shell bore diameter is nominally 46 mm. It will accept cartridge bearings mounted permanently into plastic or aluminum adaptors. These are pressed into the shell with a mild interference fit.

Bearings are pressed into place in the same manner with the same tool as the BB30 above. Push on bearings until both sides are contacting outer shell faces (figure 7.42). There is no internal stop ring in the PF30 system. The bearing adaptors have a lip that contacts the outside shell face. Press the bearing adaptors only until this lip contacts the shell face.

Removal of the PF30 uses the BBT-30.3 in the fashion of the BB30. The tool is installed through one side and the foot of the tool is pushed over to contact the opposite bearing. The end of the tool is struck with a hammer to remove one bearing (figure 7.43). The tool is then reversed to remove the remaining bearing. Plastic adaptors are likely to be marred by the removal process. Remove adaptors with the intention of installing new ones.

FIGURE 7.42

Press PF30 bearings until both left and right bearing stops contact frame

FIGURE 7.43

Remove PF30 adaptors with Park Tool BBT-30.3

BB30 AND PF30 ADAPTORS FOR NON-BB30 CRANKS

BB30 and PF30 frame shells accept various manufacturers' adaptors to permit the installation of non-BB30 cranks.

BB30 frame shells may be converted to the threaded BSC/ISO standard with an aluminum sleeve from FSA®, SRAM®, and Problem Solvers™. The sleeve is a press fit to BB30 shell, and has internal threading. Conventional threaded bottom bracket bearing adaptors or cups can then be installed. This conversion should be considered semipermanent because a professional mechanic should perform removal.

To install this conversion, begin by removing the C-clips from the BB30 frame shell (figure 7.44). Use a small-tipped screwdriver, snap ring pliers, or needle nose pliers.

FIGURE 7.44

Remove C-clips bearing stops in the BB30 frame shell before installing conversion sleeves

To prevent the chance of creaking and looseness in the future, apply a mild thread locker such a Loctite® #242 to the inside of the shell. Double-check the sleeve thread orientation. The drive side (right side) thread is a left-hand thread, and the internal thread will slope upward to the right. The non-drive side external thread is a right-hand thread and the internal threads of the sleeve will slope upwards to the left. Use a headset press to push the sleeve fully into place (figure 7.45).

Removal of this conversion sleeve can be difficult. Should it need removal, it is best to take the bike to an experienced shop. For more details see www.parktool.com/blog/repair-help.

FIGURE 7.45

Pressing the aluminium conversion sleeve into a BB30 shell

24 mm spindle cranks (Shimano®, SRAM® GXP®, Race Face®, FSA®, etc) can also be fitted into the BB30 compatible bottom bracket shells by using simple downsizing adaptors. The bearing hole for the standard BB30 bearing is 30 mm. These adaptors are simple, downsizing the current bearing to accept the smaller spindles (figure 7.46). The adaptors act as spacers against the bearings to effectively widen the shell to the BB86 or BB92 shell standard.

FIGURE 7.46

Plastic reducers for the PF30 bearing allowing the fit of the 24 mm Shimano® crank

Praxis Works® offers bearing systems that install inside BB30 or PF30 systems to reduce their internal diameter for the 24 mm spindle size of Shimano®, FSA®, and SRAM® cranksets (figure 7.47). A tube with internal threading is pressed into the bottom bracket shell. Threaded bearing adaptors screw into the tube and tighten the left and right adaptors against one another to hold the assembly securely.

FIGURE 7.47

Praxis Works® bottom bracket adaptor inside a PF30 frame shell

FIGURE 7.48

SRAM® threaded converters for the PF30 standard

SRAM® offers a PF30 to a 68 mm or 73 mm adaptor insert with internal threads in the BSC/ISO standard (figure 7.48). To install this unit, begin with an empty PF30 shell. The threaded bearing adaptors are installed into the internal thread of the PF30 adaptor *before* they are pressed into the frame. Grab the PF30 adaptor on the flats in a vise and tighten each threaded bearing adaptor to a relatively low torque of 18 Nm. Each adaptor is then pressed one at a time into the frame. The plastic is squeezed and is compressed during the interference fit, and this adds to the effective torque or holding power of the internal threads.

BB86, BB90, BB92, BB95 BEARINGS (SHIMANO® PF AND GXP® PF)

The BB86, BB90, BB92 and BB95 standards are similar in their service details. Pressed adaptors designed for 24 mm spindles are pushed into a smooth bore frame shell with a nominal inside diameter of 41 mm. The adaptors have lips that stop against the frame shell face.

Procedure for bearing adaptor removal:

a. Remove cranks.
b. Insert small end of bearing driver BBT-90.3 through one side and pull slowly until it engages backside of adaptor (figure 7.49). It engages with a "click" noise.

FIGURE 7.49

Pull BBT-90.3 driver through shell until it engages back of adaptor

FIGURE 7.50

Remove bearing adaptor one at a time

c. Use hammer to drive out one adaptor (figure 7.50). Hold frame near bottom bracket to support while tapping. Expect backside of adaptor to have cosmetic scarring from tool.
d. Insert small end of bearing driver BBT-90.3 through second adaptor and repeat process.

It is the intent of the manufacturer to have bearings and adaptors removed only for replacement. The left and right adaptors are symmetrical, with the exception of the SRAM® GXP®. The GXP® cranks have a stepped spindle, nominally 24 mm on the right side and 22 mm on the left. The adaptors are marked for drive side and non-drive side, with the non-drive side being smaller. When working with the GXP® press fit bottom bracket, orient the adaptor with the smaller bearing hole on the left side.

If drive train creaking has been an issue in the bike, it may be necessary to apply a retaining compound, such as the Loctite® RC609. This liquid compound will expand and harden once installed. For removal, it may require mild heat. Use only a hot air gun or a hair dryer to warm the bottom bracket shell, softening the compound.

Procedure for bearing adaptor installation:

a. Clean pressed surfaces of grease. If desired, apply a retaining compound.
b. Use a headset press and engage one bearing each on the bushings from the BBT-90.3 set. Bushings will keep bearings aligned during the press (figure 7.51). If no guide bushings are available, press one adaptor at a time using the press.

FIGURE 7.51

Install headset press through shell and engage bushings and bearings

c. Turn headset press handles until plates contact bushing, bearings, and shell. Stop briefly and inspect alignment of bearings into shell.
d. Continue to press bearings until both adaptors are pressed against shell face. Do not continue to press beyond this point.
e. Remove headset press and bushings.
f. Install cranks according to crank brand and model.

CAMPAGNOLO® ULTRA-TORQUE® AND FULCRUM® BEARINGS

The Campagnolo® Ultra-Torque® crank bearings are pressed on the spindle section of each crank. Bearings are removed only for the purpose of replacement. Use the Park Tool CBP-3 Bearing Puller set to remove and install these bearings.

Procedure for bearing removal:

a. Remove cranks from bike.

FIGURE 7.52

Remove right side clip before pulling bearing

FIGURE 7.53

Engage puller caliper fingers over bearing and secure knobs

b. Remove C-clip from right side crank. Use snap ring pliers or a small tipped screwdriver to pry up clip (figure 7.52).
c. Arrange the bearing puller assembly over the spindle. Use the side knobs to snug the fingers under the bearing (figure 7.53).
d. Turn handle of puller clockwise to push tool plunger against spindle end. The bearing will be pulled away from crank.
e. Remove tool from crank and repeat process on second crank.

Both crank bearings should be replaced if removed. Do not reuse bearings that were removed. The new bearing must be pressed back onto spindle with an interference fit, much like a headset fork crown race.

Procedure for bearing installation:

a. Replace any seals that were removed on the crank.
b. Install bearing over spindle.
c. Place crank on wooden bench or other firm non-marring surface. Place driver from Park Tool CPB-3 Bearing Puller Set over spindle and drive bearing downward by striking with a hammer (figure 7.54). The CBP-2 driver is a precise fit to the inner bearing race and will not damage bearing surfaces.
d. Engage C-clip over spindle end. Use driver CPB-2 to push bearing down until bearing engages groove in spindle.
e. Repeat installation of bearing on second crank. Install cranks into bike as described on page 76.

FIGURE 7.54

Drive bearing firmly into place and then install C-clip

CAMPAGNOLO® POWER TORQUE™ BEARINGS

The right side bearing for the Power Torque™ is a press fit to the spindle. The left side bearing is a slip fit to the spindle, but this bearing is pressed tightly to the adaptor or cup. The left side bearing is replaced together with the adaptor as a unit. The right side bearing mounted to the spindle can be removed and replaced. The aluminum and carbon arms share the same service procedure for bearing removal and replacement. Bearing removal requires a bearing puller set such as the Park Tool CBP-5 Crank and Bearing Adaptor Set. This tool set is used in conjunction with the CBP-3 Bearing Puller Set. **Note:** For Campagnolo® compact style cranks remove the chainrings before using the CBP-5.

Procedure for right side bearing removal:

a. Remove cranks from bike. See page 76.

FIGURE 7.55

Remove right side clip before pulling bearing

FIGURE 7.56

Install bearing adaptor from direction of crank arm

b. Use a screwdriver to remove C-clip adjacent to right side. Clip must be removed before bearing can be pulled (figure 7.55).

c. Install the bearing remover adaptor on the crank (figure 7.56). Install adaptor aligned with the arm of crank. Push adaptor until fully engaged under bearing.

d. Install puller over spindle end. Engage fingers into arms of adaptors. Adjust knobs of puller to remove play in puller (figure 7.57).

FIGURE 7.57

Engage caliper fingers over bearing adaptor and tighten knobs

e. Tighten handle of puller to lift adaptor and bearing from crank. Inspect that the puller and adaptor are lifting evenly and not twisting.

Procedure for right side bearing installation:

a. Install new seal and bearing on crank spindle. Place crank on smooth workbench, and place bearing installer over spindle.

b. Use a hammer and strike bearing installer to drive bearing fully into place (figure 7.58).

c. Engage C-clip over spindle end. Use driver to push bearing down until bearing engages groove in spindle.

d. Install cranks in bike.

FIGURE 7.58

Drive bearing to arm using hammer and bearing installer

CAMPAGNOLO® BB30 BEARING ADAPTORS

Power Torque™ and Ultra-Torque® adaptors are available for both the BB30 and PF30 shell standards (figure 7.59). For the BB30 frames, begin by removing the bearing stop C-clips from inside the frame on both sides of the shell (figure 7.60).

FIGURE 7.59

Left side adaptor shown uninstalled with right side adaptor fully pressed in place

FIGURE 7.60

Remove C-clips bearing stops in the BB30 frame shell before installing Campagnolo® adaptors

Use a headset press and press one adaptor at a time. If either cup appears to have a loose fit, use retaining compound such as Loctite RC680.

Campagnolo® pressed adaptors use an internal seal that interferes with removal. Use a screwdriver and/or needle nose pliers to displace both internal seals inward. This will permit use of the Park Tool RT-1 head cup remover tool. Insert the RT-1 through the adaptor and engage it behind the adaptor. Use a hammer to drive out one cup. Reverse the tool and drive out the second adaptor. Expect some cosmetic scarring of the backside of the adaptor.

BOTTOM BRACKET BEARING SERVICE FOR THREADED SHELLS

The common bearing system used for three-piece cranks in threaded shells is the "cartridge bearing." The crank spindle is built into the bearings and the unit is held in the frame by threaded adaptors. The cranks attach to the end of the spindles, and consequently the crank must be compatible with the spindle.

In square spindle types, there are different square spindle lengths available as measured from end to end. The longer the right side of the square-type bottom bracket spindle, the farther the chainrings will sit to the right of the frame. The chainrings may rub against the frame if the right side is too short. There are limits to where the cranks can be positioned in the frame, as described in Chapter 9, Derailleur Systems, Chainline, page 129.

Round spindle-end standards for three-piece include the Shimano® Octalink®, ISIS Drive, FSA® Power Drive™, and SRAM® Power Spline™ cranks. These spindles are also available in different lengths, measured end to end. When replacing a bottom bracket spindle, measure and duplicate the same length in a new model.

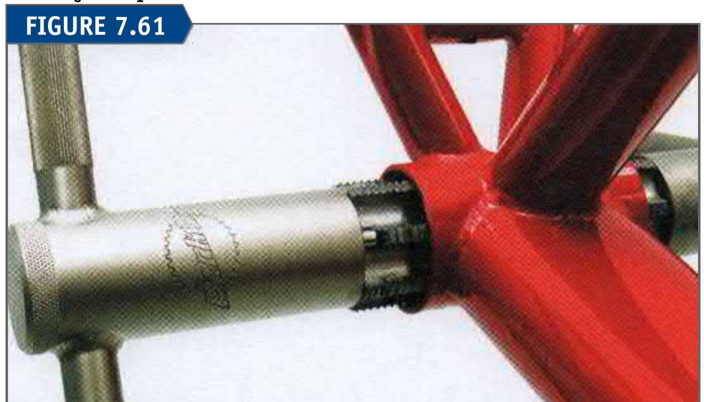
The common threading for bottom brackets is called the BSC (British Standard Cycle), English threading, or ISO standard (International Thread Standard). The thread size is 1.37 inches (35 mm) x 24 tpi. The left side (non-drive side) thread is a right-hand direction thread, which removes counter-clockwise and tightens clockwise. The right side (drive side) thread is a left-hand direction thread. It is installed counter-clockwise and is removed clockwise.

There are some exceptions to the ISO bottom bracket threading. Bikes made in Italy may have both drive and non-drive right-hand thread, which are both removed counter-clockwise. The thread sizing is 36 mm x 24 tpi. This bottom bracket is too large to fit into an ISO sized frame. An ISO bottom bracket will simply slide into the larger Italian threading with no thread engagement. An Italian thread bottom bracket is often designated with "36 x 24" markings on the flange of the bottom bracket bearing.

If a bottom bracket bearing adaptor or cup seems to install with excessive force, the shell threads may require tapping (figure 7.61). A professional mechanic will be able to diagnose and repair this problem.

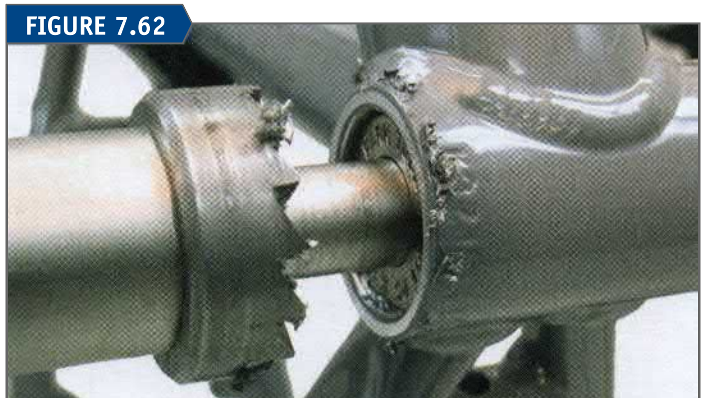
Another machining issue is called "facing" (figure 7.62). The left and right shell faces should be machined or faced so they are parallel to one another. The shell can become

FIGURE 7.61



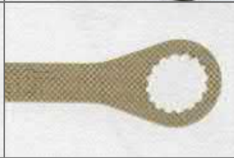
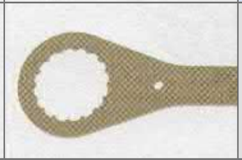
Tapping the bottom bracket internal thread

FIGURE 7.62



Facing the shell face surface

TABLE 7.2 *Threaded Bottom Bracket Tool Selection*

BRAND / MODEL EXAMPLES	BOTTOM BRACKET FITTING	APPROPRIATE PARK TOOL PRODUCT	TOOL & NUMBER OF SPLINES OR NOTCHES IN BOTTOM BRACKET FITTING
Many Shimano® cartridge types, also Race Face®, FSA®			Park Tool BBT-22 20 splines
Bontrager®, Truvativ®			Park Tool BBT-18 8 notches
External bearing systems for Shimano® Hollowtech® II, Campagnolo®, Race Face®, FSA®, Truvativ®			Park Tool BBT-9 16 notches Park Tool BBT-19 16 notches
Shimano® Dura-Ace® FC-9000			Park Tool BBT-29 16 notches
FSA® 386 MegaEVO®			Park Tool BBT-29 16 notches
Campagnolo® Veloce®, Mirage®, Xenon®			Park Tool BBT-4 6 notches
Campagnolo® Record®, Chorus®, Centaur®			Park Tool BBT-5 12 splines
Adjustable type Shimano® Dura-Ace® bottom brackets (BB-7700)			Park Tool BBT-7 6 notches
Lockring of various brands of adjustable bottom brackets			Park Tool HCW-5 3 or 6 notches (lockring on cup)
Adjustable bottom bracket, right side cup. Two wrench flats			Park Tool HCW-4 2 flats at 36 mm
Various adjustable bottom bracket left side cups			Park Tool SPA-1 2, 4, 6 or 8 holes of 3 mm diameter

deformed during welding or even simply from being made less than precisely. If the shell faces are deformed, left and right side bearings may not be properly aligned to one another.

As a rule, if the bearings use the shell face as a reference for the bearing race alignment, facing is important. If the bearings do not use the shell face for bearing race alignment, facing is not needed. Many modern bicycles use cartridge-type bottom bracket bearings. These bearing systems consist of a bottom bracket bearing housing containing non-removable and non-adjustable bearings. The bearing adjustment is made at the component factory and does not rely on the shell faces for bearing surface referencing, and the unit is held in position by threaded locating rings, expanding cups, and/or threads on the housing. Unless the shell faces are extremely deformed, facing will not be required with these components.

Threaded bottom bracket bearing cups and adaptors are designed with tool fittings to allow installation and removal. Do not attempt to “fake” the tool by using unusual service techniques, such as trying to tap the bottom bracket out with a punch and hammer. Table 7.2 outlines the common bottom bracket fittings and the Park Tool choice of tools. The list of brands and models is not exhaustive because new models are brought to market often. Inspect the lockring or cups of the bottom bracket and check the Table 7.2.

THREADED BOTTOM BRACKET WITH TWO-PIECE CRANKS

A two-piece crank system may be installed in a threaded bottom bracket shell using “external cartridge bearings.” The adaptor cups thread inside the shell, but the bearings sit outboard or externally of the shell. The spindle for these systems is part of the crank. Both left and right side bearings have holes to accept the crank. Two-piece cranks are designed to match the distance between their bearings when installed in the shell. There are two basic shell widths: road at 68 mm and mountain at 73 mm.

The triple crankset bearing cups of Shimano®, Race Face®, and FSA® are designed to be spaced 75.5 mm apart at the frame shell. These cranks are supplied with three spacers of 2.5 mm thickness to locate them relative to the frame and the bearings. The cranksets can be fitted to bikes with a 68 mm or 73 mm bottom bracket shell width. If the bike uses a front derailleur with a built-in mounting bracket (“E-type”), it is counted as a spacer. Any chain guide mount is also counted toward the width total. See Table 7.3 for arrangement of spacers.

TABLE 7.3 *External Bearing Crankset Spacer Arrangement*

BB SHELL WIDTH	LEFT SIDE OF BIKE	FRONT DERAILLEUR	RIGHT SIDE OF BIKE
68 mm	One 2.5 mm spacer	Clamp-on front derailleur Two 2.5 mm spacers	Two 2.5 mm spacers
68 mm	One 2.5 mm spacer	E-type front derailleur	One 2.5 mm spacer plus E-type bracket
73 mm	No spacers	Clamp-on front derailleur	One 2.5 mm spacer
73 mm	No spacers	E-type front derailleur	E-type bracket

Truvativ® GXP® cranks use spacers under the bearing adaptors. If the shell is 68 mm wide, use one of the 2.5 mm spacers per side. For 73 mm wide shells, no spacers are needed; thread adaptors directly into shell.

The external bearing system design for double chainring cranksets (road) from Shimano®, FSA®, and Truvativ® are made for 68 mm bottom bracket shells. No extra spacers are required or used for these systems. Bearings simply install into the shell.

The bearing cups from Shimano®, Campagnolo®, FSA®, Truvativ®, SRAM®, and Race Face® all use the Park Tool BBT-9 or BBT-19 Bottom Bracket Tool. The cups have 16 notches that are engaged by the tool. The BBT-9 is a one-piece hand tool. The BBT-19 may be used with a torque wrench.

Shimano® offers a proprietary adaptor sized for 11-speed Dura-Ace® systems, which requires their own wrench. Additionally, FSA® has a proprietary size for the threaded 386EVO adaptors.

Procedure for bearing installation:

a. Prepare bottom bracket shell threads with grease, anti-seize, or a mild thread locker.
b. If applicable to the component, install correct number of spacers as described above on cup marked with “R” (drive side). Install dust seal on cup. Thread the drive side cup counter-clockwise into right side of bike. Tighten fully, approximately 305 to 435 inch-pounds. Using the BBT-9, apply approximately 45 to 60 pounds of effort on the handle (figure 7.63).

FIGURE 7.63

Tighten bearings using Park Tool BBT-9 Bottom Bracket Tool

c. Install correct spacers as needed on cup marked “L” (non-drive side). Thread cup clockwise into left side (non-drive) of bike and tighten fully as before. Cups are ready for crank installation.

Removal of the threaded cartridge adaptors is simply unthreading them from the frame after the crank has been removed. For the common BSC/ISO frame thread, turn the drive side adaptor clockwise to remove. Turn the left side adaptor counter-clockwise to remove.

THREADED CARTRIDGE BOTTOM BRACKETS: ISIS DRIVE, OCTALINK®, AND SQUARE SPINDLE

Cartridge bottom brackets use industrial bearing designs, similar to bearings found in pumps, electrical motors, etc. These bearings are intended to be disposable. For most brands of bottom brackets, the entire bottom bracket unit is replaced, including the spindle.

To determine if the bottom bracket is worn out or has developed play, drop the chain off the chainrings to the inside. Grab both cranks firmly at the ends, but do not hold the pedals. Push laterally with one hand and pull laterally with the other hand to force the arms side to side. If a knocking is felt, remove cranks and double-check tightness of bearing locking cups or rings and check play again. If the cups are adequately tight and knocking continues, the bearings are worn, and the bottom bracket should be replaced. Next, spin the cranks while holding the frame (figure 7.64). Worn bearings will grind, and this can be felt through the frame as a vibration. If in doubt, compare the feeling of an old bottom bracket to that of one on a new bike.

FIGURE 7.64

Spin cranks to feel for grinding of a worn bottom bracket bearing

Procedure for bottom bracket removal:

a. Remove both cranks.
b. Insert bottom bracket cartridge tool fully into or onto fittings of non-drive cup (left side). Hold tool firmly in place while turning counter-clockwise to remove left or non-drive adaptor or cup.
c. Insert tool fully into or onto fitting of drive side (right side) adaptor or cup. Remove by turning clockwise on BSC or ISO threaded bikes. For Italian threaded bikes, turn counter-clockwise.
d. Pull bottom bracket spindle from bike if not already removed.

If the bottom bracket is difficult to unthread or remove, it can be useful to clamp the tool to the adaptor cup. If the spindle is hollow, use a quick release lever to hold the tool firmly in place (figure 7.65). If the spindle is not hollow, use a long bolt of the same thread as the crank bolt. The teeth of the cups may be shallow, and this technique can prevent the tool from slipping.

FIGURE 7.65

Use wheel skewer to secure tool snug to adaptor fittings

FIGURE 7.66

Bottom bracket marking indicating side of bike

It is common for new cartridge bottom brackets to be marked "Left" and "Right." These refer to side of bike, not thread direction (figure 7.66). The drive side of the bike is the right side, and the non-drive side is the left side. With the common BCS/ISO threading, the right side will have left-hand thread direction, and the left will have right-hand thread direction.

There are two critical issues regarding thread preparation for the bottom bracket. First, the threads need lubrication to pull up fully tight. Second, the threads should be protected from corrosion. Grease will help for both issues, but anti-seize compounds are far more durable and are better at preventing corrosion (figure 7.67). Anti-seize is especially recommended for titanium and aluminum frames.

Another thread option is to use a service removable threadlocker. Place a bead of the threadlocker around the first

FIGURE 7.67

Lubricating threads of the bottom bracket

FIGURE 7.68

If spindle appears off-center in shell, bottom bracket adaptor may be cross threaded three or four threads on both lockrings. The threadlock will form a seal against water. Use of a threadlocker is especially recommended for Italian-threaded bottom brackets, which tend to loosen during use.

Plastic lockrings or cup threads may be greased or left dry. Do not use threadlocker compounds on plastic as they may cause the plastic to become brittle.

When threading a bottom bracket into the frame, begin turning by hand to feel and avoid cross threading. Look at opposite side of the bottom bracket shell, and keep the spindle centered in the shell. If spindle appears off-center in the shell, it may be cross-threaded (figure 7.68).

Procedure for bottom bracket installation:

a. Prepare the threads of the bottom bracket with grease, anti-seize, or threadlocker.
b. Look on body of cartridge for “L” and “R” marking. The “L” goes to the left side of bike, and the “R” goes to the right (drive train) side. For the common BSC threaded bikes, right side (“R”) has a left-hand thread direction. Thread the drive train side by turning counter-clockwise. If bottom bracket has a plastic threaded side and a metal threaded side, install the metal threaded side first.
c. Once threads are correctly aligned, thread body fully into bottom bracket shell using bottom bracket tool.
d. Install locking cup or ring into other side of shell and tighten both sides to manufacturer’s torque (figure 7.69).

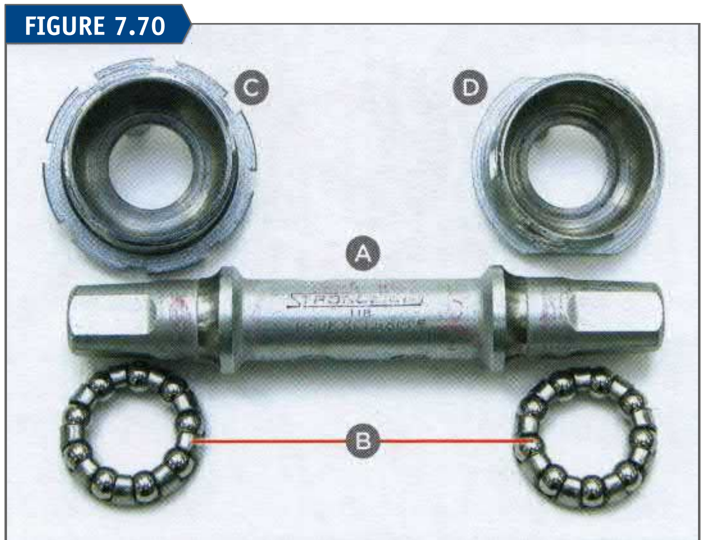
FIGURE 7.69

Use a torque wrench to secure and lock bottom bracket adapter inside frame shell

THREADED ADJUSTABLE BOTTOM BRACKET BEARINGS

Adjustable bottom brackets include some square-spindle bottom brackets and the Shimano® Dura-Ace® 7700 bottom bracket. These bottom brackets may be dismantled and cleaned (figure 7.70). Adjustable-type bearing systems are sometimes referred to as “cup and cone” systems. A convex and a concave bearing race oppose one another, trapping the ball bearings between them. If the adjustment is too tight, there will be too much pressure on the bearing surfaces. The system will “bind” and quickly wear out. If the adjustment is too loose, there will be movement or “play” between the parts. This causes a knocking in the bearing surfaces, and the surfaces will also wear out prematurely.

FIGURE 7.70



“Cup and cone” design of adjustable bottom bracket. (A) Spindle, (B) Bearings, (C) Left side cup and lockring, (D) Right side cup

In adjustable bearing systems the bearing surfaces move on threaded parts. It is normal for threaded parts to have play between the internal and external threads. For example, a bearing cup will wiggle in the shell thread until the lockring is tightened down against the frame. Play in the thread is removed when a locking nut or ring is tightened. When checking bearing adjustments, the lockring must be tight. Play felt after the ring is tight will come from the bearing adjustment, not from thread movement.

The goal for adjustable-type bearings is to have the bearings rotate as freely as possible without any knocking or play. When beginning a bearing adjustment, start with it loose and then proceed to tighten the adjustment in small increments until the play disappears. This ensures the adjustment is as loose as possible but is without play. In most cases, try to make small changes in increments of 1⁄32 of a complete rotation.

Bottom Bracket Removal

When dismantling components, it is a good idea to take written notes of the part’s orientation. Another option is to take digital images before and during the process to help in assembly.

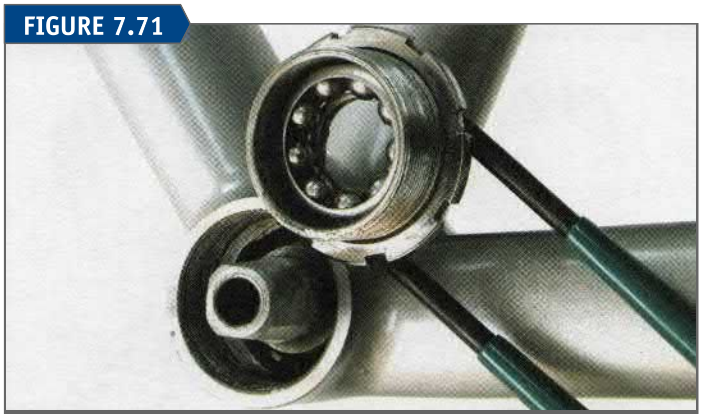
For a bottom bracket spindle, one side of the spindle may be longer than the other side. Note which side was longer or shorter, and reassemble in the same orientation.

If the bottom bracket is being overhauled, it is optional to remove the fixed side (right side) cup. Removal makes inspection and cleaning easier. The cup may remain in the frame. Leaving the cup in place will slow the service slightly.

Procedure for bottom bracket disassembly:

a. Remove cranks.
b. Using a lockring spanner, loosen and remove left side lockring.
c. Use a pin spanner or other appropriate tool and remove adjustable cup from the left side of bike (figure 7.71).
d. Remove bearings and spindle. Note and record if right side or left side of spindle seems longer. Note number of bearings if bearings were not caged.

FIGURE 7.71

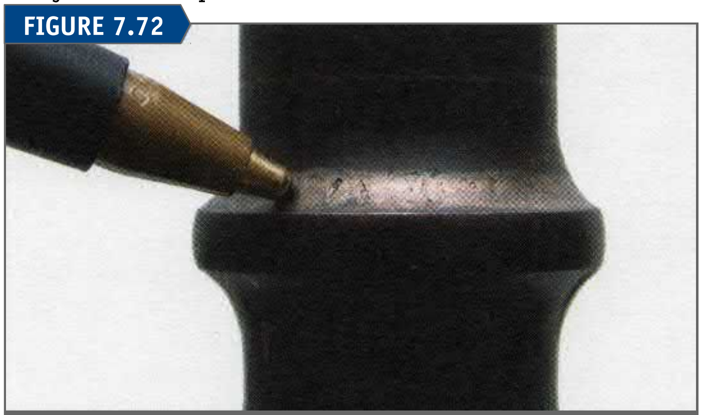


Remove adjustable cup (left side) lockring, bearing cup and bearings

e. Remove any dust sleeve from inside the bottom bracket shell.
f. Reach through shell and remove bearings from inside right side cup. Use a long spoke or other object as necessary.
g. Fixed cups (right side) are commonly left-hand threaded. If removing for service, use a fixed cup spanner and remove clockwise (for the common BSC/ISO threading).
h. Clean all parts in solvent and dry. After cleaning and drying all parts, inspect for wear and damage. View cups and spindle races for pitting and other damage. There will likely be a smooth line worn on both cup and spindle. There should not be holes or gouges in either. Use a ballpoint pen to trace the bearing path (figure 7.72). Roughness and wear will be felt as the ball of the pen passes over worn areas. This roughness will get worse with use. It does not "smooth out" or "break-in" with time.

If the ball bearings have a shiny silver color and are smooth, they can be reused. If the bearings appear discolored, they should be replaced. The ball bearings are generally the last part of the system to wear out. If the bearings are worn, it is likely that the cups and races are also worn.

FIGURE 7.72



Trace bearing surfaces to feel for roughness and pits

Bottom Bracket Installation

Thread preparation is critical in bottom brackets. Use either grease or anti-seize for cups. Fixed cups (right-side) may also use mild threadlockers rather than lubrication. The common bearing size for square-spindle adjustable bottom brackets is ¼ inch.

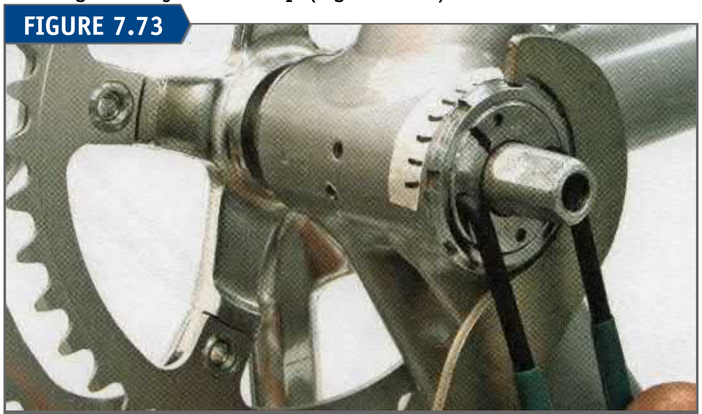
Procedure for bottom bracket installation:

a. Prepare threads using grease or anti-seize compound. Right side (drive side) cup may use a threadlocker as an option.
b. If removed, install fixed cup (right side). Even if fixed cup was not removed, check for cup tightness. For ISO/English threading, turn counter-clockwise. Secure to a minimum of 360 inch-pounds.
c. Heavily grease bearing cages. Press grease into cage and between bearings.
d. Refer to notes from disassembly and place bearing retainer on fixed cup side (right side) of spindle. Place the open side of cage against the cone-shape of the spindle. Install spindle through shell and into fixed cup.
e. Install any dust sleeve.
f. Heavily grease second bearing cage and install into adjustable cup (left side). Place the open side of the cage towards cone-shape of the spindle.
g. Thread adjustable cup (left side) into place.
h. Install but do not tighten lockring onto adjustable cup.

Bottom Bracket Adjustment

Rotating bearings should be adjusted to be as loose a possible, but without play or knocking. To ensure you are making adjustments in small increments, use a piece of tape as a reference. Use about 2 inches of masking tape and make pen marks on one edge every ⅛ inch (3 mm). Stick the tape on the left side of the bottom bracket shell so the marks face outward. These will be reference marks when adjusting the bearings and represent the small increments used when turning the adjustable cup (figure 7.73).

FIGURE 7.73



Use a sticker for reference marks when making small adjustments to the bearing cup

If bottom bracket bearing surfaces are worn out, it will not be possible to have a smooth adjustment with no play. Worn bottom bracket parts will need to be replaced.

The adjustment procedure below assumes the fixed cup (right side) is fully secure. If the bottom bracket was not disassembled, it is still important to test that it is secure. Remove cranks and loosen left side cup by turning counter-clockwise ½ turn. Hold spanner firmly to right side cup and check its security by tightening counter-clockwise. If cup seems tight, trust that it is tight.

Procedure for bottom bracket bearing adjustment:

a. Reinstall right crank only and tighten fully. Arm will be used as a lever to check for play in adjustment.
b. Gently tighten adjustable cup (left side) clockwise. Turn it just to the point you can feel it bump into the ball bearings.

c. Use marker and make a line on the cup face. Have a look at the reference tape and note which mark aligns with cup reference mark. It is also possible to use a mark already on the cup, such as the first letter of the manufacturer if the cup is stamped.
d. Hold the adjustable cup firmly with the correct spanner. Using the lockring spanner, tighten the lockring fully. Locking typically requires 300 to 360 inch-pounds.
e. Check for knocking in the spindle. Grab end of right crank and push left to right. Repeat this as you rotate the crank all the way around.
f. If there is no play, adjustment may be too tight. Loosen lockring and loosen cup slightly to create play. Secure lockring and check for play.
g. If there is knocking (play), make note of which reference tape mark aligns with the cup mark. Loosen the lockring counter-clockwise. Move the adjustable cup clockwise one mark on the reference tape. Secure the lockring and check for play.
h. Repeat tightening one mark at a time until play disappears, checking for play with the right crank in different positions of rotation. When play is not felt at any rotation, adjustment is finished.
i. Use solvent to remove pen mark from cup or frame.
j. Install left side crank.

CHAINRINGS

Chainrings are toothed sprockets attached to the cranks. Cranks may be designed to accept one, two, or three chainrings. Most models of cranks are designed so the rings are replaceable. The old ring is removed and a new ring is installed. Different rings may also be fitted if the rider desires a different gear ratio. There are less expensive models of cranks that use chainrings permanently mounted to the arm, which means the entire crankset must be replaced if the rings wear out or are damaged.

The part of the crank that attaches to the chainrings is called the "spider." The spider may have three, four, five, or six mounting arms. The chainring mounting holes must match the spider mounting holes in order to fit. As the chainrings turn, the mounting bolts of the spider trace a circle. The diameter of this circle is called the "bolt circle diameter," abbreviated as BCD. New chainrings must match both the number of mounting holes and the bolt circle diameter (figure 7.74).

FIGURE 7.74

Bolt circle diameter of a five-arm crank

FIGURE 7.75

Measure one cord of pentagon by measuring from bolt-to-bolt

If there are four or six arms on the crank, measure the bolt circle diameter using opposing chainring bolts. It is easier to measure edge to edge on the bolts, rather than center to center.

It is difficult to directly measure the BCD of three-arm or five-arm spiders. Measure one "cord," which is one side of the pentagon created by the bolts (figure 7.75). Measure from bolt to adjacent bolt. Multiply this figure by 1.70 (the mathematical constant for pentagons) to get the bolt circle diameter (BCD). For chainrings with three mounting holes, use 1.155.

Table 7.4 below lists the bolt-to-bolt (cord) measurements for the common BCD's for the three-, four-, and five-bolt chainrings.

TABLE 7.4 *Bolt Circle Diameter*

BOLT-TO-BOLT MEASUREMENT	BCD	COMMON USE
Three-Arm Cranks		
74.5 mm	86 mm	3-bolt of FSA® inner and outer
Four-Arm Cranks		
45.3 mm	64 mm	Inner ring of standard MTB triple
53.7 mm	76 mm	SRAM® XX1 chainring
56.6 mm	80 mm	Inner MTB double
62.2 mm	88 mm	Inner/outer XTR® M985 double ring
72.1 mm	102 mm	Middle/outer MTB standard
73.6 mm	104 mm	Middle/outer MTB standard
N/A	110 mm	Shimano® 11-speed Dura-Ace®
84.7 mm	120 mm	Outer, double SRAM®
103.3 mm	146 mm	Outer XTR® M960
Five-Arm Cranks		
34.3 mm	58 mm	Inner ring of compact MTB triple
43.5 mm	74 mm	Inner compact road
53.3 mm	92 mm	Inner triple Shimano®
55.4 mm	94 mm	Middle/outer MTB compact
64.7 mm	110 mm	Middle/outer compact road
76.4 mm	130 mm	Inner/outer standard road
79.5 mm	135 mm	Inner/outer Campagnolo® road
84.6 mm	144 mm	Track

CHAINRING REPLACEMENT

Replaceable chainrings are held to the crank by special fine thread fasteners called chainring bolts. The bolt may use a 5 mm hex, 6 mm hex, or Torx® T30 wrench. Usually, the nut is round, and uses a slot to engage a tool instead of external faces. Use a chainring nut wrench, such as the Park Tool CNW-2, to hold the chainring nut while the bolt is turned (figure 7.76). Chainring bolt threads should be lubricated or treated with a mild thread locker before installing and tightening.

FIGURE 7.76

Use a chainring nut wrench behind the ring to hold nut while turning the bolt in the front

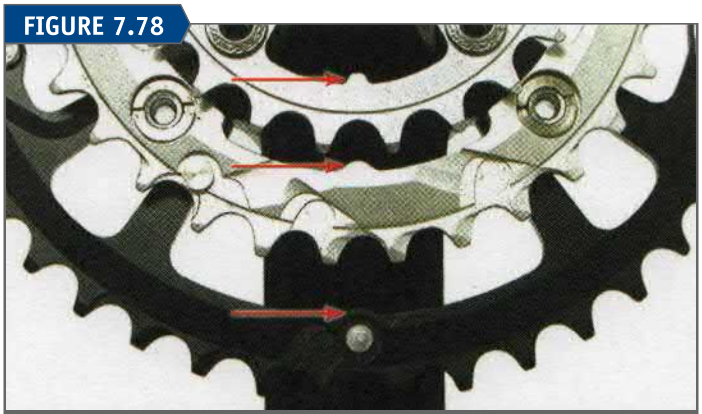
Chainrings can be designed with specially shaped teeth and "shifting ramps" built into the ring (figure 7.77). Shift pegs may be designed into the ring to help lift the ring upward to the large ring. Large chainring teeth may be shortened to allow the chain to disengage and drop inward. Even if two chainrings have the same BCD and same number of teeth, they may not interchange well if one ring lacks these design features.

FIGURE 7.77

Note wear mark as the black anodizing wears off during shift. A) Upshift "pick up pegs" to lift chain to large ring. B) Downshift ramps;

Before removing the old chainrings, pay special attention to how they are oriented on the cranks because there is a left and right side of the rings. Additionally, some chainrings may have specially shaped teeth and shifting ramps to assist shifting. These features assist the shift of the chain and are designed to work within a proprietary system. The chainrings must be correctly aligned on the crank to be timed for the shifting feature to work best. Inspect chainrings before removal, and make a note of the location of special ramps or markings (figure 7.78).

FIGURE 7.78



Inspect for any special marking to indicate chainring orientation relative to crank

CHAINRING WEAR AND DAMAGE

The chainring engages with the chain as it turns. The leading or forward part of the chainring tooth takes the load as the bike is ridden. With use, the teeth wear down, and eventually develops a hooked or shark tooth shape. The chainring teeth will also wear thin. Modern chainrings have special shapes in the rings that act as a "shifting ramp" that picks up the chain during the shift. Shifting performance will suffer as these ramps wear. A worn ring may even skip under the chain when pressure is applied to the pedals. Worn teeth can also grab the chain and pull it upward into the frame, a phenomenon called "chain suck" that jams the chain between chainring and chainstay. Compare old, suspect rings to new ones of the same type (figure 7.79). If there is an obvious difference or if shifting seems to have suffered, replace the chainring.

FIGURE 7.79

An obvious difference between an old ring and new ring

If a tooth bends from impact, it may cause shifting problems. It may be possible to pry it back in line. Use a small adjustable wrench and close the jaws on the bent tooth. Bend the tooth back slowly while checking often so as not to over-correct. Severely bent teeth may break off. However, even if the tooth breaks the ring may still be useable. Ride the bike after the repair and shift back and forth testing the result. If shifting performance is adequate, the ring is useable.

A bent tooth on the largest ring can be directly gripped by a tool while mounted on the spider for alignment. Bent teeth on the middle or smallest rings are difficult to access with a tool. The bent tooth will typically have been bent inward, towards the bottom bracket. It must be bent back to the outside (away from the bottom bracket). The outer ring usually prevents any tool from working on the tooth while mounted. When necessary, remove the ring from the crank for tooth alignment.

To repair a bent tooth, begin by spinning the rings without the chain in place. Locate which tooth appears bent and mark this tooth on the ring. For small or middle rings, remove the ring from the spider. Use a small adjustable wrench to straighten the tooth. Do not grab the ring itself with the tool, just the tooth. Hold the ring firmly below the wrench and bend the tooth slightly back. Compare the bent tooth to straightness of other teeth (figure 7.80). It may be necessary to remount the ring and try shifting. If the tooth makes a noise when pedaling or has other shifting issues, repeat the repair.

FIGURE 7.80

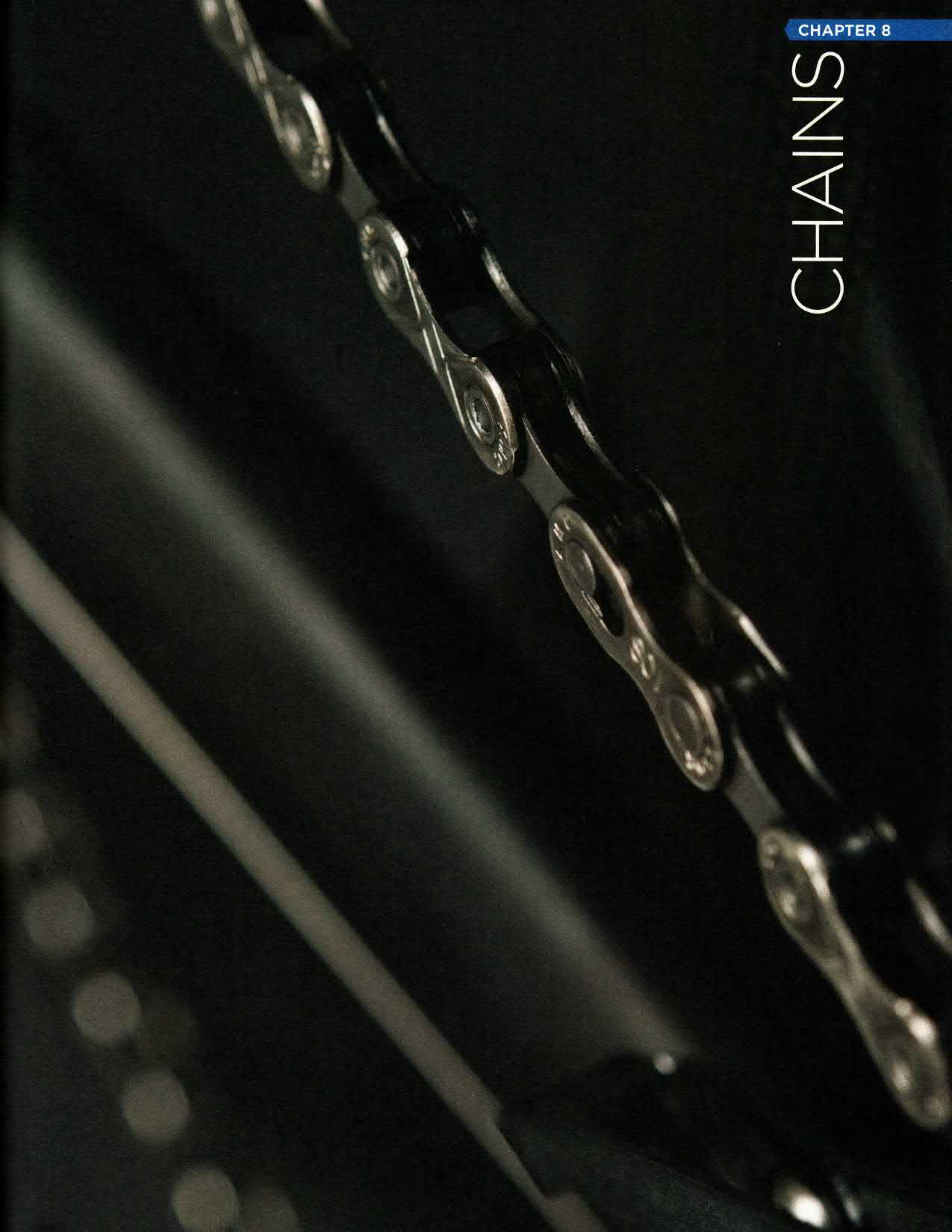
Sight along the chainring to find any bent teeth

If the chainring is bent, it will appear to wobble from side to side as the cranks turn. Impacts from crashing, impacts from shipping damage, or even damage from falling over and striking something may bend the rings. The bend may be in the ring, or it may be in the mounting arm. If the lateral movement is enough to affect derailleur setting, it is sometimes possible to re-bend rings to improve run-out or wobble. Because a loose chainring mounting bolt causes the ring to appear bent, always begin first by checking the security of the chainring mounting bolts. Use the shaft of a long screwdriver as a lever to straighten a bent chainring. Spin the rings without a chain in place and sight the left-to-right movement. Attempt to leverage the bent section. If there is no improvement after three or four attempts, it is best to replace the ring(s).

If an emergency repair is needed during a ride, you might try to impact the ring. Look for sticks or pieces of wood with a blunt end. Use this as a punch and strike the opposite end with a rock. The ring will never be perfect, but it may get you back from the ride. Four-arm spider rings are especially susceptible to bending under hard use. Again, it is best to replace bent rings rather than repair them.

CHAPTER 8

CHAINS



The chain transfers motion from the front chainring(s) to the rear sprocket(s). Chains are made of multiple pairs of steel outer plates and inner plates held together by rivets (figure 8.1). A roller separates each pair of inner plates. The rivet is pressed tightly through both outer plates and pivots freely on the inner plates and roller.

FIGURE 8.1

Component parts of the bicycle chain:
(A) Side plates, (B) Inner plates, (C) Rivet, (D) Rollers

Chains pass between the right seat stay and right chain stay to form a closed loop. Some chains use either a special connection rivet or a "master link" to close the loop. Master links are specially made outer plates that mate together to hold the chain closed. Older-style chains have no master link or special rivet and use any of the original rivets to join the chain. This is a weaker system and is not used for modern derailleur systems.

Drivetrain manufacturers design the derailleurs, rear sprockets, shifters, and chain to work together as a system. Chains vary in plate design, shape, and width. These differences cause variations in shifting performance between brands and models. Chains should be selected to be brand-compatible with the particular shifting system of the bicycle. Contact chain manufacturers for details on compatibility.

Chain specification is designated by width of the roller and by rivet length. Derailleur shifting bikes use rollers of nominally 3/32 inch width. Actual roller measurements vary slightly depending upon the design of the chain and the number of rear sprockets. The 1/8 inch roller chains are used on some one-speed bikes, such as coaster bikes and single-speed freewheel bikes.

Chain width is also determined by rivet length and varies with the number of rear sprockets. The greater the number of rear sprockets, the shorter the rivet tends to be. Approximate widths measured across the rivets are:

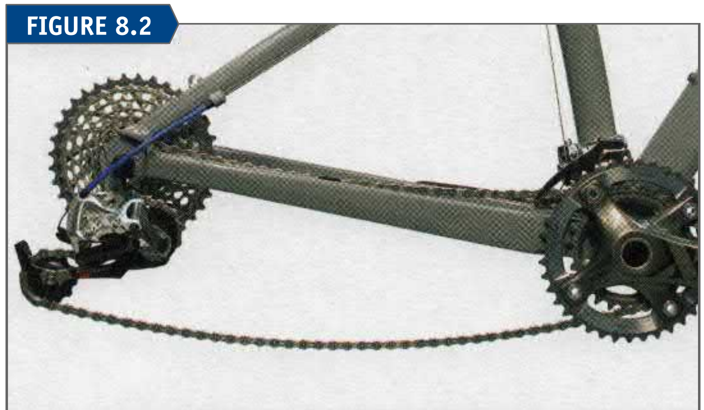
- 11 cogs — 5.5 mm
- 10 cogs — 6 mm
- 9 cogs — 6.5 to 7 mm
- 6, 7, and 8 cogs — 7 mm

The 1/8 inch chains measure approximately 9 mm across the rivet and are designed for use on one wider rear sprocket, not for derailleur shifting on multi-speed cog systems.

CHAIN SIZING FOR DERAILLEUR BIKES

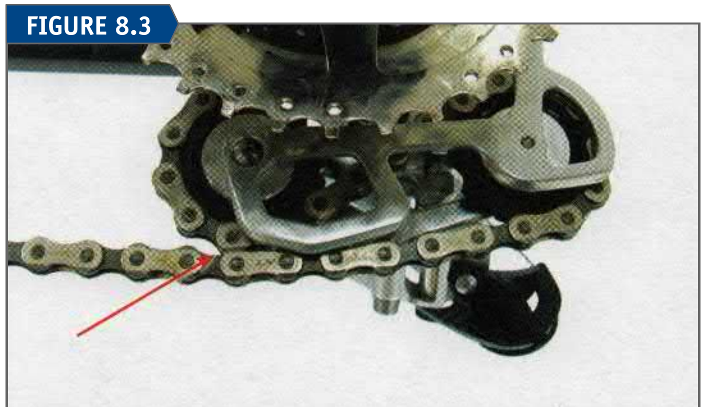
A chain that is too long or too short may cause shifting and riding problems. A chain that is too long will sag between derailleur and chainrings when the bike is in the smallest rear sprocket and smallest front chainring (figure 8.2). The chain may have low tension in this position, but it should not droop or sag very much between the front and rear sprockets.

FIGURE 8.2



Chain sag in the smallest front to smallest rear sprocket position

FIGURE 8.3



Chain contact indicating chain is too long

Another symptom that indicates the chain is too long is the chain contacting itself as it passes by the upper derailleur pulley when the bike is in the smallest rear sprocket and smallest front chainring (figure 8.3).

Conversely, there can be problems when the chain is too short. Diagnose a short chain by shifting to the largest chainring and second-largest rear sprocket. Chain tension will normally be tighter in this position. Inspect chain for a double bend ("S" bend) as it passes through the pulley wheels (figure 8.4). Shift slowly and carefully to largest rear sprocket. If chain appears to jam, it is too short. Even if the chain shifts but loses the double bend at the pulley wheels, it is too short (figure 8.5).

FIGURE 8.4

Double bends at each pulley indicate adequate chain length

FIGURE 8.5

Double bends at pulleys are lost with too short of a chain

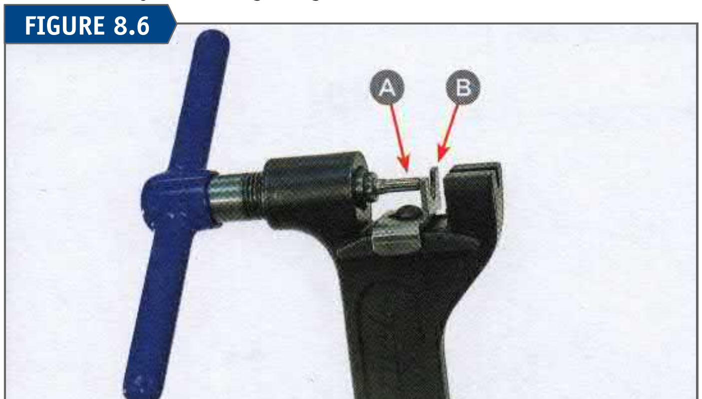
In extreme cases when the chain is too short, trying to shift to the large rear sprocket and largest front chainring combination may damage the derailleur and/or the derailleur hanger.

The rear derailleur cage takes up chain slack as the chain is moved between the various front and rear sprocket combinations. Some bicycles are fitted with sprocket combinations and derailleur models that do not allow the derailleur to wrap up the chain slack in every possible gear combination. The sprocket selections in these cases exceed the "Chain Wrap Capacity" of the derailleur.

If the rear derailleur Chain Wrap Capacity does not match or exceed the sprocket range on the bike, the chain length will appear either too long in the smallest sprocket to smallest chainring combination or too short in the largest sprocket to largest chainring combination. This is seen commonly when a "short cage" derailleur is used on a bike with a wide gear range. When using a derailleur that does not meet the gearing capacity, it will be necessary to avoid certain gear combinations that cause problems in pedaling or shifting. For more discussion of derailleur capacity, see Derailleur Capacity and Maximum Sprocket Size in Chapter 9, Derailleur Systems.

New chains are packaged longer than needed for most bicycles. New chains need to be "cut" (links separated or removed) to fit each bike. To install and size a new chain, a chain tool is required. Chain tools are made up of a driving pin and a system to align and hold the chain-roller (figure 8.6). Some models have two chain alignment prongs (cradles). The primary set of locating prongs support the chain for pressing the chain rivet in and out. The "tight link" prongs are used only for fixing a tight link. The Park Tool CT-4.2 Professional Chain Tool uses a pocket to hold the chain rather than the alignment prong system.

FIGURE 8.6



Park Tool CT-3.2 chain tool (A) driving pin and (B) alignment prongs

The chain is sized to the particular bike and gear combination. If the rear cassettes will be changed for different rides, be sure to size the chain for the largest rear cassette of the different options.

Rear suspension bikes may use designs that move the rear hub and sprocket relative to the bottom bracket as the rear suspension compresses. If the pivot of the suspension moves the rear cog further away from the bottom bracket, size the chain to the longest rear hub to bottom bracket distance. Release shock pressure to fully compress rear suspension.

If a new chain is being installed and the old chain is the correct length, the new chain may be shortened to match. Test the length of the old chain by shifting to both the largest front and rear sprockets and then the smallest front and rear sprockets. If the chain passes both tests it is an acceptable length. Remove the old chain and lay it on a flat surface with the plates aligned vertically. Pull the chain straight. Lay the new chain next to the old chain in the same fashion, with inner plates of both chains at one end. The new chain may not exactly match rivet to rivet toward the end of the chains. Push the links of the old worn chain together to match up with pins or rivets of the new chain. Account for any master link by placing it in one end on the new chain. Locate the matching end rivet on the new chain with the rivet on the old chain and cut the new chain.

The procedure below permits the chain to be shifted to the largest front and rear sprockets. While most cyclists may not use this combination, it should be assumed someone might shift to that combination. A short chain would jam and potentially cause damage in the large front ring to large rear sprocket combination.

Procedure for derailleur chain sizing:

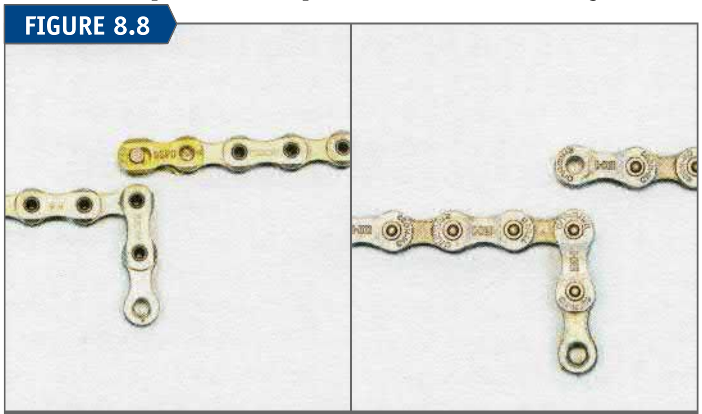
a. With no chain in place, use shift levers to position the front derailleur over the largest chainring and the rear derailleur under the smallest sprocket.
b. Thread the new chain through the front derailleur, but do not thread the chain through the rear derailleur. This is for sizing the chain only and is easier than fighting cage tension. After cutting, the chain is routed through the rear derailleur and joined. For sizing, simply wrap the chain around the largest front chainring and around the largest rear sprocket. For master link chains, install one side of link to simulate full length with master link.

FIGURE 8.7

Wrap chain on largest front and rear sprocket.

c. Pull the chain tight and note the rivet closest to where the two ends could be joined (figure 8.7). Keep in mind a chain can be joined only by mating inner and outer plates. If the selected inner and outer sections will not meet, round up and move to the next closest pair that would be possible to join.
d. From the closest rivet where it could be joined, count over an additional two rivets (figure 8.8). This adds 1 inch to the length to the shortest length from step "c".
e. Cut the chain at this point. Cutting the chain too long will be easier to rectify than cutting it too short. Select the chain side ending with inner plates to cut. See below for the specific brand procedures when installing.

FIGURE 8.8



The left example has one inch added including master link. The right example uses special connecting rivet and also has one inch added

CHAIN SIZING WITH CHAIN RETENTION SYSTEM

Chain retention systems prevent the chain from falling off the front chainrings and are available in single-ring models and double-ring models. The chain passes through pulleys that add to the required chain length. To determine the chain length, route the chain over the largest rear sprocket, the largest front chainring, and through the retention system (figure 8.9). Pull the chain together without routing it through the rear derailleur, as if it were a one-speed, and then add 1 inch additional length as described above.

FIGURE 8.9

Sizing on chain guide with pulley uses the same large-to-large procedure

CHAIN REMOVAL

For modern chains, simply leave the chain installed until it is worn out and then replace it. Removing and reinstalling the chain for frequent cleaning only increases the chance for chain failure. Clean the chain in place on the bike with a chain cleaning system such as the Park Tool CM-5.2 Chain Scrubber.

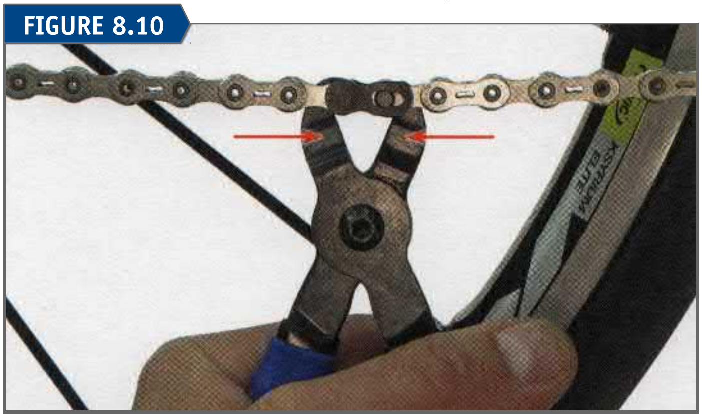
If the chain is not being reused, it may be cut at any rivet and then removed from the bike. However, if removing and reinstalling the same chain with special connection rivets, such as Shimano® and Campagnolo®, do not select a previously installed connecting rivet. Find a rivet some distance from this original rivet and cut at this point.

For chains that reuse the chain rivet, see Chains With Reusable Rivets in this chapter.

Procedure for chain removal:

a. Shift the bike to the smallest sprockets front and rear.
b. Inspect for a master link. If present, rotate cranks until link is in the lower section of chain.
c. When possible, drop chain from front chainrings to remove any chain tension.
d. If master link is present, push both outer plates of master link toward each other. Squeeze plate together between thumb and fingers while sliding link apart. When available, use a master link plier such as the Park Tool MLP-1.2. Engage pliers on rollers and squeeze handles of the MLP-1.2 to disengage link (figure 8.10).
e. If no master link is present, select any rivet that is not a special connection rivet. Non-special rivets will appear the same as adjacent rivets.
f. Install chain roller into alignment prong of chain tool and bring driving pin of chain tool into contact with rivet. For CT-4.3, insert chain into pocket.

FIGURE 8.10



MLP-1.2 Master Link Pliers disengaging master link side plates

FIGURE 8.11

Drive chain rivet from chain

g. Ensure that chain tool pin is driving in a straight line to chain rivet. Turn handle and drive chain rivet from side plates (figure 8.11).
h. Pull chain through front and rear derailleur cages and remove from bike.

NEW CHAIN INSTALLATION ON DERAILLEUR BIKES

It is necessary to route the correctly sized or cut chain through the front derailleur, rear derailleur, and frame before it is joined. It may be useful to have another derailleur bike on hand as an example of chain routing when attempting this procedure.

After cutting chain to size, cut any zip ties from outer side plates. Feed chain through rear derailleur and front derailleur. Join ends together below chain stays. Any special connection rivet (Shimano®, Campagnolo®, FSA®) is installed so the rivet is pushed from the inside outward. In other words, press with the handle of the chain tool closest to the spokes with the drive pin moving to the right, away from the frame (figure 8.12).

FIGURE 8.12

Push connection rivets from the inside toward the outside

The Shimano® recommended procedure is to install the chain so the connection rivet of the outer plate leads the plate onto the lower pulley. In other words, when looking at the chain on the lower loop from the drive side, the connection rivet is on the left hole of the outer plate.

Procedure for installation of correctly sized chain:

a. Shift derailleurs over the smallest front and rear sprockets.
b. Inspect chain side plates. If there is printing, lettering, or a logo on one side only, route the chain so writing faces to the right, away from the frame.
c. Beginning at rear derailleur, pass the chain end with outer plates over the top of the lower rear pulley and in front of the upper pulley.
d. Pull the chain behind the rear sprockets, allowing the wheel to spin to get a section of chain to work with.
e. Pass the chain end forward and between the front derailleur cage plates and down onto the smallest front sprocket.
f. Turn crank slowly to gain more slack.
g. Pull chain ends toward one another and join chain according to type or model of chain. If chain tension is making chain difficult to join, drop chain off chainring and onto bottom bracket.
h. Test chain for tight link and repair as necessary.

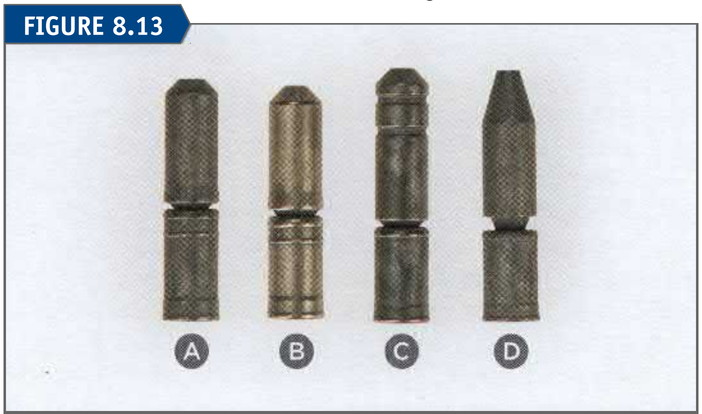
Chain links are joined by different procedures depending upon the manufacturer. The joining process is critical, and a poorly joined chain is the common cause of a broken chain. Consult the manufacturer's literature if in doubt.

SHIMANO® AND FSA® CHAINS WITH CONNECTING RIVET

Shimano® and FSA® chains use a special connecting rivet to install new chains. If the chain is removed and reinstalled, a new connecting rivet must also be used. The connecting rivet has special flaring that is guided in by a long, tapered pilot (figure 8.13). The pilot is snapped off after the rivet is fully installed. Shimano® brand chains should use only the Shimano® connecting rivet. Use the FSA® connecting rivet for the FSA® chains. The Shimano® 7- and 8-speed chains share the same black connecting rivet. The connecting section of the rivet is nominally 7.8 mm (excluding the pilot section). The 9-speed chain uses a silver-colored connecting rivet with a connection section that is nominally 6.7 mm. The 10-speed chains use a rivet with a two machined lines for identification on the pilot. The connection length of the 10-speed connection rivet is nominally 6 mm. The 11-speed chains have a tapered point on the pilot and the connection section is nominally 5.7 mm. These Shimano® connection rivets are not interchangeable.

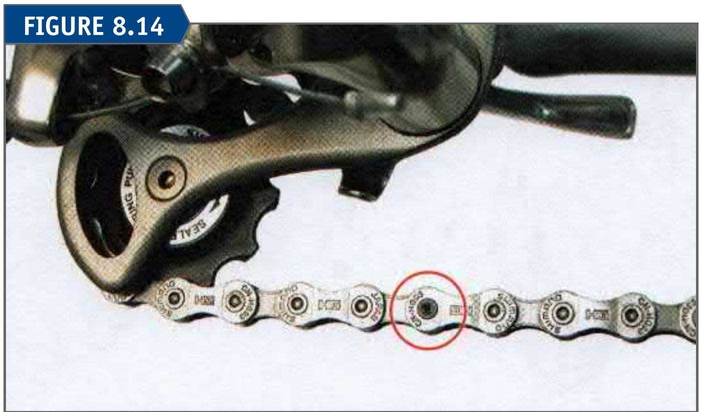
The design of the Shimano® chain and drivetrain requires that the special connecting rivet lead the outer chain plates as it engages the sprockets (figure 8.14). When installing the Shimano® chain, insert the connecting rivet into the left rivet

FIGURE 8.13



Special connecting rivets from Shomano®: (A) 7- or 8-speed chains, (B) 9-speed chain, (C) 10-speed chain, (D) 11-speed chain

FIGURE 8.14



Shimano® connection rivet correctly pressed into leading side of outer plates of an outer plate when viewing the chain between the lower derailleur pulley and lower section of front chain wheel.

The modern rivets for Shimano®, FSA®, Campagnolo®, and other manufacturers may actually leave a ring of rivet material on the chain tool driving pin. Do not allow these rings to stack up on the tool because they may interfere with pressing new rivets. Use pliers to remove the old rings (figure 8.15).

FIGURE 8.15

Remove old remnants of rivets from driving pin of tool

Procedure for Shimano® and FSA® chain installation:

a. Inspect chain side plates. If there is printing or a logo, route chain so writing faces toward the right. There are asymmetrical chains that require mounting in one direction. Any logo or printed letters face outward toward mechanic on the drive side.
b. Lubricate connecting rivet.
c. Install correct Shimano® connecting rivet into chain outer plate away from the mechanic on the drive side. The tapered end enters the left side plate first and holds chain together while connecting rivet is pressed (figure 8.16).
d. Unthread chain tool pin into tool body to make room for special connecting chain rivet in alignment prongs of tool.
e. Place chain roller into alignment prongs of chain tool.
f. Drive connecting rivet into chain (figure 8.17). Continue to drive chain tool pin until head of connection rivet appears to protrude the same as adjacent rivets.
g. Remove the chain from the tool and inspect the rivet. The non-tapered end of connecting rivet should protrude same as any neighboring rivet. Press further with the chain tool pin if necessary.
h. Break off pilot section of connecting rivet. Use groove of CT-3.2 or CT-5 Chain Tool body, or hole in body of CT-4.3 or CT-6.3, and twist pilot sideways (figure 8.18). Pliers can also be used to break pilot. Inspect rivet again and press further if necessary. Rivet should be centered between outer plates.
i. Inspect for tight links and repair as necessary. Rivet should be centered between outer plates.

FIGURE 8.16

Insert connection rivet, tapered end first

FIGURE 8.17

Driving chain rivet from outer side plates of chain

FIGURE 8.18

Break off pilot after connecting rivet is properly pressed

A connection chain rivet is never used or removed to separate the chain. Reusing the same rivet hole wears plate holes and may weaken the chain and cause it to snap during a ride. Use other original rivets for future chain cutting.

CAMPAGNOLO® 10-SPEED CHAIN

Campagnolo® 10-speed chains must be joined by use of their “coupling rivet” system. A new chain is packaged with one of these coupling rivets. New chains out of the package should be sized and cut from the end the chain with inner plates. Do not cut the end of the chain with outer plates.

If a used chain is to be removed from a bike and then reinstalled, it must be joined with the Campagnolo® HD-Link™ system. The HD-Link is seven links (3½ inches) of new chain plus two coupling rivets, one for either end of the HD-Link™ (figure 8.19). When using the HD-Link™, shorten the used chain from the outer plate side by an amount equal to the HD-Link™. The Campagnolo® 10-speed chains do not require the “setting,” or “peening,” process used on the Campagnolo® 11-speed chains.

FIGURE 8.19

Campagnolo® HD-Link and the piloted rivets

Procedure for Campagnolo® 10-speed chain installation:

a. Remove old chain. Cut the chain in a section opposite any other coupling rivets. Pull chain from bike.
b. If reinstalling the original chain, shorten chain by the amount equal to HD-Link™. Remove seven links from side with outer plates.
c. Lubricate coupling rivet(s).
d. Engage the coupling rivet with the pilot pushed into the left side of the chain plate. The coupling rivet will be pushed outward and away from bike. The chain tool handle should be toward the spokes, and the tool pin should drive toward the mechanic and away from the bike's mid plane (figure 8.20). When driving the rivet, inspect to ensure straight alignment between chain tool pin and rivet.
e. After the rivet is fully pressed into position, remove the pilot by pulling it from chain. Pilot does not snap off. It is a simple slip fit onto the rivet. Inspect rivet for centering between outer plates.
f. If reinstalling a used chain with the HD-Link™, repeat process for second rivet.

FIGURE 8.20

Push connecting rivet from the inside toward the outside

CAMPAGNOLO® 11-SPEED CHAIN

Campagnolo® 11-speed chains have very narrow rollers of nominally 2.0 mm width. A typical 10-speed has rollers of approximately 2.1 mm. This small amount makes a difference how the chain sits in a chain tool. Use the Park Tool CT-4.2, CT-4.3, or CT-6.3 for work on Campagnolo® 11-speed chains. Do not use the Park Tool CT-5, CT-6.2, CT-2, CT-3, or CT-3.2.

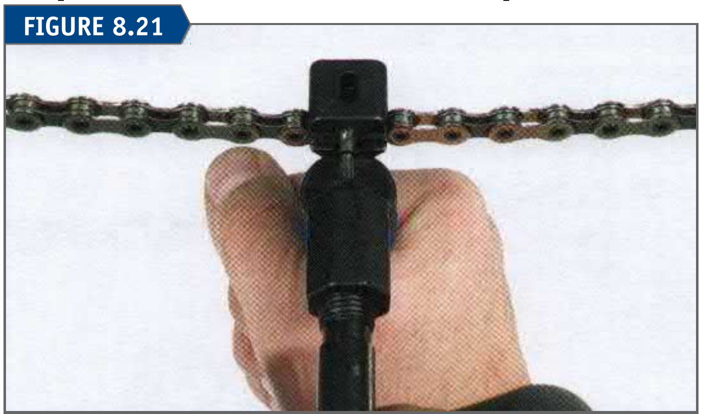
The Campagnolo® 11-speed chains are joined with a special connection rivet called a "coupling pin." This 11-speed coupling rivet is used only once for the life of the chain. If the chain is removed for any reason, the original connection rivet should not be selected to press out.

A new Campagnolo® 11-speed chain will have one end with inner plates, and the other end will have outer plates. Shorten new chains from the end with the inner plates. New chains will have a zip tie in the outer plates as a reminder to shorten from the inner-plate side.

Procedure for Campagnolo® 11-speed chain installation:

a. Lubricate coupling rivet and install the tapered end of rivet into chain plates by hand. Pilot will hold chain together while chain tool drives in rivet.
b. Use the Park Tool CT-4.3, CT-6.3, or appropriate chain tool to drive coupling pin into side plates. Press the coupling pin fully into the chain plates (figure 8.21). The coupling pin has flared sections and these can be felt as you push the pin fully home. Carefully press coupling pin until the head of the pin is flush with the side plate. The pressure on the handle will ease at this point.

FIGURE 8.21



Pressing the 11-speed coupling rivet

c. Unthread the chain tool handle and remove chain from tool. Inspect the rivet for centering in the chain. Head of rivet should appear to protrude as much as adjacent rivets.
d. Snap off the pilot. Use pliers or hole in body of chain tool. Support backside of chain and place the end of tool over the pilot. Twist horizontally either left or right to snap the pilot.
e. Proceed to setting, or peening, process.

Setting or Peening of 11-Speed Coupling Rivet

Campagnolo® requires a secondary operation for the 11-speed coupling pin after it is installed and the pilot is broken off. Only the Campagnolo® 11-speed requires this step. The coupling pin pilot leaves a burr after breaking off. This burr is set or pushed back by a special chain tool against an anvil. Campagnolo® term is "deforming." The purpose is to push on the burr. The rivet should not move relative to the side plates. This is sometimes called peening, even though there is no change in the rivet diameter. The Park Tool CT-4.3, CT-6.3, CT-11, or similar tool can perform this secondary process.

The CT-4.3, CT-6.3, and CT-11 offer an anvil for pressing the coupling rivet. The CT-4.3 uses an anvil stud that is stored in handle of the tool. The anvil stud fits into the chain link pocket to provide support for the coupling rivet. The coupling rivet rests against the anvil stud as the driving pin of the tool drives the broken pilot into the rivet (figure 8.22). The CT-6.3 uses a swinging lever that drops into the tool slot to act as an anvil stop (figure 8.23). The anvil features of these tools take the pressure on the driving pin so that only the rivet is feeling the pressure from setting the rivet. The rivet will not move in this process.

FIGURE 8.22

The CT-4.3 anvil stud in place for the process of setting coupling rivet

FIGURE 8.23

CT-6.3 used to set the Campagnolo 11-speed coupling pin

Procedure for setting Campagnolo® 11-speed coupling rivet:

a. Install chain at coupling pin into the anvil feature of CT-11, CT-4.3, or CT-6.3. Driving pin of chain tool should face broken end of coupling rivet.
b. Turn handle of tool until driving pin just contacts coupling rivet (figure 8.23). From this point, turn handle no more then ¼ turn clockwise.
c. Remove chain from tool and inspect for tight link.

CHAINS WITH MASTER LINK

Several chain manufacturers such as SRAM®, KMC®, Wipperman®, and others offer a master link to join the chain, which allows the end of the chain to be joined without a special connecting rivet. Be sure to read the manufacturer's specific directions. Typically, the bicycle chain ends must have inner plates on each end before joining. Neither chain end will present outer plates. The master link comes as two outer plates joined by a rivet, which then snaps together. Install one piece of the master link through one end of the chain. Install the second piece through the other end of the chain but facing the opposite direction (figure 8.24). Engage the two pieces so link rivet mates to link plate hole. Pull chain to lock the link. To fully lock chain, move link to top section

FIGURE 8.24

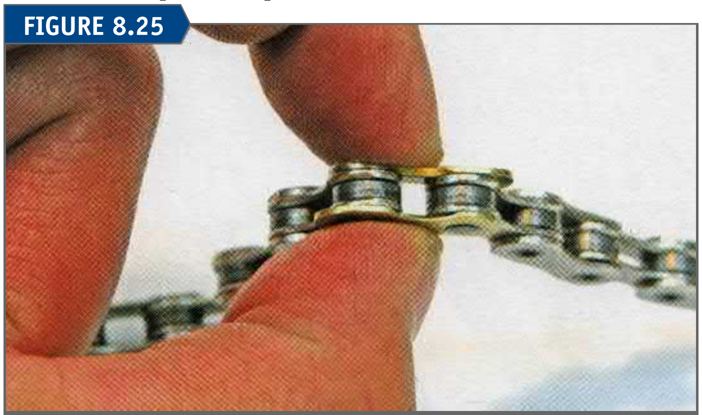
Common derailleur chain master link

between rear sprockets and front chainrings. Hold wheel and press on pedals to lock link. Inspect link to ensure that it is fully engaged.

Some brands of master links are reusable, while others must be replaced after each removal. Use a chain tool on the rivet of a non-removable master link and push it through the outer plate. This will destroy the link. Install a new master link when installing the chain.

For reusable master links, drop the chain off the front rings to relax tension. Squeeze the outer plates together. Push one plate forward and one plate backward. This will disengage the two outer plates. Pull plates sideways and remove the master link pieces from the chain (figure 8.25). Use of the Park Tool MLP-1.2 will speed the process.

FIGURE 8.25



Push plates of removable master links to disengage

CHAIN WITH REUSABLE RIVETS

There are some brands and models of chains that are serviced by partially pressing out a rivet for the outer plate, then re-pressing the same rivet to rejoin the chain. Generally, these tend to be only older style for the wider chains use on 5, 6, or 7 rear sprocket sets, or for two-sprocket bikes. Check the manufacturer's literature when in doubt.

Procedure for removal of chain with reusable rivets:

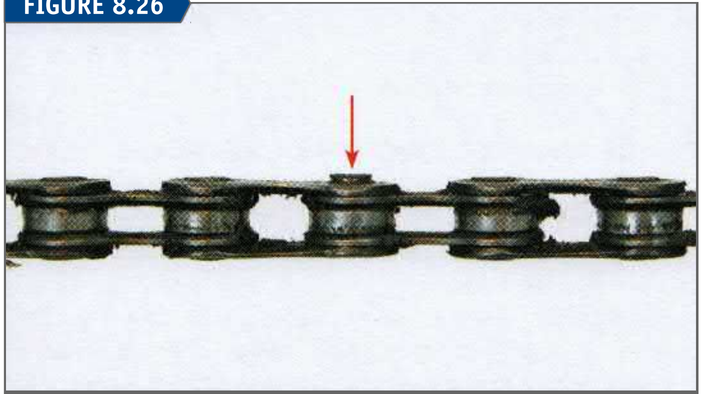
a. Place the chain in the chain tool.
b. Drive chain tool pin until it contacts chain rivet.
c. For most brand chain tools, turn handle five complete turns (four complete turns for the Park Tool CT-3 and CT-3.2). Use care not to drive out chain rivet.
d. Turn handle counter-clockwise to back out chain tool pin from chain. Lift chain out of the tool.

e. Grab chain on either side of protruding rivet. Flex chain toward the protruding chain rivet and pull on chain to separate.
f. If chain does not easily separate, place chain back into chain tool, press rivet slightly, and attempt to pull chain apart as in step "e."

Procedure for installation of chain with reusable rivets:

a. Reinstall chain on bike with protruding rivet facing toward mechanic.
b. Open empty outer plates slightly and insert inner plates. Push inner plates until hole aligns with chain rivet.
c. Back the chain tool pin into tool body to make room for chain rivet.
d. Place roller into alignment prongs with chain rivet facing chain tool pin.
e. Drive chain rivet back into chain. Take care to center rivet exactly between both outer plates. If more chain rivet appears on one side of outer plate than other, push rivet until it is evenly spaced (figure 8.26).
f. Inspect for tight links and repair as necessary.

FIGURE 8.26



This rivet is not centered between outer plates and will likely fail under use

TIGHT LINK REPAIR

A tight link occurs when a chain does not pass smoothly through the bends of the rear derailleur. The inner plates and outer plates do not pivot freely around the rivet and feel "tight" when the chain bends. This may be from a lack of lubrication at the offending link or the result of improper chain installation. If the two outer chain plates are pushed tightly against the inner chain plates, the link will tend to hop and skip at the derailleur. If the pressure on the inner plates can be removed, the tight link can be fixed.

To locate a tight link, put the chain in the smallest rear sprocket in back and on the middle ring of a triple crankset or the smallest ring of a double crankset. This relieves tension on the chain and allows problem links to show up. Backpedal slowly by hand and watch chain as it passes through the two pulley wheels of the rear derailleur. Look for popping or jumping of the chain or movement in the derailleur arm. Keep backpedaling slowly. Tight links should show up as they pass by the bends of the lower pulley wheel (figure 8.27).

Physically stressing and flexing the chain laterally typically repairs tight links. Use care not to bend and deform the plates by using too much force. To avoid damaging your chain, practice on a section of scrap chain. Use care when

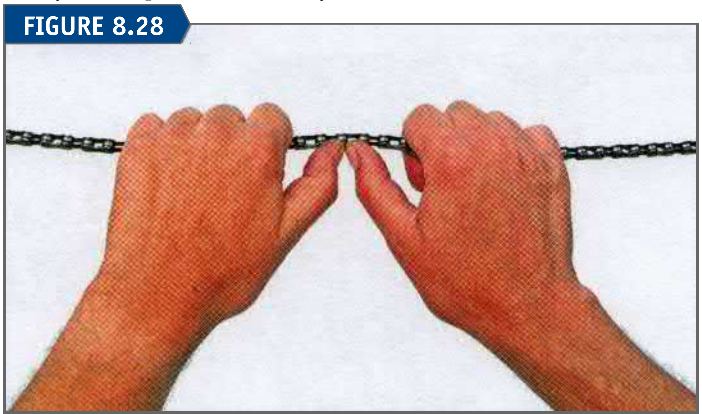
FIGURE 8.27

Watch for jumping or hopping of chain while backpedaling

handling a dirty chain. If this is a problem, use a rag over the chain.

Locate the tight link as described above. Grab either side of chain with your hands, and place both thumbs at the tight rivet. Pull backward with your fingers, while pressing forward with your thumbs to flex the tight link (figure 8.28). Reverse pressure to flex chain the opposite direction. Press forward with your hands while pressing backward with the index fingers centered on tight rivet. Test link to see if it moves freely and repeat if necessary.

FIGURE 8.28



Grab chain and flex laterally at tight link

FIGURE 8.29

Press as little as necessary to spread outer plates of tight link

Some chain tools have a tight link repair system built into the tool. Some very narrow chains may not fit the tight link prongs. Tight link prongs hold an inner chain plate but do not support the outer plate on the far side. The tool pin will drive the rivet and widen the chain at the point of the tight link. To use this feature, engage the tight rivet in the tight link prongs. Turn chain tool handle until the pin just touches rivet of tight link and note the position of the handle (figure 8.29). Turn handle only ⅛ turn clockwise. Remove chain tool and feel tight link. Repeat as necessary, pushing rivet from other side of chain. Inspect chain rivet. Rivet must be centered in chain plates.

CHAIN SIZING AND TENSION ADJUSTMENT: TWO-SPROCKET BICYCLES

Two-sprocket bicycles use a single sprocket, or chainring, at the cranks and a single sprocket at the rear wheel. Two-sprocket bikes include internally-geared hub bikes, one-speed bikes, coaster brake bikes, BMX/Freestyle, and track bikes. These bikes require a shorter chain than derailleur-equipped bicycles.

Typically, two-sprocket bicycles use horizontal dropouts. This allows chain tension to be adjusted by moving the rear sprocket forward or backwards relative to the front sprocket. Dropouts may be either forward or backwards facing (figure 8.30).

Chain length for bikes without a chain tension device is ideally set to allow the hub axle to sit approximately halfway in the dropouts. Similar to derailleur chains, length is changed in increments of 1 inch. As a rule of thumb, if a chain is lengthened or shortened by 1 inch, it will move the rear axle ¼ to ½ inch (6–13 mm) in the rear dropouts.

FIGURE 8.30

Horizontal dropout on a one-speed bike

Procedure for chain sizing with two-sprocket bike:

a. Install rear wheel in the bike. For horizontal dropouts, place the axle all the way forward in the dropout slot. With forward facing dropouts, secure the axle nut so they are fully engaged on dropouts but as far forward as possible.
b. Wrap the chain around the front and rear sprockets. The front sprocket can be used to help hold both ends of the chain while determining chain length, as described in the next steps.
c. Place the chain end on the front ring so the chain end will be on the ring about the two or three o'clock position (figure 8.31). Engage any master link to account for all the links when determining chain length.
d. Pull the chain snug and find the closest rivet on the lower section that would connect to end coming from the upper section. The outer plate must attach to an inner plate.
e. If the appropriate inner and outer plates of the chain ends are too short to meet, add two rivets (1 inch) to the chain length. If appropriate chain ends meet with no chain slack, add 1 inch to chain length. The chain must have enough slack in this position to allow it to be lifted from front ring.

FIGURE 8.31

Use front ring to help hold chain end for chain sizing

f. Make note of the appropriate rivet to use in shortening the chain.
g. Remove the rear wheel and shorten the chain accordingly.
h. With chain correctly routed through frame, join ends of chain.
i. Install wheel and confirm that chain length and chain tension are acceptable.

CHAIN TENSION: TWO-SPROCKET BIKES

Chain tension on two-sprocket bikes should be set tight enough so that it does not come off during use and operates smoothly when pedaled. Bikes without a chain tension idler arm are adjusted by moving the rear hub forward or backward in the dropouts. When checking chain tension, do not touch chain on its inner perimeter. Check tension by touching only the outside loop of the chain to minimize any risk of getting your fingers caught in sprocket teeth.

Procedure for tension adjustment with two-sprocket bike:

a. Install the rear wheel with chain engaged on both rear and front sprockets.
b. Pull wheel back in dropouts and align wheel centered between chain stays.
c. If the bike uses a coaster brake or a band brake, secure the brake arm to the bike frame.
d. Secure axle nuts or quick release.
e. Check tension on chain. Touch only outer perimeter of chain loop. Push the chain downward and upward in the

FIGURE 8.32

Pull up and down at middle of chain to test chain tension middle. There should be approximately ½ inch (12 mm) movement of the chain up and down at a point half way between front and rear sprockets (figure 8.32).

f. To change the tension, loosen the axle nuts and move the wheel forward or backward slightly. Check that rear wheel is centered in frame and re-secure axle nuts.

g. Rotate cranks and inspect the chain tension for any tight or loose positions as the crank arms turn. It is not uncommon for sprockets to be out of round. This will result in the chain being tighter at some points of its rotation. After setting chain tension, pedal the bike in a repair stand and check the tension all the way through the crank rotation. If necessary, readjust so there is only ¼ inch (6 mm) movement at the tightest point.

h. Test for a loose adjustment. Rotate pedals and push sideways on the chain at a point in between the front and rear sprockets. The chain will make a rattling sound, but it should not derail. If the chain comes off either front or rear sprocket, increase tension by moving the wheel further back.

CHAIN TENSION: TWO-SPROCKET BIKES WITH CHAIN TENSION IDLER DEVICE

If the bicycle uses a vertical dropout, it is typically necessary to use an idler wheel as a chain tension device. Vertical dropouts do not permit the adjustments necessary to set chain tension. A chain tensioner is fitted to the derailleur mount and provides a single pulley wheel that will tension the chain (figure 8.33). A common rear derailleur may also be used as a tensioner idler simply by setting the limit screw so the upper pulley is aligned with the single cog.

FIGURE 8.33

Vertical dropout with a chain tension device

The chain tension idler arm is similar to the cage of a derailleur. A spring gives tension to the idler pulley, which will take up chain slack. To determine chain length, wrap the chain over front and rear sprockets, and around the pulley. Pull chain tightly to determine shortest possible length and then add 1 inch (two links) of extra chain. Select link and cut chain accordingly.

CHAIN TENSION: ECCENTRIC BOTTOM BRACKETS ON TANDEM AND SINGLE-SPEEDS

Eccentric bottom bracket designs allow the crank to move forward or backward relative to the rear sprocket to adjust chain tension. They are found on the front cranks of tandems and some single-speed bikes. Eccentric bottom brackets use an oversized shell that houses the bottom bracket bearing unit (figure 8.34). The axle is offset from the center of the shell. The crank will move further away from or closer to the rear axle as the eccentric is rotated around in the frame shell. The eccentric is rotated until there is correct chain tension and then locked into position.

FIGURE 8.34

Eccentric bottom bracket with setscrews binder

There are several systems of locking the eccentric. The frame shell may be split and held secure with a pinch-bolt, similar to stems or seat tube clamping systems. Other designs use a wedge-bolt system, similar to wedge-type quill stems. The bolt tightens and the wedge jams inside the frame shell to hold the eccentric. Another option uses setscrew fittings welded into the shell.

To set chain tension with eccentric systems begin by loosening the binder on the bottom bracket shell. There will commonly be pinholes for a pin spanner such as the Park Tool SPA-1. Rotate the eccentric in the shell and note changes in chain tension. Tension increases when crank is rotated forward. Set tension so there is approximately ½ inch (12 mm) play in chain when pulled up and down between front and rear sprockets.

Tandem Crank Synchronizing

Tandem bicycles connect the front rider ("captain") to the person behind ("stoker") with a single loop of chain. The chain is engaged on the front ring and rear ring such that front and rear cranks are synchronized.

To install a front tandem chain, loosen the eccentric and rotate the bottom bracket so the spindle is closer to the stoker crank, creating slack in the chain. Begin with both of the left side cranks pointing directly down at the six o'clock position. It can help to remove the right side cranks, which allows the left side arms to point downward from their weight.

Pull the connecting chain taut above the front and rear rings. Engage the chain on each ring simultaneously using care not to move cranks. Wrap chain below each ring and join chain at lower section of loop. Chain length is set in one-inch increments. Only inner link and outer link segments of chain may be joined. Pull chain snug to determine which link to cut. Cut the next link 1 inch longer if necessary. Set chain tension with eccentric as described above.

CHAIN WEAR AND DAMAGE

The chain is a critical part of bicycle performance and safety. Chain will tend to fail when under load and stress, which is the worst possible time. The common cause of chain failure is a rivet pulled from an outer plate (figure 8.35). This is typically the result of a poorly installed chain. Inspect chains often. Sight the chain from above and look at each rivet for centering in the side plates. If a rivet sticks out of one side plate more than the other links, the suspect link may fail. Use the chain tool to correct this problem. Also inspect the outer side plates for spreading from the inner plates. Each link should look the same. If a chain becomes jammed during an over shift, it may stress the plates, pulling them apart. This can also result in a twisted link (figure 8.36). Inspect the rollers for any signs of wear (figure 8.37).

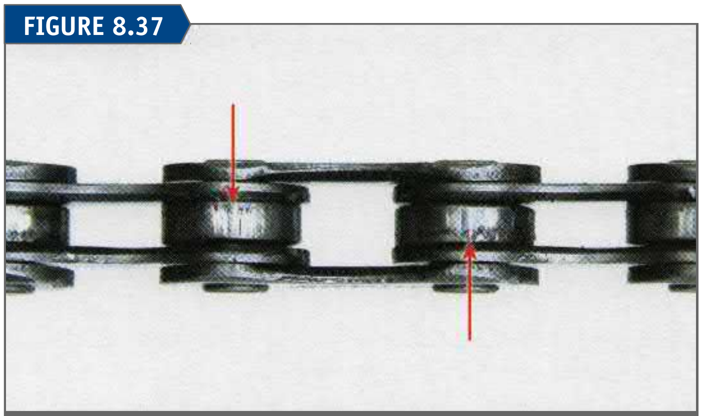
FIGURE 8.35

Damaged side plate. Repair of plate is not possible.

FIGURE 8.36

Any twist in the chain requires complete chain replacement

FIGURE 8.37



Rollers showing signs of wear will require complete chain replacement

As the chain is used, wear develops at the rivet and inner plates where it pivots. The play occurs at each link of the chain. The cumulative effect of wear across many links is that the chain appears to "stretch." However, chain plates do not literally stretch and get longer; the wear is in the joint at each rivet. Reversing the chain or flipping the chain around will not add to chain life, as the rivets will still have the same amount of wear.

Figure 8.38 shows a chain and chainring shown under a forward pedaling pressure. A worn chain rides up the chainring profile and will no longer engage between the sprocket teeth. On a rear cog, the problem is worse because there may be only two or three teeth engaged. A worn chain may then skip over the rear sprocket under pedaling load.

FIGURE 8.38

Left: a new chain fully engaging teeth of sprocket
Right: worn chain not sitting fully on sprocket

Bicycle sprocket teeth are cut to fit chains with ½ inch between each roller and rivet. However, not even brand new bicycle chains measure exactly ½ inch between rivets. A small amount of play must be included for new chains to bend. As the chain is ridden and it wears, play at each link gets greater, and the distance between each rivet increases. Eventually, the chain rollers no longer sit fully down in the sprocket teeth. The rollers ride up the shoulder of the sprocket teeth. The chain then skips over the teeth, especially when extra force is applied to the pedals, such as when climbing or sprinting. Although chain manufacturers vary, most recommend 9- and 10-speed chains be replaced when the chain reaches wear between 0.5% to 0.75% from the nominal ½ inch pitch. Thiswear can be measured with chain measuring tools such as the Park Tool CC-2 or CC-3.2 Chain Wear Indicators (figure 8.39). Replacing worn chains will

FIGURE 8.39

Park Tool CC-3.2 Chain Checker indicating a worn chain help to get more life out the rear sprockets, which tend to be more expensive. However, even with regular chain replacement, the rear cogs will eventually wear out and require replacement.

As the bike is ridden, the entire drivetrain will wear. Generally, it is most economical to replace the cheapest item first in order to extend the overall life of the drivetrain. The cheapest component of the drivetrain (the chainrings, chain, and rear sprocket cluster) is the chain, and it also suffers the most wear. Chains and sprockets often wear out together. If a new chain skips over worn rear or front sprockets, then the sprockets must also be replaced.

CHAIN CLEANING

There are more moving parts in the chain than any other part on the bike. Dirt and grit in the chain will wear on the rivets. Cleaning will add life to the chain and improve performance. Before cleaning the chain, brush clean the derailleur pulley wheels. It may be necessary to scrape the sides with a screwdriver if extremely dirty. Scrape rear sprockets with gear comb, such as the Park Tool GSC-1, or the blade of a thin screwdriver. For thorough cleaning, use a rag and pull a section taut to “floss” between sprockets. Also wipe the chainrings before cleaning the chain if they are extremely dirty.

Chain cleaning tools, such as the Park Tool CM-5.2 Cyclone Chain Scrubber, make cleaning the chain easier. Generally, these systems are boxes that hold solvent and brushes. Passing the chain through the brushes and solvent cleans the chain. Follow manufacturer’s directions for use. Expect some spray of dirt and solvent when using any chain cleaner. Using a diluted soap solution for a second scrub will also help the cleaning process. To protect the floor, place a newspaper or drop cloth under the bike. Used as part of a regular cleaning schedule, these systems can add to the life of the chain (figure 8.40).

If the chain system uses a reusable master link, it can also be removed and cleaned off the bike. Use a sink, pan, or large can. Remove the chain, grab by one end, and fold once in the middle. Lay the chain on a flat surface and coil the chain with loose ends in middle. Place chain in the pan and cover with solvent. Allow it to soak for some time. Use rubber gloves to protect the hands and work with adequate ventilation. Use a stiff bristle brush and scrub the plates on both sides of the chain. Unfold the chain and scrub downward on rollers and between side plates. flip chain and scrub other side the same way. Rinse chain in solvent. Remove it from pan and allow solvent to drip off as much as possible. Wipe with rag and allow to completely dry before lubricating. If available, use compressed air to blow-dry the chain, especially between rollers. Wear safety glasses when using compressed air to blow-dry the chain.

Dispose of old solvent properly. Contact your local hazardous waste agency.

CHAIN LUBRICATION

Chain rivets and link pivots require lubrication. The chain rivet and the narrower pair of chain plates rotate when traveling around a sprocket. Lubrication is required only at the rivet, not all over the outer plates. A drip applicator helps avoid applying too much lubrication, which can attract dirt. Proper lubrication will take time and patience. While lubricating, inspect the chain rollers and rivets.

The type of riding and location best determines the type of chain lubrication. If the user is in a generally wet and humid area with a lot of precipitation, select a thicker lubricant that will adhere to the chain. Very dry areas tend to also be dusty, and a thick, heavy lubricant will result in collecting lots of dirt on the chain. A thin lubricant such as “dry” lubricant would do better in these locations. Riding on gravel bike paths also throws more dirt up on the drivetrain.

To properly lubricate a chain, it is best to begin with a clean chain. In any case, wipe chain off with a rag. Inspect chain for a master link or connecting rivet to act as a reference. Apply a drop of lubricant on each roller and at each side plate at the rivet (figure 8.41). Lubricate each rivet between rear sprockets and front chainring. Turn cranks backwards to advance to the next section of un-lubricated chain. Lubricate this section and advance chain again. Continue until each rivet is lubricated once. Avoid over-lubricating the chain. Turn pedals to allow lubricant to work into pivots. Wipe outside of chain with a rag to remove excess lubricant. Repeat the process when the chain appears dry or begins to squeak.

FIGURE 8.40

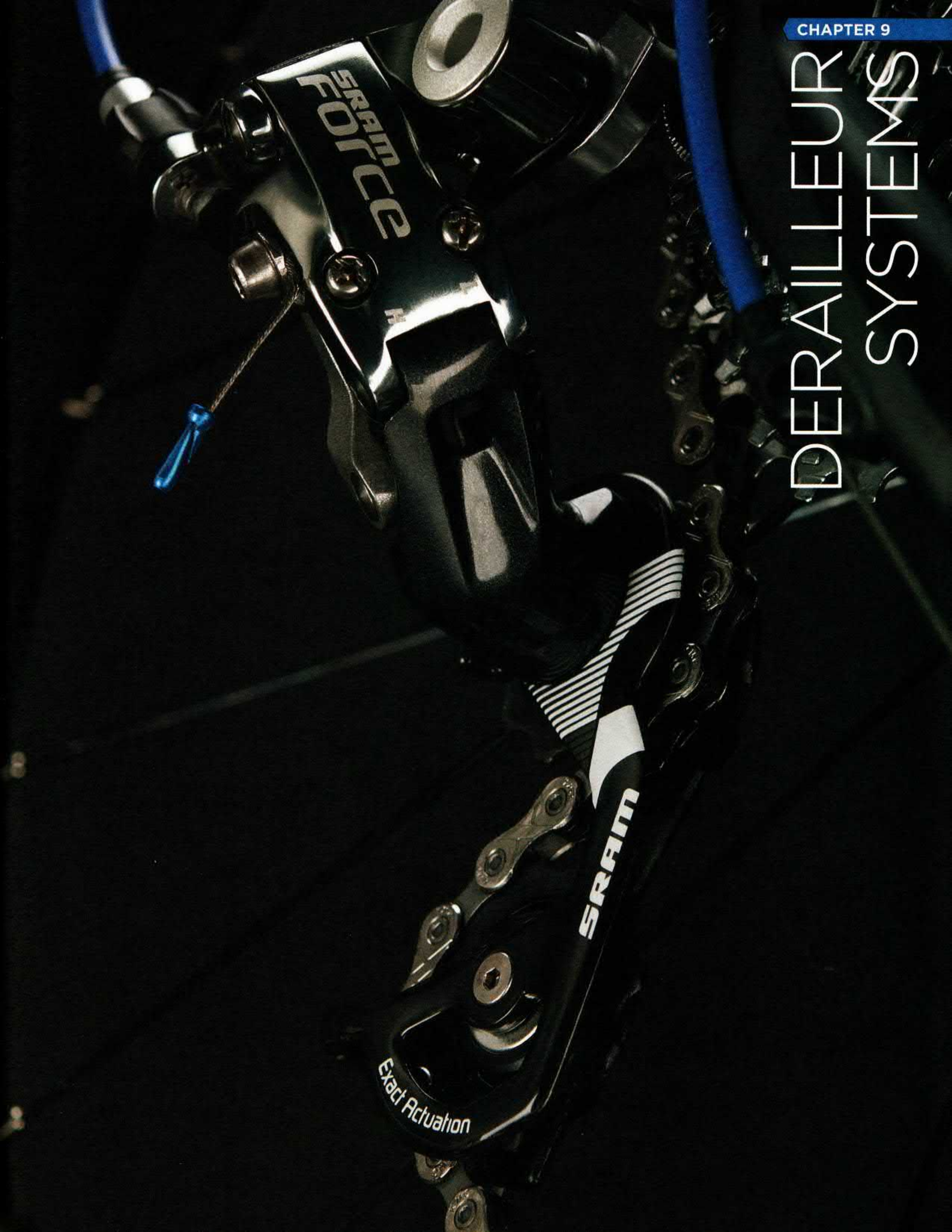
Chain cleaning with chain still on the bike

FIGURE 8.41

Lubricate and inspect chain in the same procedure

CHAPTER 9

DERAILLEUR SYSTEMS



Derailleurs are mechanisms that move the chain from sprocket to sprocket. They allow the cyclist to use different sprocket combinations for low gear ratios for going uphill and high gear ratios for going downhill. A derailleur pushes or "derails" the chain to move it from one sprocket to another. The derailleur system consists of the shift levers, cable housing, derailleur cable, and the derailleur. Some derailleur systems are now electronically controlled and are reviewed at the end of this chapter. All derailleur systems require occasional maintenance, adjustment, and parts replacement.

Some shift levers use a dial showing the cyclist reference numbers for gears. These are arbitrary numbers and do not represent the order of gear ratios in the shifting sequence. For example, the number "6" showing on a lever dial does not mean the sixth gear out of the total number of ratios available. These reference numbers will not be used here. This chapter will use the terms "inner" and "outer" sprockets, as well as "smallest" and "largest" sprocket. The rear cog closest to the spokes is the "innermost" cog, and the smallest cog nearest the rear dropout is the "outermost" cog. For chainrings, largest chainring is the outermost ring, and smallest chainring is also the innermost ring. The "middle" on a triple crankset is the one between the inner and outer rings.

CABLE SYSTEM

The connection between the shift lever and the derailleur is the cable system. The cable system consists of an inner derailleur cable, an outer derailleur housing, and derailleur housing end caps. The housing is the casing that routes the derailleur cable from the shift lever to the frame and then eventually to the derailleur. Motion of the derailleur cable causes the derailleur to move. Dirty, rusty, or worn derailleur cables and housing will not consistently and effectively transfer the shift lever motion to the derailleur because of friction inside the housing.

Derailleur cable housing for index shifting bikes is called "compressionless" derailleur housing. Compressionless housing is stiffer than brake housing and provides better shifting performance, even for non-indexing "friction" shifting systems. The derailleur cable runs inside a plastic liner, which is surrounded by support wires that run longitudinally with the cable (figure 9.1). Compressionless housing is available in a 4 mm or 5 mm outside diameter. There is no effective difference between the two. However, housing end caps must fit snuggly over the housing outside diameter.

FIGURE 9.1

Compressionless derailleur housing with outer plastic cover cut away showing support wires inside

"Braided" or "woven" housing may be used for both brake and derailleur housing (figure 9.2). The outer support wires are woven in a mesh around the liner.

FIGURE 9.2

Braided housing usable for shift or brake housing

FIGURE 9.3

Articulated housing on a rear derailleur

A third housing option is "articulated housing," which uses small metal segments strung together like beads over a liner (figure 9.3). Articulated housing can be effective when tight bends in the housing are required. With articulated housings, there is very little flex along the length of the housing.

Compressionless and woven derailleur housing should be cut with proper bicycle cable cutters. Bicycle cable cutter jaws surround the cut and shear the multiple strands of compressionless housing, woven housing, brake cable, or derailleur cable, causing less fraying. Firmly hold the housing

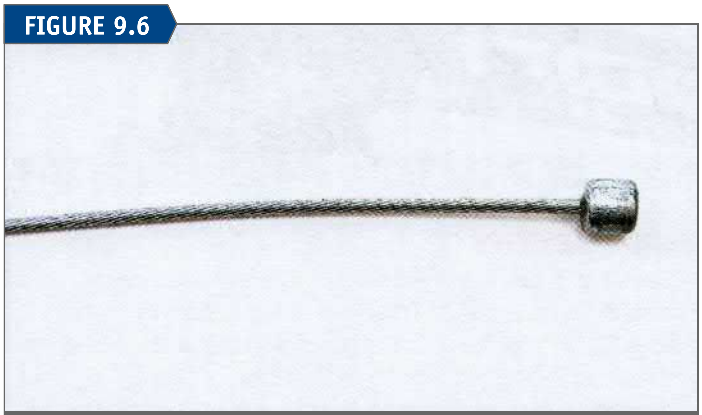
FIGURE 9.4

Hold compressionless housing square to jaws of cable cutter or cable adjacent to cutting point. Hold housing or cable squarely with the cutting jaws and squeeze the handle (figure 9.4). Cutting may slightly deform the housing end. Use the reforming jaws section of the Park Tool CN-10 Professional Cable and Housing Cutter and gently reshape the housing (figure 9.5). If the housing liner is pinched closed, open the liner with a sharp pointed object, such as a seal pick or safety pin.

FIGURE 9.5

Reshape compressionless housing after cutting

FIGURE 9.6



Derailleur cable with head

Common derailleur cable is 1.2 mm in diameter with a small cylindrical head at one end, which is about 4.3 mm in diameter (figure 9.6). However, Campagnolo shift levers use a slightly smaller cable end of 4 mm. Do not use the common 4.3 mm cable end in Campagnolo levers, or the cable end may become stuck in the shifter. The lever moves the cable end carrier, or cable end socket, which pulls on the cable end. High quality derailleur cables have a smooth outer finish to reduce drag in the derailleur housing. Some brands of derailleur cable are coated to help reduce drag and friction. A derailleur cable should never be used as a brake cable.

FIGURE 9.7

Inspect and replace cables with broken wires

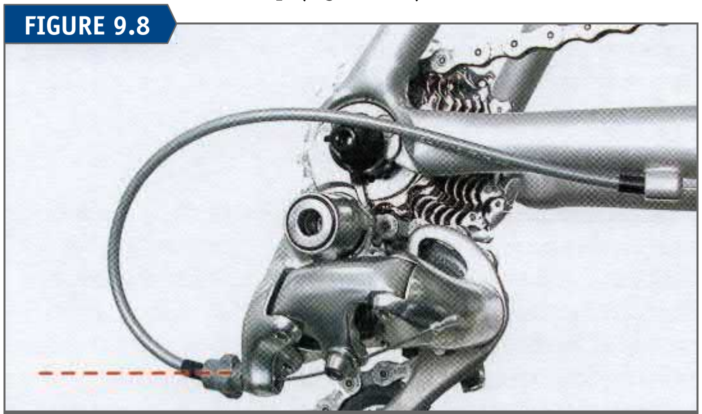
If the derailleur cable is partially cut anywhere from use or damage between the lever and the cable pinch bolt, it should be replaced. Even the failure of a single strand of cable will eventually lead to a cable break (figure 9.7).

CABLE HOUSING LENGTH AND ROUTING

The cable and housing must travel from the front shift levers to the corresponding derailleur. It is useful to look at the previous routing, but do not assume it is correct. Appropriate derailleur housing lengths will help ensure that the bike shifts well. Generally, derailleur housing should be as short as possible yet still approach the derailleur housing stops in the frame, adjusting barrel, shift lever, and derailleur in a straight line. If the housing is too long and forces the cable to pass through excessive housing, it will add friction.

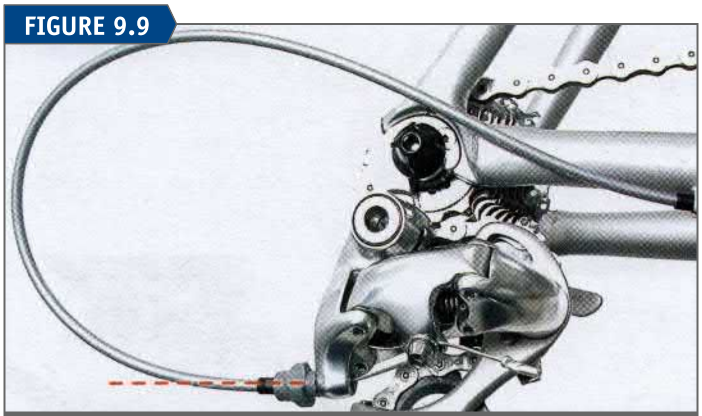
If the housing is too short and creates kinks, it will cause excessive friction. Short housing will also bend or twist the end cap as it sits in the barrel adjuster (figure 9.8). Properly sized housing will enter the derailleur in a straight line and will not bend the end cap (figure 9.9).

FIGURE 9.8



Housing does not enter the barrel adjuster in a straight line, indicating housing is too short

FIGURE 9.9



Housing enters derailleur adjusting barrel without a severe bend

On some bicycles, the front housing loops from the shift levers to the frame may be purposely switched from left to right side housing stops to improve the routing. The left shifter housing is passed to the right side stop and *vice versa*. This is called “crossing-over” (figure 9.10). The derailleur cable must then cross back over in order to arrive at the corresponding derailleur. Crossing-over may in some cases

FIGURE 9.10

Shift housing routed to crossing-over from levers to housing stop. Notice cable must again cross back under down tube.

reduce bends in the housing by creating a straighter line for the housing. This can also help eliminate housing rub on the frame. Crossing-over, however, will not work well on all bikes. If the cable rubs on a frame tube, such as the down tube, or if there are severe bends resulting in other parts of the system, do not cross over. It is both common and acceptable for the derailleur cables to lightly touch when crossing back.

CABLE LUBRICATION

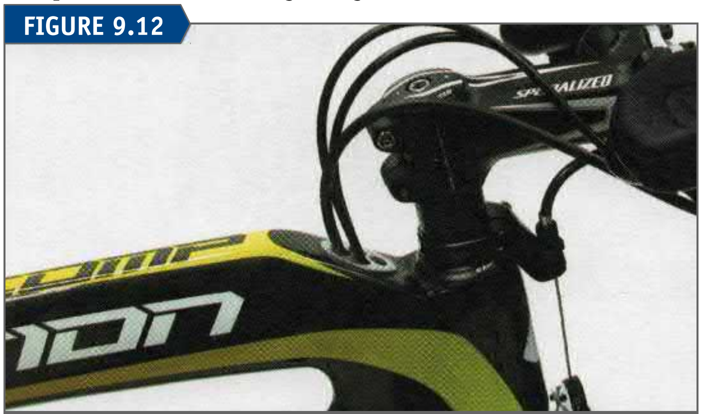
Dirt, corrosion, or rust in the cable systems will cause drag as the cable move through the housing, resulting in poor shifting. Derailleur cables can often be wiped clean and re-lubricated without taking them off the bike. Shift the rear derailleur to the sprocket with the tightest derailleur cable tension. Stop rotating the cranks and release derailleur cable tension by shifting the lever as if shifting to the other extreme sprocket. Do not rotate the cranks. Push the derailleur body to the outside to further release tension for extra slack on the derailleur cable. Pull housing ends from guides and stops (figure 9.11). Wipe derailleur cable clean and apply light lubricant. If wiping does not remove rust, the derailleur cable should be replaced. Push derailleur again to release tension in order to replace the housing in the stops. Rotate the cranks to shift the derailleur. Double-check that the housing is fully inserted into all stops.

FIGURE 9.11

Remove housing from frame stop to clean and lubricate cable

Some bicycle designs route the housing internally through the frame tubing (figure 9.12). Better bike designs use an inner guide to route the derailleur cable and/or housing in and out of the frame. If there is no guide inside, it can be difficult to get the housing through the frame. Feed the housing through one end and then use a stiff wire, such as a spoke, to help catch and guide the housing out the frame hole at the other end. To replace housing that is already in place, feed a derailleur cable into the back end of the housing and out the front. Pull the housing from the frame while leaving the derailleur cable in place to act as a guide when installing the new piece. Feed the derailleur cable into the new housing and push the new housing along the cable into the frame.

FIGURE 9.12



Internal routing for shift and brake housing

SHIFT LEVERS

The derailleur cable head will sit in a socket or carrier in the shift lever. The shift lever moves the carrier or socket and pulls the derailleur cable, which will move the derailleur. Indexing shift levers use a "dwell" system of "clicks" or stops at predetermined positions to align the derailleur pulleys and chain to the sprockets.

Some bicycles use a friction shift lever system where the lever has no preset stops. Cyclists must listen and feel when the derailleur has reached correct alignment under the appropriate sprocket to properly engage the sprocket and prevent excessive chain noise from misalignment.

Shift levers with indexing features must be compatible with the derailleur, cassette, and crankset. The spacing between rear cogs will vary with the number of cogs. As the number of cassette cogs increases, the spacing between cogs narrows, and the shifter must pull the corresponding correct amount of cable. Cog spacing can also vary between different manufacturers. There is no comprehensive table of interchangeable systems. In some cases, it may not be possible to know if different models/brands are compatible until they are installed, adjusted, and test ridden.

Some models of front derailleur shifters allow for "half-clicks" and allow the front derailleur to be "trimmed." This slight movement of the cage is used to prevent rubbing when the chain moves left to right on the rear sprocket combinations. Not all gear combinations are useable even with a trim feature because the chain may rub against the chainrings and not the front derailleur cage. In these cases, simply avoid using that gear combination.

The type and design of shift lever varies with the handlebar or bike it is intended to fit. Flat bars shifters are designed for 22 mm diameter handlebar ends. Road brake/shift levers are designed for the larger 23.5 mm diameter curved drop handlebars.

For shift cable installation and removal, all shift lever models and brands should be set so the cable is in the slackest or most relaxed position. The cable tension will be lowest when the derailleurs are set to the smallest sprockets front and rear. The Shimano® Rapid Rise™ system is an exception to this setting. Setting the rear Rapid Rise™ derailleur to the largest rear sprocket places its cable in the most relaxed position.

FLAT BAR TRIGGER SHIFTERS

Flat bar trigger shifters mount adjacent to the grips. Shimano® produces “dual control” brake/shifter combination sets. If the lever is integrated with the brake, alignment preference should be given to the brake lever. Set levers at approximately a 45-degree downward slope from horizontal using the mounting bolt. Some models of shifters also include a separate shift lever lateral positioning option.

Shimano® has numerous models and generations of trigger-type shifters. There are two common cable installation methods. Inspect the lever and follow a line from the cable housing, looking for a screw head. Shift the lever so the cable is in the most relaxed position with no tension. Remove the screw. Detach cable from derailleur and push the cable head out of the lever (figure 9.13). Install new cable and install screw.

FIGURE 9.13

Shimano® trigger shifter with outboard cable installation

Another Shimano® trigger shifter design involves removing shrouding that covers the cable end. Shift to the most relaxed derailleur cable position and detach the cable from the derailleur. Inspect for small screws on shifter cover. Remove screw(s) and remove cover. The cable end is fitted to a cable end carrier. It may require a small screwdriver to lift the carrier and install the cable end (figure 9.14).

SRAM® trigger shifters use different cable installation ports depending upon model and year. Inspect for a plastic access screw head on the outboard side of the lever. Shift to the most relaxed derailleur cable position and detach cable from derailleur. Remove screw and push cable out. For installation, make sure the small shift lever has been pushed to return cable carrier to the most relaxed position. Feed cable through hole and out barrel adjuster. It can be difficult to find the

FIGURE 9.14

Remove plastic cover to install cable into cable carrier

FIGURE 9.15

Feed cable through sifter aiming for the light

hole for the cable, and it can be helpful to shine a flashlight through the barrel adjuster (figure 9.15). Look for the light source and feed cable accordingly.

The SRAM® trigger shifters such as the current “X” series (X7, X9, X.0, XX and XX1) use a plastic or carbon fiber cover over the cable access hole. It may be difficult or impossible to remove the cable access cover with the shifter in place on the handlebars. These shifter models may be unbolted from clamps or from the brake lever mounts. When necessary, remove the shifter from the bracket to get the cover off and install a new cable.

Inspect the shifter for the type of cover. Some models (X9, X7) use a rubber cover over the cable end. Lift up the end of the cover to expose the cable end (figure 9.16). Feed out and in through this hole. Replace the rubber cover and reinstall the shifter to the handlebar mount.

FIGURE 9.16

Pull up on the rubber cover to expose the cable access hole

For SRAM® trigger shifters using a carbon fiber or plastic plate, again, remove the lever from the handlebar. Inspect for a fastener in the middle of the cover. Remove the nut counter-clockwise relative to the plate. Depending upon the model, use either your fingers or a T10 Torx® wrench to loosen and remove the cover plate screw or nut. The cable end carrier is under shifter return spring or plate. Use a small-tipped screwdriver or seal pick to carefully lift cable end while pushing on cable (figure 9.17).

Installation of the cable is the reverse process. It can help to slightly bend the end of the cable to help feed it through cable carrier. Removing the barrel adjuster provides a large hole for cable to pass. Pull cable into place and check that the spring was not displaced. Reinstall barrel adjuster and reinstall cover plate.

FIGURE 9.17

Removing cable end from SRAM® trigger shifter

TWIST GRIP SHIFTERS

Twist grip shifters mount to flat or upright handlebars. The twist grip body can be rotated around the handlebars. Twist grip shifters mount to the handlebar between the brake levers and a bar grips. Check that shifters do not interfere with brake levers when brake levers are squeezed with maximum force. Look for a setscrew that locks the lever to the handlebars (figure 9.18). Use a hex wrench to loosen the screw and rotate shifter body so cable housing follows a smooth line to the frame stop.

There have been different generations of twist grip shift levers, and installation of the derailleur cable can vary. A common style has an access hole with a plastic or rubber cover. Shift the lever to the most relaxed derailleur cable

FIGURE 9.18

SRAM® twist grip shifter and location of setscrew

position and remove the cover. Detach the derailleur cable from the derailleur and then push the derailleur cable toward the lever. Some models may have a small setscrew over the derailleur cable end. Use a hex wrench to remove this screw. Other models use a small clip to hold the derailleur cable end. Use a small screwdriver to pry back the clip and then push the cable to remove it from the lever (figure 9.19).

FIGURE 9.19

Use small screwdriver to access cable end

The SRAM® XX1 twist grip has a cable access hole below a plastic cover. Shift the derailleur to the smallest sprocket and unbolt the cable from the derailleur. Loosen the brake lever clamp to move the brake lever inwards to allow room for removal of the retaining ring and cover. Use a 3 mm hex wrench to loosen the retaining ring and pull in away from the shifter. Pull the shrouding away from the lever to expose the cable end (figure 9.20). Push the cable from the adjusting barrel side to free the cable end from the lever.

After installing a new cable, reinstall the shrouding. Push retaining ring back into place and secure. Move brake lever back to original position and secure.

FIGURE 9.20

Remove SRAM® XX1 twist grip retaining ring and shrouding to expose cable end

ABOVE-THE-BAR SHIFTERS

The above-the-bar shifters (also called “thumb shifters”) are designed for upright handlebars. Placement should be close to the grip, and the body of the shifter should point downward at a slight angle (figure 9.21).

The derailleur cable is simply fed through a hole in the shift lever and then through the housing to the derailleur.

FIGURE 9.21

Above-the-bar shift lever

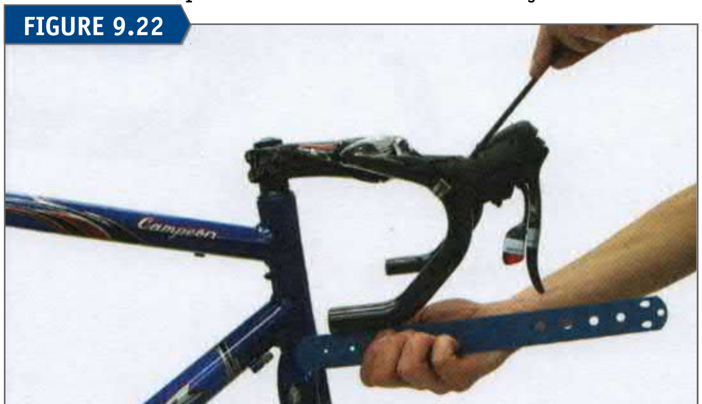
DROP BAR INTEGRAL BRAKE/SHIFT LEVERS

Shimano®, SRAM®, and Campagnolo® drop bar levers combine shifting and braking into the same lever system. Brake lever placement will determine how the shift levers are aligned (figure 9.22).

Shimano® shifters have two different shift cable routing styles. One design routes the shift cable and housing inward from the front of the lever body to the housing stops on the frame. The housing is not run under the handlebar tape but loops in front of the head tube. For this style, feed the cut end of the cable through the socket from the outboard side (figure 9.23). Pull cable fully through until the head engages inside the socket.

Shimano® also uses designs that run the shift housing under the bar tape to the back of the lever body. Pull the

FIGURE 9.22



Align brake/shift levers relative to lower section of drop handlebars

FIGURE 9.23

Feed cable through socket at top of lever

FIGURE 9.24

Cable access hole located under the body

rubber brake lever hood forward to expose the cable entry under the lever body. The cable feeds upward through this hole and exits out the back of the body into the shift housing (figure 9.24).

The Shimano® Dura-Ace® ST-9000 is a mechanical 11-speed shift/brake lever. A plastic cover on the inboard side of the lever covers the cable entrance. Pull the brake lever hood forward to expose the cable access cover. Pull the housing from the lever and remove the inboard cable cover by pulling the exposed cable inward and forward (figure 9.25). Push the cable from the inboard side outward. The cable end must exit from the larger opening out the outboard side. Pull on the cable end to remove.

As with all shifters, to install a new cable the lever must be in the smallest sprocket position. Pull back on the lever

FIGURE 9.25

Use cable to pull open cable access cover

FIGURE 9.26

Installing the cable on the BR-9000 lever. Cable end is bent down to engage cable carrier.

hood to expose the cable entrance on the outboard side of the body. If still in place, remove the plastic cover on the inboard side of the lever. Feed the cable end through the upper hole and in straight line through the lever body (figure 9.26). The cable head is bent downward to fit through the larger hole in the access slot into the cable carrier.

Campagnolo®

For Campagnolo® Ergopower® levers, pull the rubber lever hood forward to expose the cable anchor under the lever body. Feed derailleur cable upward through anchor and out the top of the lever (figure 9.27). Housing and end cap enter lever from the top and run underneath the handlebar tape.

FIGURE 9.27

Cable access is under lever body

For SRAM® Double Tap levers, the cables install from the inside face of the lever body. Pull cover back on lower portion of lever to expose wire access hole. The wire must make a relatively quick 90-degree turn from entering horizontal to exiting vertical. It can be useful to give the cable a slight curve by bending it (figure 9.28). It is best to use new shift wires or to solder the end of used wires. Freshly cut wires may have difficulty making the bend.

FIGURE 9.28

Cable access hole is on the inside of lever body, and the cable exit hole is on upper side

DOWN TUBE SHIFTERS

Down tube shifters are mounted on the down tube and were once common on road bikes (figure 9.29). The frame will have a fitting for the levers. There is no positioning adjustment for these levers. The cut end of derailleur cable is fed through a hole in the lever and is routed down below the bottom bracket to the appropriate derailleur.

FIGURE 9.29

Typical down tube shifters

BAR END SHIFTERS

Bar end shifters are fitted into the ends of drop style handlebars or to the end of "aero" handlebars (figure 9.30). These levers secure inside the ends of the bars in place of end caps. The derailleur housing is then routed along the handlebar underneath the bar tape or, in some cases, through the bar itself. The derailleur cable is fed through a hole in the lever and through the housing.

FIGURE 9.30

Bar end shifter on aero handlebar set

FRONT DERAILLEUR

The front derailleur uses a cage surrounding the chain to shove it off one front chainring and onto another. A derailleur cable pulls the derailleur linkage to move the cage left to right across the chainrings. A spring in the derailleur linkage returns the cage when the derailleur cable is relaxed. A properly adjusted front derailleur should shift the chain between all front chainrings but should not throw the chain off the chainrings. The basic adjustments for the front derailleur are the height, rotation, limit screw settings, and index setting.

There are several possible systems to mount the front derailleur to the frame. The common system is a clamp that is sized for the seat tube diameter. Clamp sizes are available in 28.6 mm, 31.8 mm, and 35 mm diameters. Some derailleur models are sized for large tubing and use shims to accommodate smaller sized seat tubes.

The Shimano® "E-plate" front derailleur models use a plate that mounts over the bottom bracket shell and is held by threaded bottom bracket adaptors or by threaded fitting at the shell (figure 9.31). The derailleur is fixed in both height

FIGURE 9.31

E-plate front derailleur

and rotation settings. The only adjustment is with limit screw settings. The E-plate must be used with compatible chainring spacing, chainring sizes, and chainline.

The Shimano® FD-9000 front derailleur has special adjustment procedures and is reviewed later in this chapter.

A common road bike mounting system is referred to as a "braze-on." A concave bracket is mounted to the seat tube and allows limited height and rotational settings. This may be welded ("brazed") to steel frames but is riveted, bolted, or glued to aluminum or carbon fiber tubing. The braze-on compatible front derailleur body is made with a convex radius to fit the concave braze-on. Clamp-on brackets with the braze-on fitting are available for seat tubes without braze-on mounts (figure 9.32).

FIGURE 9.32

Clamp-on adapter for a "braze on" type front derailleur

The "direct mount" system is a MTB mounting system similar to the road bike braze-on. The derailleur bolts directly to a special fitting on the seat tube (figure 9.33). Height adjustment is possible on this system, but there is typically no allowance to adjust the rotational position of the direct mounts. It is assumed the frame manufacturer has determined acceptable derailleur rotation.

The front derailleur design will vary with the crank style used. Common mountain bike triple cranksets have a wide spread of chainring sizes and use a cage with a relatively wide inner plate. This type of derailleur is called a "deep cage" derailleur. Road bikes tend to have two front chainrings that are relatively closer together is size and do not require a wide plate. These derailleurs are called "shallow cage" derailleurs (figure 9.34). Consult a professional mechanic for the correct design for your bike.

FIGURE 9.33

Checking a direct mount derailleur height using a 2.5mm hex wrench. A single bolt permits height changes (A).

FIGURE 9.34

Top: shallow cage derailleur; Bottom: deep cage derailleur

Most modern front derailleur cages are moved by a parallelogram in a linkage system that allows the sides of the cage to remain parallel to the chainring as it moves laterally. There are two basic linkage designs: the "top swing" and the "bottom swing." Top swing and bottom swing derailleurs differ in placement of the parallelogram in relation to the derailleur clamp or bracket attachment to the frame.

FIGURE 9.35

Bottom swing design with bottom cable pull

FIGURE 9.36

Top swing design with bottom cable pull

FIGURE 9.37

Bottom swing design with top cable pull

FIGURE 9.38

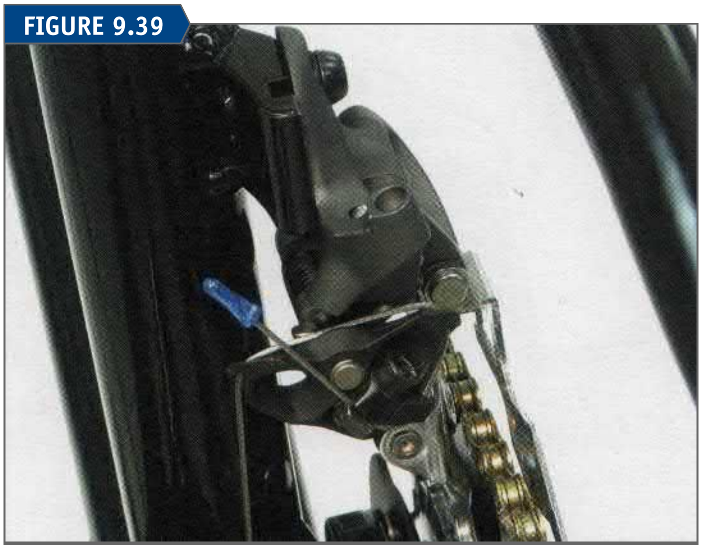
Top swing design with top cable pull

Top swing derailleurs attach with the parallelogram swinging above the frame clamp or bracket (figures 9.36 and 9.38). Top swing derailleur clamps will end up lower on the seat tube as compared to bottom swing derailleurs. Some bike frames will only allow the mounting of a top swing derailleur because of a water bottle fitting or suspension fittings on the seat tube.

Bottom swing derailleurs are designed so the parallelogram attaches and swings below the clamp (figures 9.35 and 9.37). The clamp will end up higher on the seat tube as compared to a top swing derailleur.

The derailleur cable pulls the linkage of the front derailleur. The cable may come up from the bottom bracket. These models are described as bottom pull, as their linkages are pulled from the bottom (figures 9.35 and 9.36). If the cable comes down the seat tube, it is referred to as a top pull derailleur (figures 9.37 and 9.38). There are also models that will function with either the cable pulling from the top or pulling from the bottom (figure 9.39).

FIGURE 9.39



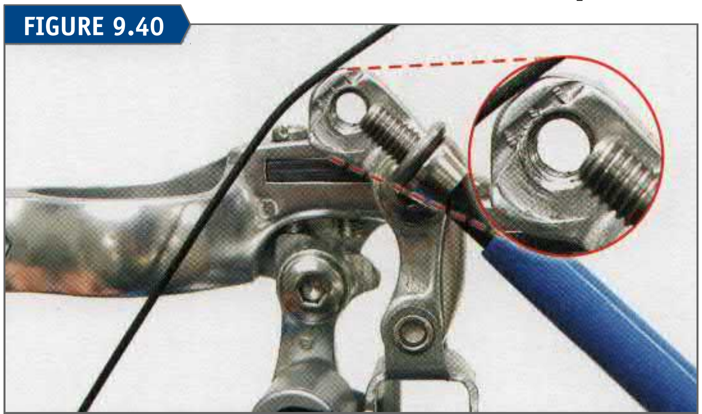
Front derailleur design allowing for either top or bottom cable pull

DERAILLEUR CABLE ATTACHMENT

The derailleur cable attaches to the front derailleur at the fixing or pinch bolt mechanism. Unthread the bolt and look for a groove in either the fixing washer or derailleur arm. The derailleur cable will lay in this notch (figure 9.40). Inspect the mechanism and keep the cable aligned with the groove. There may also be a tab on the washer used to prevent it from rotating.

While the fixing bolt is loose, lubricate the threads. Pull the derailleur cable snug and secure the bolt. The typical torque for the pinch bolt is approximately 4 Nm (35 inch-pounds). The derailleur cable should be flattened where it is pinched.

FIGURE 9.40



Derailleur cable routing is through groove under cable fixing washer

HEIGHT ADJUSTMENT

If the derailleur cage is too far above the large chainring, it will shift poorly. If the derailleur is too low, it may scrape against the chainrings and jam the chain when shifting. The proper height can be set with or without the derailleur cable attached. Derailleurs mounted to “E-plates” or direct mount systems normally do not allow height adjustment.

Procedure for front derailleur height adjustment:

a. Pull front derailleur cage plate until it is directly over outer chainring teeth. Either use the cable or pull directly on the cage.

FIGURE 9.41

Set height for 1-2mm clearance at closest point between cage and teeth

b. The gap between the teeth of the outer chainring and the lower edge of the outer cage plate should be 1–2 mm or about the thickness of a U.S. penny. Using the penny as a feeler gauge, fit it between the chainring teeth and the cage plate. It should just barely fit (figure 9.41).
c. Inspect angle of outer derailleur cage relative to the chainring. Cage plate should be approximately parallel to ring at this time.
d. To change cage height in most front derailleurs, release derailleur cable tension completely by shifting to the innermost chainring. Any cable tension will pull the derailleur downward and make height difficult to set.
e. Front derailleur clamps typically leave a mark on the frame, which is useful as a reference when changing height. Loosen the derailleur mounting bolt and change derailleur height. Use care to keep cage parallel to chainring. Tighten mounting bolt. Move the outer cage plate over outer chainring and check height again.
f. Repeat process until cage plate height is 1–2 mm above outer chainring. For triple chainring bikes, inspect that the inner derailleur cage plate is not striking the middle ring. It may be necessary to raise the derailleur above the 1–2 mm height recommendation.

If the derailleur cannot be set to an acceptable height, it may be incompatible with the front chainring sizing. Additionally, the frame may not permit an ideal setting, or there may be a chain guard that prevents a lower setting (figure 9.42).

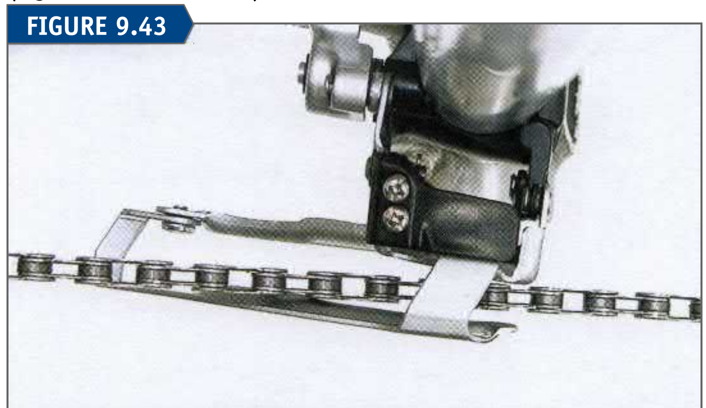
FIGURE 9.42

This chain guard prevents a lower cage height

ROTATIONAL ADJUSTMENT

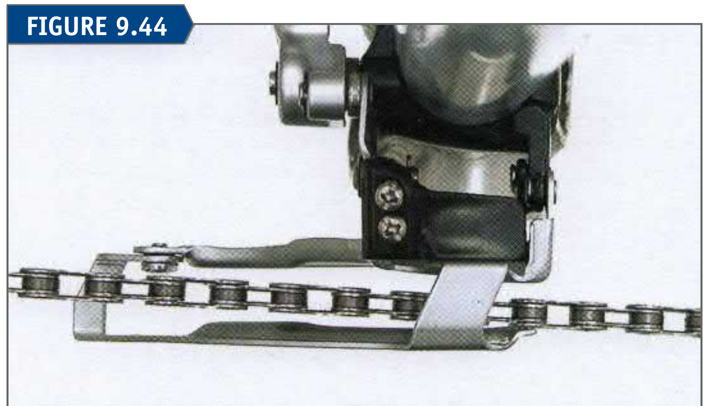
Generally, the front derailleur cage should be aligned parallel to the chain. Because the chain angle moves when the rear derailleur is shifted left and right, use the outermost (smallest) rear sprocket when checking the cage rotation. If the derailleur cage is rotated too far from parallel it may shift poorly or rub on the chain after the shift is completed. Keeping the cage and chain parallel will minimize the risk of the chain jumping off the outermost chainring. If the cage is not parallel, there will be a relatively large gap at either the back or the front end of the cage. Then the derailleur may over-shift the chain past the chainring (figures 9.43 and 9.44).

FIGURE 9.43



Derailleur cage is rotated too far clockwise. Notice rear end of cage is inward, toward bike mid plane.

FIGURE 9.44



Derailleur cage is rotated too far counter-clockwise. Notice rear end of cage is outward relative to the chain and bike mid plane.

Clamp mounted and braze-on mounted derailleurs permit a rotational adjustment. However, the E-plate or direct mounted derailleurs do not permit a rotational adjustment.

The derailleur should be moved to the largest chainring when inspecting rotation. The cable may be attached to allow the cage to be pulled over for inspection. However, to adjust the rotation it is necessary to loosen the clamp bolt. A cable pulling on the cage may change the height. To prevent this, release cable tension and move the cage inward before making adjustments.

Procedure for front derailleur rotation adjustment:

a. Shift chain to outermost chainring and outermost rear sprocket.
b. Sight chain and cage from directly above chainrings. Consider the chain as representing a straight line.

FIGURE 9.45

Acceptable derailleur cage rotation

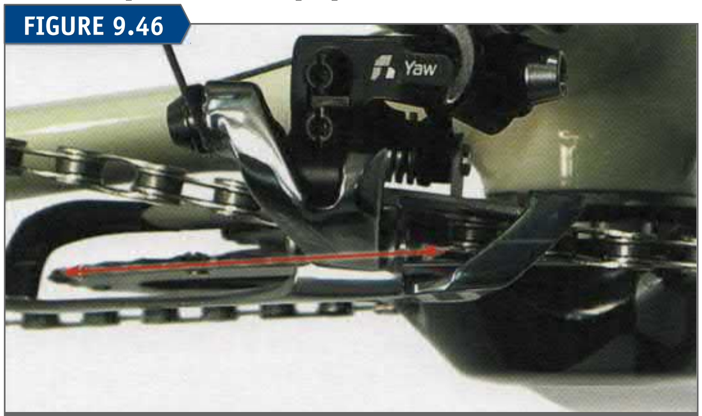
Compare this line to the outer derailleur cage plate. Outer cage plate and chain should be parallel (figure 9.45).

c. If the derailleur cage must be rotated, note direction of desired rotation.
d. For most derailleurs, release derailleur cable tension by shifting to the innermost chainring.
e. Many clamps leave a slight marking on the frame. Use a pencil to make two reference marks on the frame, one for height and a second, vertical mark to reference rotation. Use the marks to avoid inadvertently changing height.
f. Loosen mounting bolt and slightly rotate in correct direction. Use care not to change height. Tighten clamp bolt.
g. Shift to outer chainring and observe rotation alignment.
h. Repeat adjustment if necessary.

The procedure above usually creates the best front derailleur alignment. However, there are situations where you must deviate slightly from parallel. For example, after properly setting the limit screws, a derailleur may seem slow when shifting inward. It may benefit from having the cage rotated slightly clockwise. This moves the back end of the cage closer to the chain if viewed from above and this position can help push the chain inward to the next sprocket. Recheck both limit screw settings any time height or rotation is changed.

The SRAM® Red with "Yaw front" system does not align parallel to the chainrings when the cage is inward over the small ring. As the cage moves outward it rotates or "yaws" to become parallel. Check proper rotation of this model by pulling the cage over the large ring and sighting two alignment marks at the front and back of the cage directly over the largest ring (figure 9.46).

FIGURE 9.46



SRAM® Red front derailleur alignment marks set in line with largest chainring

LIMIT SCREW ADJUSTMENT

Limit screws stop the inward and outward travel of the front derailleur cage by striking the moving linkage system. Limit screws are marked "L" and (figure 9.47). The L-limit screw will stop the inward motion of the derailleur toward the smallest chainring or "low" front gear, and the H-limit screw will stop the outward motion of the derailleur toward the largest chainring or "high" front gear. The L-limit screw also keeps the chain from falling off the smallest ring on to the bottom bracket. Similarly, the H-limit screw keeps the chain from falling off the outside of the largest sprocket. Set the limit screws before setting index shifting with cable tension. The screws use a nylock fitting to prevent them from moving after adjustment. If the screws seem to move too easily, remove the screw and apply a mild thread locker. Do not lubricate these screws.

FIGURE 9.47

Location of limit screws

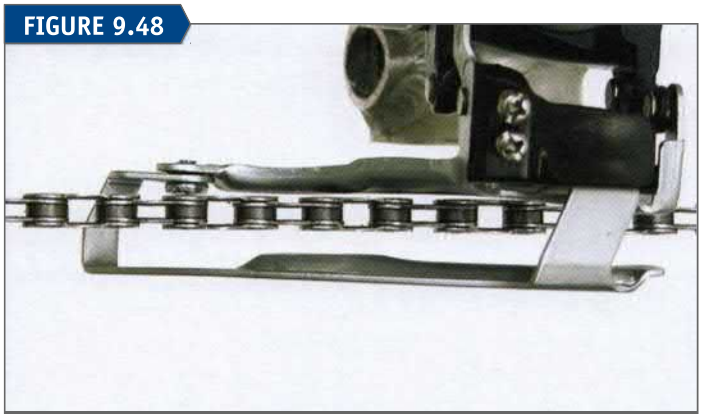
L-limit Screw

The limit screws stop the derailleur at the extremes of its motion caused by the pull of the derailleur cable and the derailleur return spring. When adjusting the front derailleur L-limit screw, it is important the derailleur rest on the L-screw stop when the cable is at low tension. If the derailleur cable has too much tension, it may prevent the derailleur resting on the L-screw stop. If you limit the derailleur with cable tension only, then when the derailleur cable tension changes, for example from the cable system setting and stretching, the derailleur inner limit will also change and possibly cause the chain to fall off the chainrings.

Procedure for L-limit screw adjustment:

a. Shift chain to innermost rear sprocket and innermost front chainring. Inspect derailleur for mark indicating "L" screw.
b. Check derailleur cable tension. It should be fairly loose at this time. If derailleur cable is taut, turn barrel adjuster clockwise into lever to provide slack. If barrel adjuster is already fully turned into the housing, loosen the derailleur cable pinch bolt, slacken the derailleur cable and retighten the bolt.
c. Sight the gap between the chain and inner cage plate. Only a small gap should be visible, 0.5–1 mm (figure 9.48).

FIGURE 9.48



Sight gap between chain and inner derailleur cage plate

d. Rotate the cranks slowly and continue to sight gap. Set clearance at narrowest or tightest point in the chainring rotation. Rotate the cranks and check that chain is not rubbing cage while chainrings and chain turn.
   4. If there is no gap and chain is rubbing cage, loosen L-limit screw ⅛ turn (counter-clockwise). Inspect for gap again and repeat until slight gap appears.
   2. If the gap appears larger than 1 mm tighten the L-limit screw ⅛ turn until the gap closes to 1 mm.

e. Test the shift by shifting chain to next chainring and then shift back to the innermost chainring. If chain shifts quickly to the smallest ring, limit screw setting is adequate. The outward shift away from the smallest ring is not determined by the L-screw. A poor outward shift will be adjusted during the index or cable tension setting.

f. If the shift to the smallest ring from the next ring is slow (requires more than one crankset revolution to initiate shift), turn L-limit screw counter-clockwise ⅛ turn and repeat test. Repeat ⅛ turn increments until shifting is adequate. The gap will open wider than the 1 mm target but will still be as small as possible with adequate shifting.

g. If chain is shifting beyond the inner chainring and falls off the chainring, the gap may be too large or cage alignment may be off. Tighten L-limit screw ⅛ turn and check shift again. If chain ends up rubbing inner cage of derailleur yet still drops off inner chainring when shifting, other problems such as chainline or derailleur rotation exist.

H-limit screw

The H-limit screw stops the outward travel of the front derailleur. The H-limit screw should be set to allow a quick shift to the largest chainring. However, the chain should not be allowed to go beyond the largest ring.

When viewing the H-limit screw adjustment, make sure there is enough tension on the derailleur cable by either keeping extra pressure on the lever or by pulling the exposed derailleur cable taut by hand. It is easy to become confused between cable pull and H-limit settings. Use a rag to protect your hand if pulling on the derailleur cable. It is not possible to directly pull the shift wire on bikes with full front cable housing or with shift wires using a full external liner. In these cases, maintain pressure on the shift lever to ensure the derailleur is pressing against the H-limit screw.

Procedure for H-limit screw adjustment:

a. Shift to outermost sprocket in rear and outermost front chainring. Inspect derailleur for mark indicating H-limit screw.

b. Pull derailleur cable with a hand on the cable itself to increase tension to ensure derailleur is against H-limit screw (figure 9.49). Alternatively, maintain pressure on shift lever.

FIGURE 9.49

Pull derailleur cable tight to force derailleur cage to limit screw

FIGURE 9.50

View gap at closest point between chain and derailleur cage

c. Check gap between chain and outer cage plate. Only a small gap should be visible, approximately 0.5 mm to 1 mm. Rotate the cranks slowly and continue to sight gap. Set clearance at tightest point in chainring rotation (figure 9.50).

d. Checking with pressure on cable, inspect if chain is rubbing outer cage. Loosen H-limit screw ⅛ turn. Add tension to cable and recheck cage to chain gap.

e. If chain is not rubbing, tighten H-limit screw repeatedly until chain does rub cage then loosen H-limit screw ⅛ turn and check again.

f. Test shift to the large chainring. Shift derailleur from small or middle chainring to largest chainring using hand pressure on derailleur cable rather than shift lever. If shifting is slow, loosen H-limit screw ⅛ turn and repeat test. If chain shifts over the outside of the large chainring and onto the crank, the outer-limit is set too loose. Tighten H-limit screw and test shift again.

g. If chain ends up rubbing outer cage of derailleur yet still drops off outer chainring when shifting, other problems such as chainline or derailleur rotation exist.

FRONT INDEX ADJUSTMENT: THREE-CHAINRING BIKES

A front derailleur shift lever may have an index setting. If the shift lever has three distinctive stops or clicks, it is indexing. If the front shift lever is a friction type without any clicks, there is no index setting. If the front shift lever has multiple clicks, such as some twist grip style shifters, it is shifted similar to friction levers. The user simply selects the shifter position so there is no chain rub at the front derailleur. Set front indexing only after completing limit screw settings.

Turning the barrel adjusters at the shift lever, frame, or derailleur performs the index setting. Turning the barrel adjuster counter-clockwise (unthreading) effectively lengthens the housing, and this pulls on the derailleur. This is said to "tighten" the index setting. Turning the barrel adjust clockwise (threading it into the shifter/frame/derailleur) effectively shortens the housing and is said to "loosen" the setting. This permits the derailleur cage to move toward the position where there is no cable tension.

Procedure for index shifting adjustment:

a. Shift chain to middle chainring in the front and innermost rear sprocket.
b. View gap between inner cage plate and chain. Gap should be as small as possible without rubbing chain. To reduce gap, turn the barrel adjuster outward (counter-clockwise). Check gap again and repeat as necessary.
c. If chain is rubbing cage at the inner plate, turn barrel adjuster clockwise to move cage inward.
d. If barrel adjuster is all the way in or out and no adjustment is possible, reset derailleur cable tension. Shift to innermost chainring and loosen derailleur cable pinch bolt. Turn the barrel adjuster all the way clockwise and then back out two to three turns. Pull derailleur cable with a fourth hand tool and tighten pinch bolt. Repeat index adjustment procedure.
e. Test by shifting front derailleur to all three front chainrings.

FRONT INDEX ADJUSTMENT: TWO-CHAINRING BIKES

If the shift lever has distinctive stops or clicks for each chainring, it is indexing. If the front shift lever is friction without any clicks, there is no index setting. For friction systems, the cyclist moves the shift lever as needed to shift between sprockets. The cyclist then adjusts the cage side to side by moving the lever to avoid any chain rubbing against the front derailleur cage.

Set the indexing feature only after checking and setting the limit screws. If the limit screws were initially set to allow no chain rub, the index feature should also produce no chain rub. Some shifters permit trim of the front cage. This is a half-click that moves the cage slightly over and is used when the chain is moved left or right from different gear selections at the rear cogs.

Procedure for index shifting adjustment:

a. Shift chain to outer chainring in the front and outermost rear sprocket.
b. View gap between outer cage plate and chain.
c. If outer cage plate clears the chain, index setting is adequate.
d. If plate is rubbing chain, increase derailleur cable tension by turning adjusting barrel counter-clockwise and check again.
e. If barrel adjuster is all the way in or out and no adjustment is possible, reset derailleur cable tension. Shift to innermost chainring and loosen derailleur cable pinch bolt. Turn the barrel adjuster all the way clockwise and then back out two to three turns. Pull the derailleur cable with a fourth hand tool and tighten pinch bolt. Repeat index adjustment procedure.
f. Test shift front derailleur between front chainrings.

FRONT DERAILLEUR PERFORMANCE

There are limits to the performance of a front derailleur. There may be certain gear combinations that simply do not work well or cause problems. For example, when the bike is used with the smallest front chainring and the smallest rear sprocket, the chain may rub against an adjacent chainring or the front derailleur. This is called "cross-chaining." As a simple rule, if a gear combination causes a rubbing problem, avoid that gear. If there is no rubbing, the gear is considered usable.

Another chain rub problem can occur when pedaling in the largest front chainring and the smallest rear sprocket. Very hard pedaling will flex the frame slightly with each stroke, which may cause a chain to rub on the front derailleur cage, even for properly adjusted derailleurs. Loosening the H-limit screw and then tightening the index setting cable tension will move the front cage out more. This may stop the rubbing, but it may also cause the chain to shift over the largest chainring and come off. If all aspects of front derailleur adjustments are correct on this bike, the rider is simply exceeding the engineering and design limits of the machine.

SHIMANO® FRONT DERAILLEUR FD-9000

The Shimano® FD-9000 front derailleur has unique features that require special considerations during installation and adjustment. The system works best with a complete Shimano® drivetrain with chain, crankset, derailleurs, and shifters. The front derailleur cable-fixing bolt (pinch bolt) uses a notched-washer with a protruding tab that changes the leverage of cable pull on the derailleur arm and subtly changes the position of the derailleur cage. The notched-washer has two possible positions depending upon the shift cable angle as it approaches the cable-fixing bolt.

The derailleur also features a replaceable "skid plate" on the inner face of the derailleur cage (figure 9.51). This is used to help prevent any accidental dropping of the chain off the smallest chainring during the shift from the largest to smallest rings. It will also reduce noise from cage scraping against chain during shifts.

Like other derailleurs, the outer cage should be set for 1–3 mm above the largest chainring. Set the cage parallel to the largest chainring. The L-limit screw is then used for a temporary lateral setting so to determine the best cable routing option and the correct position for the notched-washer at the cable-fixing bolt.

FIGURE 9.51

Skid plate on the inner cage of the Shimano® FD-9000

The outer edge of the cage should be adjusted flush with the outer edge of the large chainring's teeth. Use a straightedge such as a 4 or 5 mm hex wrench or a ruler. Place the straightedge along the outside of the largest chainring's teeth. Hold the straightedge against the machined lip at the base of the chainring teeth. Adjust the L-limit screw so the outer cage is flush with the straightedge. The cage should just contact the straightedge as the chainring is rotated next to the derailleur cage (figure 9.52). This setting is used to select the cable routing option at the cable-fixing bolt and notched cable-fixing washer.

FIGURE 9.52

Position the outer cage flush with the straightedge using the L-limit screw

To determine the cable routing, use the plastic guide, the Shimano® TL-FD90 cable routing tool, when available. To use this tool, remove the cable-fixing bolt and notched washer. Place the TL-FD90 into the cable mount. The tool will fit into the bolt hole in only one orientation. Pull the cable snug as you lay it into the slot in the TL-FD90. Compare the cable to the line drawn on the tool (figure 9.53).

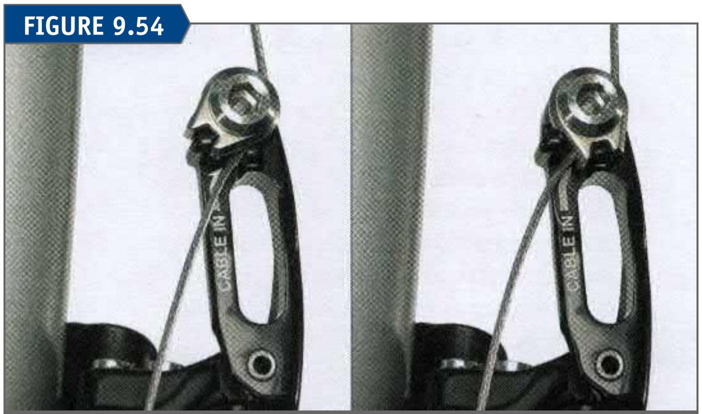
Bikes designed for cables passing on the left side of the guide will use the notched washer rotated toward the left (Shimano's term is the "OFF" position). If the design of the bike is such that the cable passes on the right side of the guide, the notched washer should be rotated to the right (Shimano's term is the "ON" position), as shown in figure 9.53.

Remove the TL-FD90 and install the fixing bolt and notched cable-fixing washer. Orient the notched cable-fixing washer

FIGURE 9.53

Determine the notched-washer location using the Shimano® TL-FD90

FIGURE 9.54



Orient the notched-wash accordingly and route cable under washer

and tab according to the position indicated by the guide tool (figure 9.54).

If the cable falls along the dividing line, select the right cable routing orientation and test the shifting. If the derailleur will adjust correctly, the routing was acceptable. If the derailleur will not adjust properly, move the cable to the left cable routing position.

When the Shimano® guide tool TL-FD90 is not available, simply make your best guess and attach the cable. Inspect how the front derailleur cable guide is positioned on the bottom bracket. If the end of the guide is either centered along the bottom bracket shell or is more toward the right side of the bike, arrange the notched cable-fixing washer oriented to the right side. If the cable guide sits so the front cable exit is obviously on the left side of the bike, assume it will use the left-rotated orientation on the notched cable-fixing washer. The two positions for cable mounting at the derailleur arm change the mechanical advantage of the cable pull during the shift. This Shimano® design allows adjustment of the leverage in the derailleur's parallelogram, so the derailleur shifts more consistently in different frame designs.

Shimano® FD-9000 Front Derailleur Adjustment

The front shift lever can be set to allow for four different index positions. There is an inner and outer setting for the small chainring and an inner and outer setting for the largest chainring. These settings serve two purposes. The primary purpose is to allow consistent and reliable chain shifting from the large ring to the small ring. The shift to the small ring does not move the cage to the L-limit. The cage moves to the small ring, but the chain will be rubbing against the skid plate. This is designed to prevent any chance of a missed shift with the chain falling to the inside, off the smallest ring. The cage can then be moved to the inner most position by again using the shift lever to prevent chain rubbing on the cage.

Procedure for FD-9000 front derailleur adjustment:

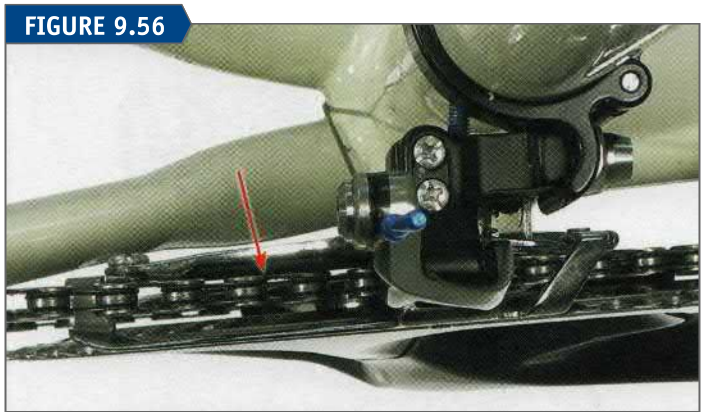
a. Shift the front to the innermost position by pressing the smaller shift lever three or more times. Shift the rear derailleur to innermost rear sprocket. Use the L-limit screw to bring the inner cage as close as possible to the chain, with the slightest visual gap (0–0.5 mm) between the skid plate and the chain.
b. Set the H-limit by shifting the rear derailleur to the outer most rear cog. Shift the front derailleur to the largest ring. Either maintain pressure on the lever, or pull the exposed cable to ensure the derailleur is pressed to the H-limit screw. Adjust the H-limit screw so there is a slight visual gap (0–0.5 mm) between the chain and the outer derailleur cage plate.
c. Shift the rear derailleur to the largest rear sprocket. This position is referred to as "cross chaining" (figure 9.55). Using the smaller shift lever, shift the derailleur cage inward to the inner position of the largest chainring.

FIGURE 9.55

Large-to-large chain combination

d. Inspect the chain for rubbing against the inside derailleur cage. If there is rubbing, turn the barrel adjuster into the stop (clockwise) to loosen cable tension. Inspect and adjust as needed to avoid chain contact with the derailleur cage.
e. Shift the chain to the inner ring using the smaller shift lever. Pushing only once moves the cage to the outer position of the small chainring. The chain should be rubbing the derailleur skid plate in this position (figure 9.56).
f. Shift the rear derailleur outward one sprocket at a time. The chain should still be striking the skid plate at least until the seventh-position cog.
g. Moving the front derailleur to the inner position on the smallest chainring should eliminate any rubbing from the innermost sprocket.

FIGURE 9.56



The outer adjustment of the smallest ring set for chain rub against skid plate.

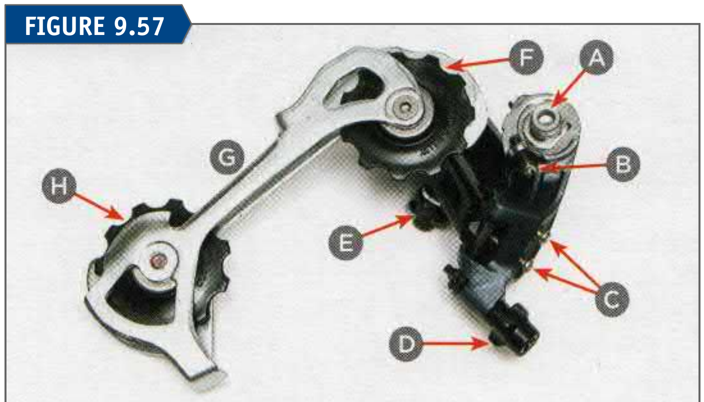
If a setting cannot be found on the barrel adjust that will both prevent the cage rubbing in the large-to-large sprocket position and also allow the skid plate to support and rub the chain while in the outer position of the smallest chainring in the inner five rear sprockets, it may be necessary to remove and rotate the cable fixing bolt and notched-washer to the opposite position.

REAR DERAILLEUR

Rear derailleurs push or "derail" the chain from one rear sprocket and move it to another. The upper derailleur pulley, also referred to as the "G-pulley" or guide pulley, moves the chain from sprocket to sprocket. The G-pulley should then sit aligned under the cog as selected by the shift lever.

The derailleur body is fitted with a spring that is pulled tightly or released by the derailleur cable. Pulling the cable at the shift lever shortens the cable, moves the derailleur cage and guide pulley, and tightens the spring. When the shift lever feeds out cable (relaxing cable tension), it allows the spring to move the body and pulley in the opposite direction. Useful terms for parts of the rear derailleur are illustrated in figure 9.57.

FIGURE 9.57



Derailleur and component parts: (A) Mounting bolt, (B) Body or B-Screw, (C) Limit screws, (D) Adjusting barrel, (E) Derailleur cable pinch bolt, (F) Upper pulley, (G) Pulley cage, (H) Lower pulley

DERAILLEUR CAPACITY AND MAXIMUM SPROCKET SIZE

The rear derailleur is usually selected to be compatible with sprocket sizing and spacing used on the bicycle. Derailleurs are made with specifications for the "maximum sprocket size" and the "total capacity." The maximum sprocket size is the largest rear sprocket the derailleur will accept. For example, a bike with a 32-tooth rear sprocket should use a rear derailleur with a maximum sprocket size of at least 32.

The total derailleur capacity refers to the derailleur's ability to take up chain slack as the derailleur shifts between different gear combinations. The capacity requirements of the bicycle are determined by the front and rear sprocket sizes. To calculate this capacity, the difference between the smallest and largest chainring sizes is added to the difference between the smallest and largest sprockets of the rear sprockets. For example, if a bike has a front crankset with 22-32-46 tooth chainrings, the spread between the front extremes is 24 teeth. If the rear sprocket sizing is 13-14-15-17-19-21-23-26-30 teeth, the spread is 17 teeth. The total capacity requirements are then 17 plus 24, or a total of 41. A derailleur rated for a total capacity of 41 or greater would take up the slack for any gear combination. However, this does not mean that every gear combination will work well, only that the derailleur will take up the chain slack.

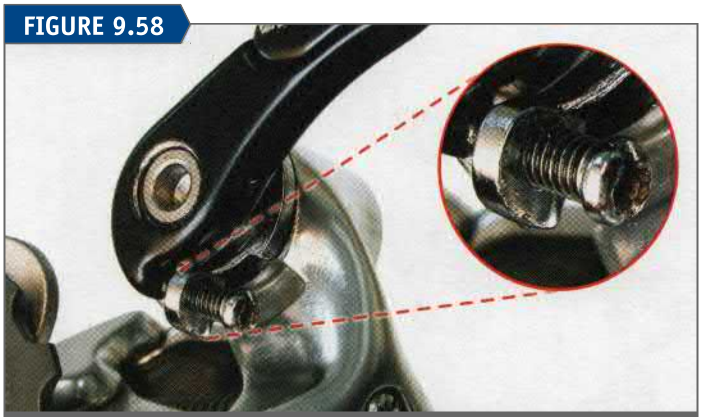
Derailleurs are available that do not take up chain slack in every gear combination. In the example above, if the bicycle is fitted with a derailleur with a rated capacity of 33, the derailleur will not be able to take up the slack in all gear combinations. The chain will hang slack when it is on the inner front chainring and in the 13, 14, 15, 17, or 19 rear sprockets. If the chain were shortened to accommodate these gear combinations, it would be too short when the bike is in the 46-tooth front chainring and the several of the larger sprockets in the back. When sizing a chain with a derailleur violating the total capacity needs of the bike, it is best to use the sizing method in Chapter 8, Chains. This will allow shifting to largest rear and front sprockets, but the chain will hang slack in some small front chainring and small rear sprocket combinations. It will be necessary to avoid those gear combinations that cause problems in pedaling or shifting or to replace the derailleur with a model of greater total capacity.

Check with derailleur manufacturer for specifications on maximum sprocket size and total capacity. As a general rule, total capacity increases as the derailleur cage gets longer, and the distance between pulley wheels increases. Short cage derailleurs, those with approximately 50 mm between pulley wheels, will have a capacity of about 29 teeth. Medium cage derailleurs (approximately 73 mm) will have a capacity of approximately 33 teeth. Long cage derailleurs (approximately 85 mm) will have a capacity of approximately 45 teeth.

DERAILLEUR INSTALLATION

The rear derailleur attaches to the frame at a fitting called the derailleur hanger. The hanger has a tab that acts as a stop for derailleur rotation (figure 9.58). Grease the bolt before installing. When installing the derailleur, use care that any stop screw or plate on the derailleur clears the hanger tab. Hold the derailleur clockwise from its "normal" position while engaging the thread. The torque for the mounting bolt is modest (Appendix C). Test that the derailleur is freely pivoting on the hanger.

FIGURE 9.58



Frame hanger tab and derailleur stop screw

DERAILLEUR CABLE ATTACHMENT

The derailleur cable attaches to the rear derailleur at the pinch bolt mechanism. The derailleur cable is flattened by a plate and bolt (figure 9.59). Unthread the bolt and look for a groove in either the plate or derailleur arm. The derailleur cable will lie in this depression or notch. Inspect the groove and keep the derailleur cable in line with it. There may also be a tab system. The tab is used to prevent the washer from rotating. The derailleur cable is not usually routed around the tab.

While the bolt is loose, take the opportunity to lubricate the threads. Pull the derailleur cable snug and secure the bolt. The derailleur cable will be flattened where it is pinched.

FIGURE 9.59

Derailleur cable routing through pinch mechanism

LIMIT SCREW ADJUSTMENT

Derailleur pulleys are limited in both inward and outward motions by using the derailleur limit screws. Limit screws will strike and stop the derailleur linkage as it articulates through its motions. The limit screws are usually marked "H" and "L". The H-limit screw controls the outermost limit of the derailleur, and the L-limit screw controls the innermost limit. The location of limit screws on the derailleur body may vary between manufacturers. Always look for the "H" and "L" marked adjacent to the screws. For some models you may need to inspect the linkage and determine which screw is the H-screw or L-screw (figure 9.60).

Properly set, the derailleur will shift to and stop on both the extreme outward sprocket (the smallest in size) and the extreme innermost sprocket (the largest in size). However, the limit screws do not control the derailleur on the sprockets

FIGURE 9.60

H-limit screw contacting derailleur linkage to stop outward travel

between the two extremes. The sprockets between the extremes are set to the clicks (dwell) in the shift lever by using the barrel adjuster during indexing adjustments.

Using the barrel adjuster on the shift lever to adjust derailleur high and low limits can cause confusion and problems because it tends to focus attention on the derailleur cable pull (indexing) rather than the limit screw settings. Instead of using the shift lever, pull the derailleur cable with one hand to simulate shift lever action (figure 9.61). This will help eliminate confusion between indexing problems and limit screw problems. Before adjusting the limit screws, practice shifting with this method. If it is not possible to pull the cable by hand, maintain pressure on the lever to ensure the derailleur is pressed to the limit screw.

FIGURE 9.61

Pull cable by hand to isolate limit screw performance from index settings

Turning the limit screws adjusts the left-to-right travel limit of the pulleys. Tightening the screw restricts the travel and loosening allows more travel. The purpose of the following procedure is to find the tightest H-limit screw setting that will allow a good shift to the outermost sprocket and the tightest L-screw setting that will allow a good shift to the innermost sprocket.

It is normal for a chain to make some noise during a shift. The shift may appear subjectively "noisy," "loud," or "rough." Factors like the type of chain or sprocket, the wear on each, and the amount and type of lubrication will affect the noise a chain makes during shifting. The limit screws do nothing to affect the noise during the shift between the two extreme sprockets.

H-Limit Screw

When adjusting the H-limit screw, pay special attention to the outward shift from the second smallest sprocket to the outermost sprocket. Also notice how the chain rides on the outermost sprocket. Do not be concerned, however, with how the chain rides when it is held on the second sprocket. That is a function of derailleur cable pull, not limit screw settings. Do not become confused between issues of derailleur cable pull and limit screw setting. Cable pull (tension) controls indexing, but limit screws control the two extreme cogs. Again, when possible, simply pull the derailleur cable by hand rather than using the shift lever.

Procedure for H-limit screw adjustment:

a. Shift chain to outermost (largest) chainring. Shift chain to outermost rear sprocket (smallest sprocket).
b. Check tension on rear derailleur cable. If derailleur cable appears to have any tension, it may interfere with the H-limit screw setting. Turn adjusting-barrel clockwise to eliminate derailleur cable tension.
c. Rotate the cranks at a quick cadence, approximately 60 rpm or more. Shift the derailleur one sprocket inward and then shift derailleur back to outermost sprocket and note shift.
d. If the shift outward seems acceptable, tighten H-limit screw ¼ turn clockwise and repeat shift. Even if the shift appears acceptable, continue tightening H-limit screw by ¼ turn increments and checking shift until the shifting becomes slow or hesitant to the outer sprocket. The goal is to find the point at which the limit screw is too tight, and then back it off until it is just right. Another symptom of an overly tight H-limit screw is when the chain is on the smallest sprocket but makes a rattle from rubbing the second sprocket inward. Look for the cause of this last symptom by looking under the rear sprockets where the chain meets the sprockets (figure 9.62). The inner plate of the chain will rub against the next sprocket inward, making an excessive rattling noise.

FIGURE 9.62

Inspect the H-limit by view behind and outer the rear cogs

e. When symptoms of an overly tight H-limit screw appear, loosen H-limit screw 1/4 turn and check shift again. Repeat process of shifting and correcting by 1/4 turn increments. When the symptoms disappear, H-limit screw is at tightest acceptable setting. The H-limit screw setting is done.

L-limit Screw

The L-limit screw stops the derailleur from moving inward (toward the spokes). The limit screw does not make the derailleur move; pulling or releasing the derailleur cable makes the derailleur move. The L-screw allows the pulley wheels to shift the chain to the innermost sprocket but not off the sprocket into the spokes. When adjusting the L-screw, be concerned with the inward shift from the second-innermost sprocket to the innermost sprocket. Additionally, notice how the chain rides on the innermost sprocket.

Procedure for L-limit screw adjustment:

a. Shift bike to middle chainring of three chainring bikes or smaller chainring of double chainring bikes.
b. With the bike in a stand or suspended, rotate the cranks at a normal riding cadence, approximately 60 rpm or more.
c. Pull rear derailleur cable by hand to shift derailleur inward from second to innermost sprocket to the innermost sprocket.
d. If shifting seems adequate, tighten L-limit screw ¼ turn and repeat shift. Continue to tighten L-screw until symptoms of an overly tight screw appear. The goal is to find the point at which the limit screw is too tight, and then back it off until it is just right. The symptoms are an unshiftable chain or even a hesitant chain while pulling on the derailleur cable. Also, listen for a loud chain rattle when the chain is riding on innermost sprocket.
e. When symptoms of an overly tight L-screw appear, loosen L-screw ¼ turn and check shift again. Repeat the process of shifting and correct each time with ¼ turn. When symptoms disappear, the L-screw is at tightest acceptable setting and limit screw setting is done.

B-Screw Adjustment

After setting the L-screw, check the "B-screw" for an adequate setting. The B-screw controls the derailleur body angle, hence the name. Adjust the distance between pulley and sprocket when the chain is on the smallest sprocket in front and on the largest sprocket in back. This places the upper pulley and largest rear sprocket at their closest point.

For the common Shimano® and SRAM® derailleurs, the B-screw is located behind the derailleur's upper mounting bolt (figure 9.63).

If the indexing is already set, shift to the innermost sprocket. Otherwise, manually pull the rear derailleur cable and shift to the innermost (largest) rear sprocket. Hold tension and View the upper pulley relative to the largest sprocket. If the pulley is rubbing against the sprocket, tighten

FIGURE 9.63

Location of B-Screw

the B-screw to increase upper pivot spring tension, which pulls the pulley back and away from the sprocket. If there is a gap between the upper pulley and sprocket, loosen the screw. Rotate the cranks backwards to double-check for rubbing. The upper pulley will wear out if it rubs against the sprocket. Additionally, the derailleur may hang up as it attempts to shift off the largest cog to the smaller cogs.

Modern Campagnolo® model derailleurs may have a tension adjustment at the pulley cage and not at the upper pivot. The screw is basically a "rack and pinion" system in the cage pivot. The cage spring plate rotates to increase or decrease tension of the cage. The tensions of the upper pivot and lower cage pivot springs oppose one another. In this system, the upper spring tension is fixed (figure 9.64). Increasing cage tension (turning screw clockwise) in the cage will bring the upper pulley closer to the sprocket. Decreasing cage tension (turning screw counter-clockwise) will increase the distance between upper pulley and sprocket.

FIGURE 9.64

Adjusting the Campagnolo® B-screw at the cage pivot

FIGURE 9.65

SRAM® and Shimano® Shadow setting for the upper pulley to largest cog

SRAM® and some models of Shimano® derailleurs do not use a spring in the upper mounting bolt. A screw behind the upper mounting bolt adjusts the distance from the upper pulley to the largest sprocket. Adjust so there is approximately a 6 mm (¼ inch) gap between the pulley and largest sprocket. Use a 6 mm hex wrench to estimate this gap (figure 9.65). Tighten B-screw to pull body back and increase the distance between sprocket and pulley. Loosen the screw to decrease gap size.

INDEX ADJUSTMENT

The indexing procedure here assumes that there are no unusual problems such as bent derailleurs, bent derailleur hangers, or excess derailleur cable friction from dirt in the housing. Additionally, manufacturers design shift levers and drivetrain components to work within their system. Mixing brands of components within the drivetrain may result in less than optimal shifting.

Indexing shift levers use dwell, which is a hesitation or click in the lever rotation. These hesitations are calculated to match the movements of the derailleur and the spacing in the rear sprockets. The design of some derailleur and shift lever brands requires a little more push (or twist) of the lever to complete the shift. The amount of extra push or twist is not consistent between manufacturers and each rider must learn the particular attributes of his or her system. In other words, an index lever may, in some cases, need to be "finessed" to shift properly, and this finesse must be learned by the user.

Changing the derailleur adjusting barrels, which effectively increase or decrease cable length, adjusts the rear indexing. For conventional derailleurs (other than Shimano® Rapid Rise™) turning the barrel adjuster counter-clockwise (outward) moves the rear derailleur guide pulley (G-pulley) toward the spokes. This is said to "tighten" the index setting. Turning the barrel adjuster clockwise (inward) allows the spring in the derailleur to pull the guide pulley outward (toward the dropout). The derailleur adjusting barrel settings will not stop the derailleur at its extreme limits. Use the H-limit and L-limit screws to stop the derailleur at its outermost and innermost settings, respectively.

Adjusting barrels may be located either at the rear derailleur, the shift lever, or both. The goal of adjusting the indexing is to find the "tightest" derailleur cable tension setting that will allow good shifting to the gears normally used. This setting will allow the longest lasting indexing adjustment as the system wears and the cable system stretches (lengthens) with use. To find the tightest derailleur cable setting, begin by purposely making the setting too tight and then relax tension slightly.

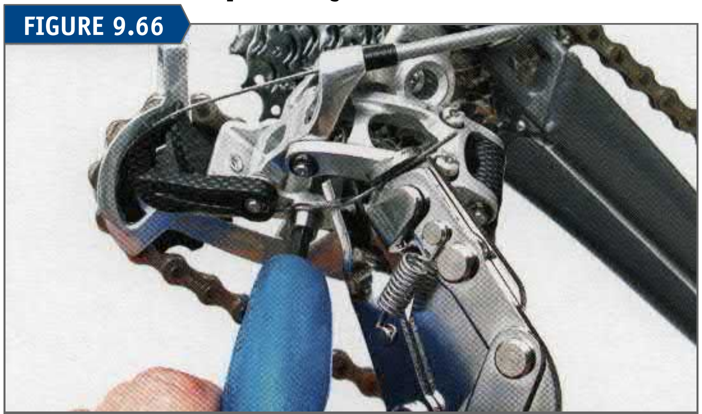
There are two basic symptoms of an overly tight derailleur cable: a rattling noise from the chain rubbing against the next sprocket inward or a slow or hesitant outward shift. These are symptoms for conventional rear derailleurs that move outward when derailleur cable tension is released.

Noise from the chain riding on the sprocket is a useful symptom for setting indexing tension. There is, for any given bike, a "base level" of noise from the chain as it passes over the sprocket teeth. To demonstrate the "base level" noise, shift the bike to the second sprocket by manually pulling the derailleur cable. Continue to rotate the cranks and move the derailleur cable slightly to hear changes in the level of noise. The quietest level of noise may be considered the base or normal level for that bike. When the derailleur jockey wheel is out of alignment, the chain may make excessive noise.

Procedure for rear index setting adjustment:

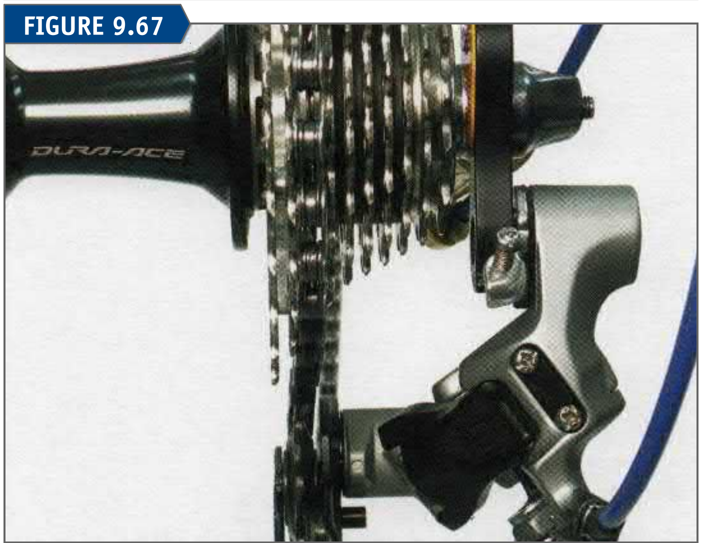
a. Set limit screws, if not already done.
b. While rotating the cranks, shift chain to outermost (smallest) rear sprocket and outermost (largest) chainring in front.
c. Test initial derailleur cable tension. Rotate the cranks at a normal cadence and shift rear derailleur with one click on lever. Use care to only move lever one position. If derailleur moves one sprocket, proceed to "e" below.
d. If derailleur fails to shift one sprocket with one derailleur shift (click), the derailleur cable may be too slack. Return shifter to a position that produces the least derailleur cable tension. Turn barrel adjuster fully into derailleur body (or shift lever) then turn counter-clockwise two turns to allow for index adjustments. Loosen derailleur cable pinch bolt and gently pull on derailleur cable with fourth hand tool or pliers to remove slack (figure 9.66). Tighten derailleur cable pinch bolt. Attempt shift again. If derailleur will not shift one sprocket after removing slack, return lever back to outermost sprocket position and increase derailleur cable tension by turning barrel adjuster counter-clockwise ¼ turn and attempt shift again.

FIGURE 9.66



Pull excessive slack from cable at pinch bolt

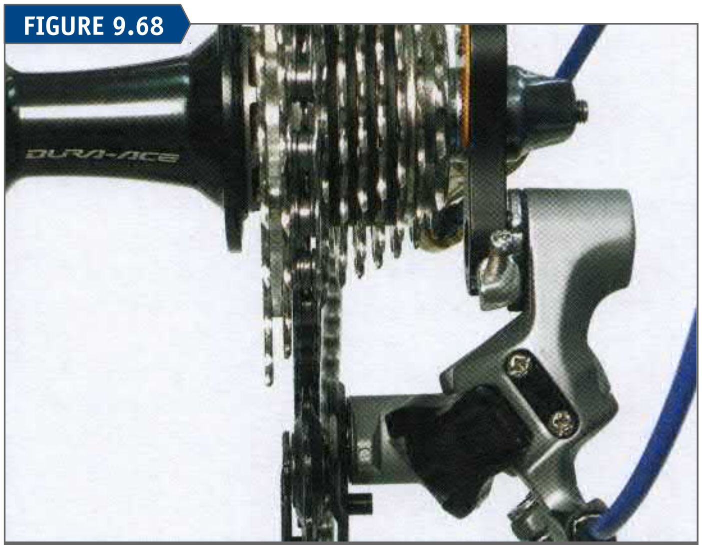
FIGURE 9.67



Chain positioned too far inward resulting in a rattle against sprocket

e. Once the derailleur has shifted inward one position of one click at the shifter, proceed to shift to other rear sprockets. To find the longest lasting index setting, purposely increase cable tension by turning adjusting barrel counter-clockwise until a definite rattling is heard. Rattle is from the chain scraping against the next sprocket (figure 9.67).
f. Once a too-tight rattle is achieved, turn barrel adjuster ¼ turn clockwise to release derailleur cable tension and rotate cranks again. Listen and look for signs of scraping

FIGURE 9.68



Index setting adjusted so chain rides under sprockets

or rattling. Continue turning barrel adjuster ¼ turn clockwise at a time until rattle disappears (figure 9.68).

g. Shift derailleur one sprocket inward at a time, listening for signs of rattle, indicating a too tight derailleur cable. Turn adjusting barrel ¼ turn clockwise to eliminate rattle. Continue shifting inward one sprocket at a time. Adjust only if rattling is heard and seen. **Note:** Do not attempt to shift to largest rear sprocket while the chain is in the largest front sprocket. This gear combination is normally not used and adjusting tension to this shift may compromise other commonly used gears.

h. Shift to innermost (smallest) chainring and check shifting again. If no rattling is present, index adjustment is done.

Shimano® Rapid Rise™ Derailleurs

Shimano Rapid Rise™ derailleurs use a return spring that puts the derailleur under the innermost rear sprocket when the derailleur cable tension is released. This is also called "low-normal." A loose derailleur cable will cause the chain to rub against the next sprocket inward from the indexed gear.

Procedure for indexing adjustment on Rapid Rise™ (low-normal) derailleurs:

a. Mount the bike in a repair stand.

b. Set limit screws.

c. Shift chain to the innermost rear sprocket and the middle chainring of a three-chainring bike (or the smaller chainring of a double-chainring bike).

d. Rotate the cranks and shift to the next-smallest rear cog. If chain will not shift, release lever and increase derailleur cable tension.

e. When the chain is on the second-largest sprocket, rotate the cranks and turn barrel adjuster clockwise to relax derailleur cable tension until chain rattles against the next sprocket inward.

f. Turn barrel adjuster counter-clockwise ¼ turn until chain runs smoothly on second-largest sprocket.

g. Shift up (outward) one sprocket at a time, trying each gear. Turn barrel adjuster ¼ turn counter-clockwise if symptoms of overly loose derailleur cable occur in other gears.

h. Shift to all other normal gear combinations and test adjustment. Make corrections to barrel adjuster in ¼ turn increments as necessary.

CLUTCH SYSTEM REAR DERAILLEURS

Shimano® and SRAM® have rear derailleurs available with a clutch system in the pulley cage. In a traditional rear derailleur, the pulleys are mounted to a cage that pivots on the derailleur body. A spring in the body applies tension to the low pulley, pulling it backward. If the bike hits a bump, the weight of the chain will force the pulley forward, and the chain will bounce up and down. This often results in the chain slapping the chainstay and can also result the chain coming off the chainrings.

A clutch system in the lower pivot provides resistance to forward movement of the lower pulley to help maintain chain tension during bumps. The cage is free to pull back on the pulley from the clutch design. This reduces the chain slap and helps maintain the chain on the chainrings.

Clutch system derailleurs make removing and installing the rear wheel more difficult. The Shimano® Shadow Plus® RD design includes a lever at the lower pivot which disengages the clutch. The up position on the lever is the "on" or working position. Pulling the lever down disengages the clutch for the "off" position (figure 9.69).

The clutch type systems are adjusted the same for limit screws and indexing. These systems often require more force at the shift lever.

FIGURE 9.69

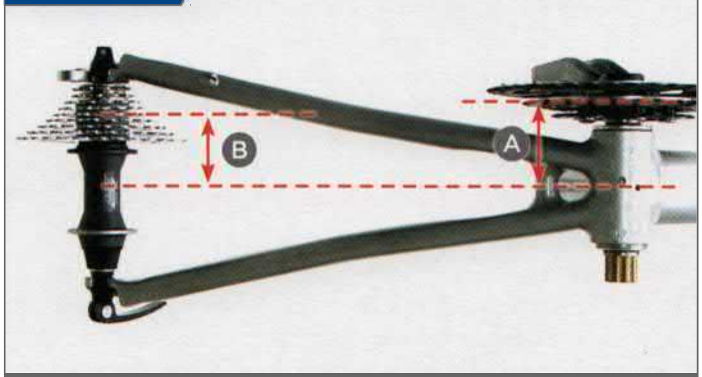
Push "on-off" lever upward to return derailleur to clutch operation mode

CHAINLINE

Chainline is the relation of the front and rear sprockets to the center plane of the bicycle (figure 9.70). The bike center plane is an imaginary plane running from front to rear through the middle of the bike. As an example, a front crankset and/or front derailleur might be designed to have a chainline of 50 mm. The front derailleur would then work best when the middle of the chainrings are 50 mm from the bike centerline.

Chainline can also refer to the relative position of the front and rear sprockets to each other without regard to the bike centerline. This is called "effective chainline." Effective chainline is simply the difference between "A" and "B," but distance "A" is not always designed to be equal to "B." For example, with most three-chainring bikes, the middle of nine rear sprockets will be approximately 45 mm from the bicycle

FIGURE 9.70



Chainline in relationship to the bike mid plane:
(A) Distance from middle of front chainrings to mid plane
(B) Distance from middle of rear sprockets to mid plane

mid plane or distance "B." The manufacturers specified chainline of triple cranksets ranges from 47 mm to 50 mm, distance "A." In this case, the front chainrings are not designed to align directly with the middle of the rear sprockets.

Drivetrain manufacturers generally do not consider all gear combinations to be usable. For example, a "27-speed" bike has three chainrings in front and nine sprockets in the rear for a total of 27 gears. There are likely to be several gear combinations that are exact or very close duplicates. It is also likely that the chain will rub the side of the middle chainring when the chain is on the smallest sprocket in front and possibly two or three of the smallest sprockets in back. This is simply the limitation of the design. If the front crankset were moved outward until there was no rubbing in these combinations, there would likely be other shifting problems in other gear combinations, such as the largest chainring and several of the inner rear sprockets.

Sprocket combinations that should be avoided are termed "cross-chaining." Drivetrain manufacturers vary on exactly which combinations should not be used. Generally, it is assumed that the smallest front chainring and smallest rear sprocket will not be used, nor will the largest rear sprocket in combination with the largest front chainring. As a practical matter, each bike may be different as to which exact gear combinations is unusable.

As a rule of thumb, if the bicycle shifts well, the chainline should be considered adequate. However, chainline adjustment may be needed if:

- Chain jumps off large chainring when front derailleur is correctly adjusted for height, rotation, and limit screw settings.
- Chain rides off lower derailleur pulley teeth when derailleur or hanger is not bent.
- Chain rattles on inner faces of front chainrings in what should be usable gears.
- Chain derails off inner chainring when front derailleur is correctly adjusted for height, rotation, and limit screw settings.
- Front derailleur cannot be adjusted to stop over-shifts while still allowing good shifting.

Moving the front chainrings can make changes to chainline. For the three-piece cranks, there may be different bottom bracket spindle widths available to move the chainring inward or outward. Shorter spindles locate the chainrings inward, and longer spindles locate the chainrings outward.

On some models, a thin spacer can be placed under the right side cup of the bottom bracket to move the chainrings outward. There are limits to this, however, because it results in less thread engagement for the right side cup. There are also limits to moving a derailleur inward, toward the bike mid plane. The chainrings may end up rubbing the frame. Additionally, the front derailleur may not work well with the front chainrings too close to the frame.

Two-piece cranks offer little opportunity to change the chainline. In some cases, the spacers under threaded bearing adapters can be moved from the left to the right side.

Chainline manipulation with rear sprockets is also limited. The freehub mechanism cannot be moved laterally on the hub shell. If the hub uses a threaded axle, spacers may sometimes be moved under the cone locknut to shift the rear sprocket positions. If spacers are moved from the right side to the left side, double-check that the chain will not strike the frame when on the smallest rear cog. It is important not to change the fit of the hub into the frame. Any change of axle spacing will also change the centering of the wheel rim over the hub. Double-check and correct dish if the spacers were manipulated.

Modern bicycles are designed for forward pedaling. There are times, such as when preventing the inside pedal from striking a tight corner, when a cyclist may want to pedal backwards briefly. When pedaling forward, the chain is guided to the rear sprocket by the upper derailleur pulley, which is very close to the sprockets. When a cyclist backpedals, the chain is guided to the rear sprocket by the front chainrings, which are relatively far away. The chain may disengage or become jammed when it is backpedaled because the front chainrings cannot keep the chain guided straight to the sprocket. Disengagement is likely to be worse in gear combinations where the chainline is offset the greatest. It may be possible to minimize backpedaling problems by changing chainline, but again, this may result in other problems.

DERAILLEUR HANGER ALIGNMENT & REPAIR

The rear derailleur is mounted to the bike at the derailleur hanger. The hanger should be aligned parallel to the rear sprockets. A bent or misaligned derailleur hanger will result in poor shifting performance (figure 9.71). The derailleur hanger can become bent when the bike is crashed, bumped with force, or if something, such as a stick, becomes caught in the derailleur when riding. A misaligned hanger may also just be a manufacturer oversight on a new bike.

Many hangers can be bent, aligned, re-bent, and realigned repeatedly. This is because there is very little stress from riding the bike or shifting gears. As a rule of thumb, if a hanger survives a repair by bending, it will survive the riding.

To check alignment and repair the derailleur hanger, use a derailleur hanger alignment gauge, such as the Park Tool DAG-2 Derailleur Alignment Gauge. The tool extends the plane of the hanger and compares it to the rim. If the hanger is aligned to a wheel rim, it will also be aligned to the rear sprockets.

FIGURE 9.71

Bent hanger from impact to rear derailleur

Bikes may use a bolt-on or replaceable hanger (figure 9.72). These hanger styles are also repairable and can be aligned. Even new hangers should be checked for proper alignment. Derailleur hangers can be difficult to fix if the method of securing the hanger to the frame is inadequate. Replaceable hangers may move in the frame mount, which changes the alignment of the hanger and derailleur. Before checking alignment on replaceable hangers, double-check the rigidity of the hanger to frame connection.

FIGURE 9.72

Replaceable type derailleur hangers should be checked for proper alignment

Procedure for derailleur hanger alignment:

a. Mount the bike in a repair stand. Level the bike in the stand, as if it were on flat ground.
b. Check that the rear wheel is mounted straight in the frame.
c. Remove rear derailleur from hanger. Derailleur may simply hang from derailleur cable and housing during hanger alignment.
d. Install DAG-2 into hanger and tighten handle. If the DAG-2 does not thread easily into the derailleur hanger, chase and clean the threads using a tap as necessary. Do not use the DAG-2 threads as a “chaser” of bad derailleur hanger threads.
e. Rotate the arm toward the left side of the rim at the nine o’clock position. Rotate the tire valve to the same position. Use the valve on the rim as a constant reference point when checking the hanger (figure 9.73). By checking the same point on the rim, wheel trueness or dish will not affect alignment.

FIGURE 9.73

Set DAG-2 gauge to reference rim at the nine o’clock position

f. Loosen the sliding gauge knob and move the sliding gauge to contact the rim, then secure the knob.
g. Push gauge bracket toward hub before rotating arm. This prevents gauge from being forced against rim.
h. Rotate DAG-2 and rim valve 180 degrees to the three o’clock position. Slide indicator toward rim to same point near valve.
i. There are three possible results:
   1. The gauge barely touches the rim or has a small gap less than 4 mm. In this case, hanger is aligned horizontally.
   2. The pointer is away from the rim some distance. The hanger is misaligned (figure 9.74). If the distance is greater than 4 mm, the hanger will need realignment. Use a 4 mm hex wrench to gauge the gap.
   3. The pointer strikes inside the rim, which indicates a misaligned hanger (figure 9.75). It is easier to

FIGURE 9.74

Gauge indicating misaligned hanger

FIGURE 9.75

Reset gauge if it falls inside the rim

determine the error by seeing the gap between the rim and gauge. Reset tool to rim contact at the nine o'clock position and rotate back to the three o'clock position. There will be a gap between the rim and the gauge.

j. Bend the derailleur hanger a small amount using the arm of the DAG-2. Then recheck both sides. Reset gauge and remeasure gap. Generally, it is best to bend with the DAG-2 arm next to the chainstay (figure 9.76). This allows you to use the stay for leverage and to control the amount of bending either inward or out.

FIGURE 9.76

Use frame to leverage and control bending of hanger

k. Repeat bending and checking until the gap is less than 4 mm. A 4 mm gap at the rim means the hanger is off less than a millimeter at the sprockets, where the derailleur actually shifts. Use a 4 mm hex wrench as a "go/no-go" gauge.

l. When the horizontal positions are aligned, move on to check the six o'clock and twelve o'clock position. Set gauge to the six o'clock position, and then check at the twelve o'clock position.

m. Rotate DAG-2 and rim valve 180 degrees. If gap exceeds the 4 mm tolerance, bend accordingly in small increments, rechecking and resetting the gauge (figure 9.77). When the gap is less than 4 mm, keep the same setting and check at the nine o'clock position. When three points that are 90 degrees apart are within 4 mm, hanger is aligned.

FIGURE 9.77

Use a 4mm hex wrench as a go/no-go gauge when checking tolerance

n. Remove the tool and reinstall the derailleur.

o. Check settings on both limit screws and check index settings.

The threads of the derailleur hanger are commonly 10 mm x 1 mm. Campagnolo uses threads that are 10 mm x 26 tpi, which can effectively interchange with the 10 mm x 1 mm thread without issue. If the derailleur installs with difficulty, the threads of the hanger should be tapped. As a test of thread acceptability, fully tighten the derailleur. If the derailleur bolt does not strip, the hanger is usable. If the threads strip and fail, it is possible for a professional mechanic to install a coil thread or a T-nut repair system (figure 9.78). These repairs work well when properly done and allow the bike to be used normally.

FIGURE 9.78

T-nut thread repair of a stripped hanger

DERAILLEUR WEAR & SERVICE

Both front and rear derailleurs will eventually wear out with use. Play and excess movement develop at the pivots. Grab the lower cage of a rear derailleur and pull left to right to test play. It may help to compare the play in the old derailleur to new models. Replace the derailleur when the cage at the lower pulley has more then a ⅛ inch (3 mm) movement.

The chain travels over the pulleys and pulley teeth, which causes wear. Worn pulley wheels will not engage well with the chain (figure 9.79). The pulley wheels can usually be replaced.

FIGURE 9.79

Unworn pulley wheel on left and extremely worn pulley on right

The rear derailleur can be brushed off and lightly scrubbed with soap or solvent. Use care not to get solvent in the upper and lower pivots. A solvent in the cage pivots will ruin the grease inside. It is also possible to disassemble, clean, and reassemble some rear derailleurs. Overhaul of the rear derailleur is not discussed in this book.

The front derailleur can be flushed with degreaser, dried, and re-lubricated at the spring and all pivot points with a light lubricant. The pivots of the cage will eventually develop play and slop with enough use. Grab the back end of the derailleur and pull from side to side. Compare the old

TABLE 9.1 *Troubleshooting Table*

SHIFTING OR RIDING SYMPTOM	POTENTIAL PROBLEM	POTENTIAL SOLUTION
Chain skips in all gear combinations	Poor indexing adjustment	Readjust indexing
Shifting is slow or hesitant for either inward or outward shifts	Friction in the cable system	Lubricate and/or replace cable and housing
Shifting is slow or hesitant on inward shifts	Poor indexing adjustment with cable tension too loose (Rapid RIse™ likely too tight)	Increase cable tension (Rapid Rise™ decrease cable tension)
Shifting is slow or hesitant on outward shifts	Poor indexing adjustment with cable tension too tight (Rapid RIse™ likely too loose)	Decrease cable tension (Rapid Rise™ increase cable tension)
Chain skips under pressure in only 1, 2, or 3 rear sprockets	Sprockets and chain may be worn out	Inspect and replace sprockets and chain
Chain shifts off of largest front chainring	Front H-limit screw too loose, or rotation of cage is off	Inspect and correct cage rotation as necessary Check H-limit screw setting
Chain shifts off of smallest front chainring	Front L-limit screw too loose, or rotation of cage is off	Inspect and correct cage rotation as necessary Check L-limit screw setting
Chain shifts slowly or not at all to largest front chainring	Front derailleur cable tension too loose, H-limit screw too tight, and/or rotation cage is off	Check front index setting Check derailleur rotation and H-limit screw setting
Chain shifts slowly or not at all to smallest front chainring	Front derailleur cable tension too tight, and/or L-limit screw too tight, and/or rotation cage is off	Check front index setting Check derailleur rotation and L-limit screw setting
Chain shifts well to largest front chainring but outer cage rubs after shift is completed	Front derailleur cable tension too loose	Increase front derailleur cable tension
Chain skips under load at front chainrings	Front chainring worn	Replace chainrings

derailleur to the movement on a new derailleur. The cage may also be gouged or damaged from dragging on a chain. Front derailleurs typically have no replaceable parts and, when the derailleur wears out, should be replaced as a unit.

TROUBLESHOOTING DERAILLEUR SYSTEMS

Poor or inconsistent shifting can be the result of several problems or combinations of problems. It is often necessary to check each part of the shifting system to find the problem and solve it (Table 9.1).

ELECTRONIC SHIFT DERAILLEURS

Electronic derailleurs use an on-board battery to power servomotors housed in the front or rear derailleur linkage. The motors move the derailleurs and push the chain to the appropriate sprockets. Each shift lever has switches to move the derailleurs inward and outward. Wires connect the electronic switches to a shift-interface unit, and this unit sends signals and power to the derailleur. Microprocessors in the system position the derailleurs correctly over the sprockets. These systems must be used with compatible rear and front sprockets, as well as a compatible chain.

SHIMANO® DI2® INTELLIGENT SYSTEM

The Shimano® Di2® electronic shifting system is available in the Dura-Ace® and Ultegra® product lines. Shifting and adjustment are the same in both models. The systems use switches housed in the brake levers, two junction boxes to route the electronic wiring, and a front and rear derailleur containing the shifting motors. Extra shifting switches can be added at additional locations such at the end of aero bars or along the handlebars.

Shifters

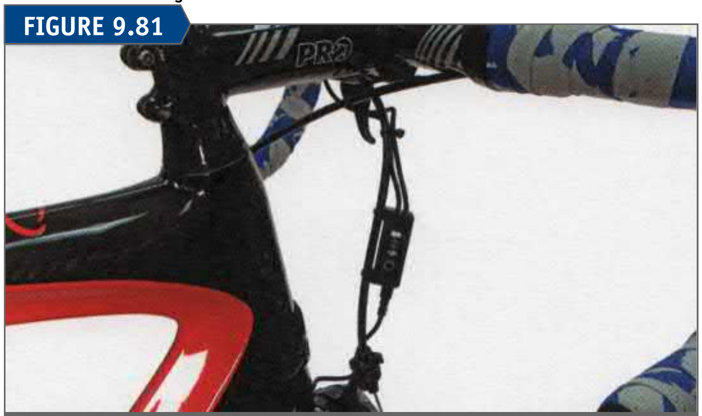
The left and right integrated shift/brake levers contain two electronic switches each (figure 9.80). The switches are similar in location and function to the STI® mechanical shifters. The Shimano® mechanical integrated system will shift the chain to larger sized sprockets when the brake lever blade is pushed inward. A small lever behind the blade will shift the chain to smaller sized sprockets. The Di2® system copies the concept, but the brake lever blade does not pivot inward. The "X"

FIGURE 9.80

"X" and "Y" switches located at brake lever switch on the side of the blade is used for shifting to larger sized sprockets. The "Y" switch is located behind the brake lever blade and permits shifting the chain to smaller cogs.

The shift levers contain microprocessors that control the derailleurs. Electronic shift wires plug into sockets at each lever and run to the "front junction box" (figure 9.81). This junction box is typically located near the stem and is used for fine-tuning the shifting of both derailleurs and for checking the battery charge. A single wire runs from the front junction box to the rear junction box.

FIGURE 9.81



Front junction box secured to housing. Under the stem is another option.

FIGURE 9.82

Externally mounted rear junction box below the bottom bracket shell

The rear junction may be located underneath the bottom bracket for externally wired bikes (figure 9.82). Some frames can also be fitted for internal wiring, with the rear junction box located inside the frame near the bottom bracket (figure 9.83). Electronic shift wires connect the front and rear derailleur to the rear junction box.

The electronic shift wires are small and should be handled with care. When installing or removing the wires from their plugs, it is recommended you use the Shimano® TL-EW02™ tool. This tool has a pronged fork end for plug removal and a socket end for plug installation (figure 9.84).

Inspect the shift wire routing. Secure any loose wire that may snag on projecting objects with small zip ties or tape. Handlebars must be free to rotate fully to the left and right without binding the wires. However, excessive wire slack may lead to the wire being caught, pulled, and damaged.

FIGURE 9.83

Rear junction box for internal wiring hidden in the frame

FIGURE 9.84

Use the Shimano® special wire tool for plugging and unplugging wire in shift levers

Di2® Battery

A lithium ion battery powers the motors in the derailleurs. Bike manufacturers may locate the battery externally, such as on the down tube, below the bottom bracket; or it may be located internally, such as inside the frame or the seat post, as noted above. Shimano® offers a charger that will plug into the front junction box. An internal battery need not be removed for charging with this system option.

Externally mounted batteries are removed for charging. For bracket-mounted batteries, pull outward on a quick release lever and push the release button. Pull battery to remove. To install, push the battery fully into holder. Close the quick release lever to secure the battery (figure 9.85)

FIGURE 9.85

Removing the Di2 battery from the battery bracket

How long a battery charge lasts will vary according to riding conditions, the number of shifts, and the age of the battery. However, anticipate approximately 1,000 miles between charges for a battery in good condition. Extreme cold may shorten the charge life of the battery. Allow at least 90 minutes of charging time for a full charge.

The battery charge level may be checked at the shift lever switches. For either front or rear shift levers, begin first by shifting to the smallest sprocket. Press and hold the Y-switch for approximately two seconds until the front junction indicator light comes on (figure 9.86). A full or nearly full battery charge will show a green indicator light for 2 seconds. A 75–50% battery charge will flash green five times. A 49–25% battery charge will illuminate red for 2 seconds. A battery with 24–1% charge will flash red five times. If there is no charge in the battery, the indicator light will not illuminate, and the derailleurs will simply stay in the current gear.

FIGURE 9.86

Press Y-switch and watch for lights at the junction box

If you will not be riding the bike for a long period of time, such as 2 months or more, remove the battery from the bike and occasionally recharge the battery fully.

Like all lithium batteries, never dispose of the Shimano® battery by throwing it in a landfill. Ask your retailer for disposal and recycling information. Batteries eventually wear out with time and use. If the battery will not accept a charge it should be replaced.

Front Derailleur

The front derailleur is available in a clamp-on style or a braze-on style. The braze-on model uses a rotation angle screw, or "support bolt," which braces the front derailleur against the frame and sets the angle of the cage relative to the chainrings.

There are three adjustment screws in the braze-on models. Height is set with the mounting screw. Rotation is set with the rotation angle screw. There are separate screws to set the H-limit and L-limits (figure 9.87).

The front derailleur cage can be safely pulled manually to the outside to assist setting its height over largest ring. Set the clearance to approximately 2 mm over largest chainring teeth. For the braze-on derailleurs, set the cage rotation using the angle rotation screw. The screw pushes against the frame and flexes the cage to the right, as seen from the rear of the bike. (Figure 9.88)

FIGURE 9.87

Front derailleur and adjustment screws

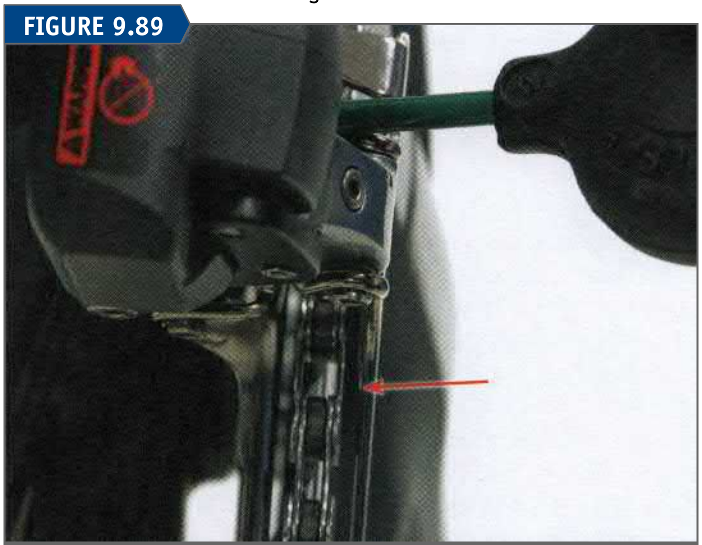
FIGURE 9.88

Setting angle of the cage in the braze-on type derailleur

Procedure for front derailleur adjustment:

a. Set L-limit screw. Shift to the smallest front ring and the largest rear cog. This will automatically trim the front cage inward.
b. Turn the L-limit screw clockwise to move the cage outward until the inner cage of the derailleur begins to contact the chain, and then loosen until there is a slight gap between the chain and inner cage of no more than 0.5 mm.

FIGURE 9.89



Sight gap from chain to cage while setting H-limit screw

c. Set H-limit screw. Shift rear derailleur to the smallest cog and front derailleur to the largest chainring.
d. Turn the H-limit screw clockwise to move the cage outwards. Turn the H-screw counter-clockwise to move the cage inward. Set derailleur for a slight gap of no more than 1 mm between outer cage and outer plate of chain (figure 9.89).
e. Test shifting performance. If shifting is slow or hesitant, double-check height, rotation, and limit screw settings.

Rear Derailleur

The rear derailleur attaches to the derailleur hanger like any mechanical derailleur. It is important for the electronic shifting system that the hanger be parallel to the cogs. Check alignment of the hanger with the Park Tool DAG-2 Derailleur Alignment Gauge. The derailleur uses limit screws similar to a mechanical derailleur. The function of mechanical type adjusting barrels is built into the electronics.

Derailleur indexing is adjusted by using the shifting mode switch on the front junction box. On a mechanical derailleur, the adjusting barrel effectively lengthens or shortens the housing ("tightening" or "loosening" the cable). This moves the upper guide pulley (the G-pulley) slightly left or right under the cogs and then holds that relative position for all indexing shifts in the normal shifting mode.

The index setting method used on the Di2® is analogous to the cable barrel adjustment of the mechanical derailleurs, but it is performed by means of small adjustments of the solenoid made at the front junction box. The adjustment mode uses the rear shifter to move the guide pulley a very small amount and then hold that position. Each push on the X-switch moves the guide pulley inward approximately 0.2 mm. Each push on the Y-switch moves the pulley outward the same amount. The switches are used to position the derailleur under the cogs.

The rear Di2® derailleur motor is designed to move the derailleur cage and guide pulley and to stop under the cogs. The derailleur also uses H-limit and L-limit screws to help prevent any over-shift beyond the cassette cogs. The H-limit screw stops pulley movement beyond the smallest sprocket, and the L-limit screw stops pulley movement beyond the largest rear sprocket.

The B-screw (body screw) setting is the same as on a mechanical unit. Increase or decrease tension as needed until the upper pulley is close to the largest rear sprocket when the chain is on the smallest front ring. Rotate the cranks backwards, and inspect for contact between upper pulley and chain. Tighten B-screw until contact stops.

Procedure for rear derailleur adjustment:

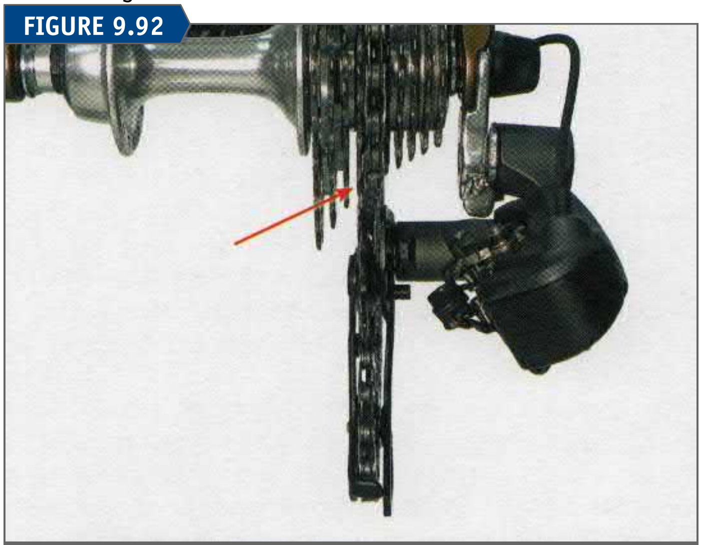
a. Shift rear derailleur to one of the middle cogs (figure 9.90).
b. Push the button at the front junction to enter Adjustment Mode. Look for the red adjustment light to illuminate (figure 9.91). The front junction will stay in Adjustment Mode for approximately 60 seconds. **Note:** pressing the button for several seconds will reset the derailleur from the "safe mode" and will make an audible beep when completed.
c. Rotate the cranks to allow shifting and sight the upper pulley relative to the cog. Press the X-lever continuously to move the pulley inward until you hear a noise from the pulley being too far inward and the chain is rubbing the next-innermost cog (figure 9.92). Press the Y-lever approximately four times until the chain noise is quiet and the chain is no longer rubbing the next-innermost cog.
d. Press button on front junction box to lock adjustment setting and to return bike to Shift Mode. Test all other

FIGURE 9.90

Shift to middle cogs to adjust rear derailleur

FIGURE 9.91

Press and release button at junction box to enter Adjustment Mode

FIGURE 9.92

Use adjust mode to move cage too far inward before moving outward until quiet

rear sprockets. Return to Adjustment Mode if necessary to fine-tune a particular gear. Similar to mechanical systems, it is often necessary to fine-tune in several positions to find a setting that works in all gear combinations.

e. Set L-limit screw. Shift derailleur to largest sprocket. Look under the derailleur and tighten the limit screw to contact the linkage in this position (figure 9.93). Test adjustment by shifting between two largest sprockets. If chain is slow to shift to largest cog, or the chain will not stay on largest cog, loosen L-limit screw ¼ turn and test again.

FIGURE 9.93

Tighten L-limit screw until lightly contacting linkage

FIGURE 9.94

Tighten H-limit screw until lightly touching, then loosen ¼ turn

f. Set H-limit screw. Shift to smallest sprocket. Sighting under the derailleur body, tighten the H-limit screw until it contacts linkage, and then loosen ½ turn counter-clockwise (figure 9.94). This loose H-limit setting allows a slight over-shift designed into the electronic shifting. Test the shift by rotating the cranks and switching the chain between the two outermost cogs.

g. Set B-screw as with mechanical derailleurs. Shift to small front ring and largest rear cog. Rotate cranks and inspect upper pulley to cog clearance. If cog is striking pulley, tighten B-screw.

Crash Feature

The rear derailleur has a built-in protection feature to help in case of a crash. During an impact, the connection between the solenoid motor and the parallelogram opens, and the rear derailleur will no longer operate. This is designed to help protect the system when the bicycle falls over. To reset the system, press the button on the front junction for at least 5 seconds to reconnect the solenoid to the parallelogram. Double-check the shifting and fine-tune the derailleur, using the shift adjust mode as necessary. If the adjustment has significantly changed, it may be an indication that the hanger has been bent. Check alignment with the Park Tool DAG-2 Derailleur Alignment Gauge.

CAMPAGNOLO® EPS® DERAILLEURS: SUPER RECORD®, RECORD®, AND ATHENA®

The "Electronic Power Shift" (EPS®) from Campagnolo® has six basic component parts. There are two integrated shift/brake levers, two derailleurs, a combined shift-interface unit, and a battery. All are connected with proprietary wires and plugs (figure 9.95). The integrated shift/brake levers look and function like the mechanical cable shifting versions. The right integrated lever controls the rear derailleur and the left lever controls the front derailleur.

FIGURE 9.95

Pull rubber hood to expose cover to brake lever wiring

The rear integrated shift/brake lever on the right side has two electronic switches and a mode-button. There is a switch located directly behind the braking lever, which is used to shift the rear derailleur inward to the larger sprockets. Your fingers operate this paddle-shaped switch, referred to here as the "paddle-switch." The thumb operates a smaller switch inboard of lever body to move the rear derailleur outward to smaller sprockets. This will be called the "thumb-switch." The mode-button is located behind the thumb-switch, and is used to adjust the system and check the available battery reserve.

The integrated shift/brake lever on the left also has two switches and a mode-button (figure 9.96). The paddle-switch moves the front derailleur outward to the large chainring.

FIGURE 9.96

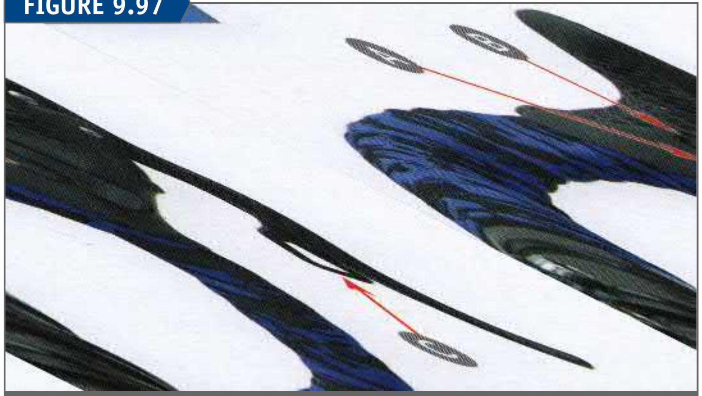
Locations of mode-button (A), thumb-switch (B), and paddle-switch (C)

The thumb-switch on the inboard side of the left lever body moves the front derailleur inward to the small chainring. The lever also has a mode-button behind the thumb-switch. The two mode buttons can be used independently to adjust their respective derailleurs or simultaneously to initially set up the system. Either mode button can check the battery charge level.

The rear derailleur has a built in dwell feature where it will move slightly beyond the intended cog and then move back under the intended cog. This is best seen when the bike is in the stand. Shift the bike and watch how, after a hesitation, the guide pulley will correct itself to align under the sprocket. The front derailleur has an automatic trim feature and will move slightly left or right to correct chain rub on the front derailleur cage as the rear derailleur moves the chain laterally left and right.

The system should be turned off when performing any mechanical work such as positioning or mounting a derailleur, or plugging and unplugging electronic cables. Insert the battery magnet supplied with the system into the back of the battery. The magnet must be removed to operate or adjust any of the electronic features of the system (figure 9.97).

FIGURE 9.97



Remove shut-off magnet before setting gear adjustments

EPS® Rear Derailleur Adjustment

The EPS® rear derailleur is designed for the spacing of the Campagnolo 11-speed cassette cogs. The electronic shifting processor controls the range of rear derailleur motion and stops the derailleur cage appropriately under each sprocket. The derailleur also has mechanical H-limit and L-limit screws that act as redundant safety limits to the derailleur's motion at the two outer cogs. Normal shifting and stopping at these outer- and innermost cogs, however, is determined electronically.

There are two different adjustment procedures. The "zero-setting" is done to set the full range of the rear gears or front chainrings. The zero-setting clears the derailleur of all previous settings, and the derailleur must "learn" the position of the cassette by being adjusted to the second and tenth position cogs. The "ride-setting" is analogous to a mechanical index cable adjustment, and is used to fine-tune the alignment of the derailleur, if necessary.

During adjustments, the left side of the shift-interface unit will indicate the current mode of adjustment via the color of the LED light on the shift-interface unit. When making the adjustments described below, you have approximately 40 seconds after the last use of the lever switch to make other adjustments before the adjustment mode shuts off. Should you allow 40 seconds to elapse, the system will return the previous adjustment setting; it will not hold your latest work unless you lock in the setting by pressing a mode button briefly.

It is safest to always adjust the bike in a repair stand rather than adjusting while riding.

Procedure for zero-setting EPS® rear derailleur:

a. If in place, remove the shut-off magnet from the battery.
b. Shift rear derailleur to largest (innermost) rear cog. Shift front derailleur to the largest (outermost) chainring.
c. Simultaneously push both front and rear mode-buttons and hold for at least 6 seconds. Watch for solid blue light at shift-interface (figure 9.98).

FIGURE 9.98

Watch for blue light on shift-interface

d. Rotate the cranks to allow shifting. At the right side lever, push and hold the thumb-switch to move the rear derailleur to the second-smallest (second position) rear cog. Pushing the lever will move guide pulley in continuous motion, not in an indexing mode. Use care to stop on second position cog and not shift outward into the frame or dropout. Use paddle-switch if you have shifted too far, returning the chain to the second position cog (figure 9.99).
e. Fine-tune position of guide pulley to second position cog. Blue light at shift-interface should still be on at this time. Rotate the cranks, and inspect position of guide pulley relative to the second position cog. Push paddle-

FIGURE 9.99

Move rear derailleur to second smallest cog switch to move pulley inward slightly. Push thumb-switch to move guide pulley slightly outward. Adjust guide pulley using switches for the rear shifter so chain runs quietly and smoothly on this second-smallest rear cog.

f. On rear shift lever, push and release mode-button once. Inspect for a white light at shift-interface LED (figure 9.100).

FIGURE 9.100

White light of the shift-interface

FIGURE 9.101

Move derailleur to second largest rear sprocket

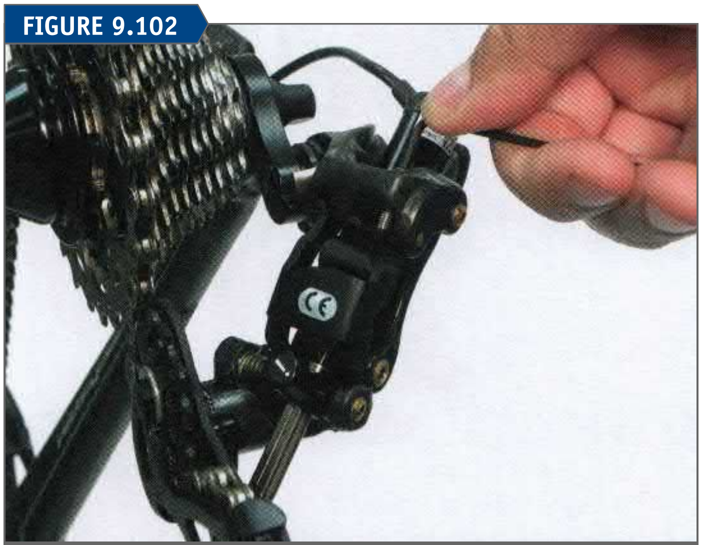
g. Rotate the cranks to allow shifting. Press and hold paddle-switch on right lever to move chain to the second-largest rear sprocket (tenth position cog) (figure 9.101). Chain will move continuously.

h. Fine-tune chain position for quiet running in the tenth position using switches for rear shifter. White light is still on at shift-interface. Inspect pulley and chain as you rotate the cranks. Push paddle-switch to move guide pulley inward toward spokes. Push thumb-switch to move pulley slightly outward. Adjust guide pulley so chain runs quietly under tenth position cog.

i. Push mode-button at rear shifter once and release. Inspect for shift-interface LED light to flash blue three times. The rear derailleur adjustment is now stored in the shifting processors. If the mode-button is not pushed, the adjustment will not be stored and will be lost within 40 seconds. You must begin again to set derailleur adjustments.

j. Test shift by shifting to all gears with rear derailleur.

FIGURE 9.102



Tighten L-limit screw until contact, and proceed to loosen approximately ¼ turn

k. Shift derailleur to largest sprocket. View derailleur from backside and turn L-limit screw to contact derailleur linkage and turn counter-clockwise ¼–½ turn (figure 9.102). This limit screw helps to prevent the derailleur from shifting beyond the last cog into the spokes.

The B-screw is adjusted after the rear derailleur zero-setting is finished. The EPS® B-screw setting is similar to Campagnolo® mechanical models. Put the front derailleur on the small chainring and the rear derailleur on the largest rear cog. Inspect for a guide-pulley-to-cog clearance of 5–7 mm. Adjust the B-screw located at the cage pivot. Tightening the B-screw brings the guide pulley closer to the sprocket. Loosening the B-screw moves the pulley further away.

EPS® Front Derailleur Adjustment

The front derailleur is fitted with an electronic motor to drive the derailleur cage left and right. The battery uses digital technology to communicate simultaneously with the rear and front derailleurs. This permits the EPS® system to make adjustments to the position of the front cage depending upon the chain position on the rear sprockets. The front derailleur assumes the bike is using the Campagnolo® crankset and will shift according to that spacing.

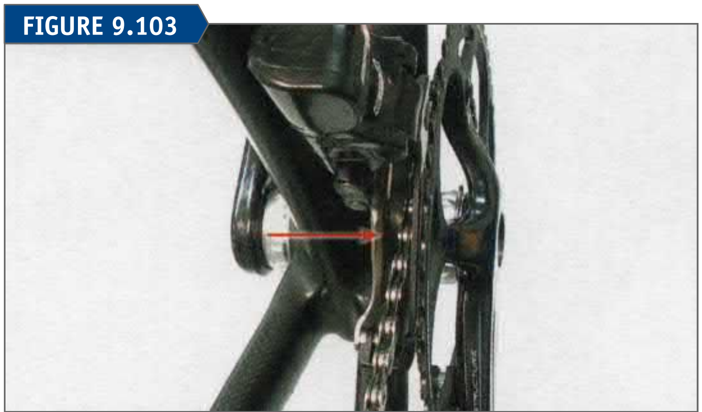
Procedure for zero-setting EPS® front derailleur:

a. Shift rear derailleur to largest rear sprocket and front derailleur to largest chainring.

b. Depress and hold both shift lever mode-buttons for 6 seconds. Hold until a solid blue light comes on in the shift-interface LED.

c. Rotate the cranks. Push and release the left side thumb-switch once. Next, rotate the cranks and hold down thumb-switch to move chain to the small chainring. Rotate the cranks slowly and inspect the derailleur as it moves to the closest approach between chain and inner derailleur cage. Stop rotating the cranks and use this point to set clearance between cage and chain. Use paddle-switch and thumb-switch to adjust front derailleur cage for a small gap of 0.5–1.0 mm between chain and inner cage of derailleur (figure 9.103).

FIGURE 9.103



Set gap at chain-to-cage to be 0.5–1.0 mm

d. Push mode-button on left lever and watch for the LED light flashing blue three times.

e. Test shift of front derailleur between large and small chainrings. Test front shift with rear derailleur on largest rear sprocket and repeat front shift test with rear derailleur on smallest rear sprocket. If necessary for either large or small ring, use ride-setting to fine-tune adjustment. For example, if front derailleur cage strikes crank as bike is pedaled, use front derailleur ride-mode in large chainring to fine-tune the setting.

EPS® Derailleur Ride-Setting

The ride-setting is used to fine-tune the shift if you are on a ride and it seems out of adjustment. The ride setting will not change the derailleur's extreme range of travel. Ride-setting offers a way to fine-tune either the front or rear derailleur. Although this procedure is called the ride-setting, it is best done by having someone hold the bike while you perform the adjustment rather than riding the bike while you make adjustments.

Procedure for ride-setting EPS® rear derailleur:

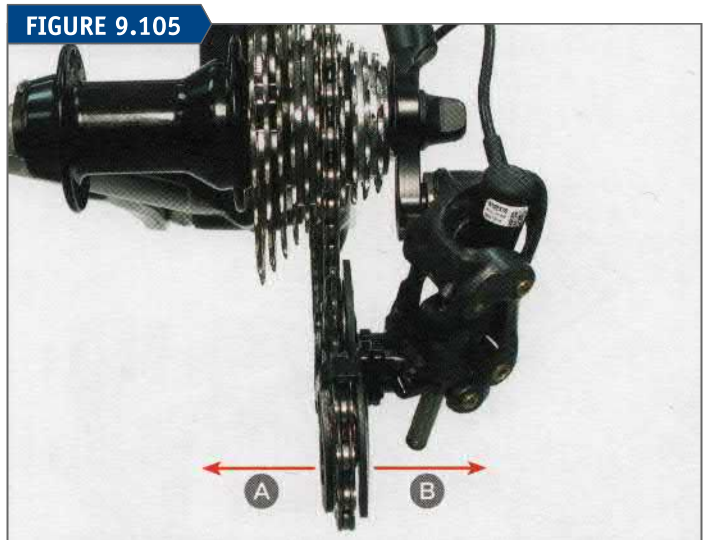
a. Depress and hold mode-button on the right lever for 6 seconds. Watch for a solid purple light at the shift-interface (figure 9.104).

FIGURE 9.104

Set shift-interface to rear derailleur adjust mode

b. Rotate the cranks and note position of guide pulley relative to the rear cog the chain is currently engaged on. Using the thumb-switch and the paddle-switch, move the guide pulley in small, incremental amounts (figure 9.105). Position the pulley and chain for quiet running on the sprocket.

FIGURE 9.105



Position for quiet running under sprocket using paddle-switch to move derailleur inward (A) and thumb-switch to move outward (B)

c. After the guide pulley is adjusted, push and release the mode-button to lock this setting. The LED light will flash three times to confirm the bike has returned to normal cog-to-cog shifting.

d. Rotate the cranks and shift rear derailleur to test setting. Repeat adjustment if necessary.

Procedure for ride-setting EPS® front derailleur:

a. If ride-setting to the large front ring position, shift chain to smallest rear cog. If ride-setting to the small front ring position, shift chain to largest rear cog.

b. Press and hold mode-button on the left lever for 6 seconds. Watch for a solid purple light at the shift-interface.

c. Rotate the cranks and note position of front cage relative to chain (figure 9.106). Ride-setting will only fine-tune position on the chainring it is currently on, do not use ride-setting mode to shift chain to a different ring. Use left side thumb-switch or paddle-switch to move cage small, incremental amounts. For the large front chainring, position outer cage close to chain but not touching. If ride-setting the small front ring, position inner derailleur cage close to chain but not touching.

d. Push and release the mode-button to lock this setting. The LED light will flash purple three times to confirm the bike has returned to normal shifting.

FIGURE 9.106

Check for small gap between outer cage and chain

e. Shift bike between both front chainrings. Repeat front shift with chain at the two extreme chainline positions. Test with chain in largest rear cog and then in the smallest rear cog.

Crash Mode and Ride Home Mode

Should the bike fall over or crash, the rear derailleur cage may "disengage" from the detents in the shifting mechanism. The cage will be pushed inward to help prevent damage. It is recommended someone on the ride help by holding the bike while you hand pedal and adjust the bike. To return the derailleur to proper shifting, rotate the cranks while supporting the main body of the derailleur, and pull the cage outward until you feel it stop. Continue rotating the cranks and depress the rear thumb-switch to get the cage to the smallest rear cog. Carefully shift to each rear gear using the paddle-switch and note the alignment of the guide pulley under the cogs. After any crash on the right side of the bike, inspect for a bent derailleur hanger.

The EPS™ rear derailleur also has a "ride home" feature where the cage can be manually pushed inward from the current sprocket position. This is useful should the battery fail or a wire become disconnected or cut. Manual shifting of the bike is done off the bike. Hold the main body of the derailleur and push the cage inward to larger sprockets while rotating the cranks (figure 9.107). The cage cannot be pulled outward beyond the position it was in when the battery died. After charging a dead battery, perform a full zero setting adjustment on both derailleurs.

The front derailleur has no crash mode or ride home mode. It cannot be manually pushed to different chainrings.

FIGURE 9.107

Push lower pivot of derailleur inward to manually shift

EPS® Battery and Charging Unit

To test the battery capacity, push either mode-button once and release. Inspect shift-interface LED color for an indication of the remaining battery charge:

- Solid green: 60–100%
- Flashing green: 40–60%
- Solid yellow: 20–40%
- Solid red: 6–20%
- Flashing red, with buzzer noise at battery: below 6%

Use only the Campagnolo® EPS® battery charger to charge the battery. Be sure the plug connection at the battery is fully dry before plugging into the charging unit. The battery charger includes a built in LED display. An orange LED indicates the unit is in the process of charging. A green LED indicates charging is complete. The battery requires approximately 4 hours to fully charge a battery with no reserve.

Troubleshooting

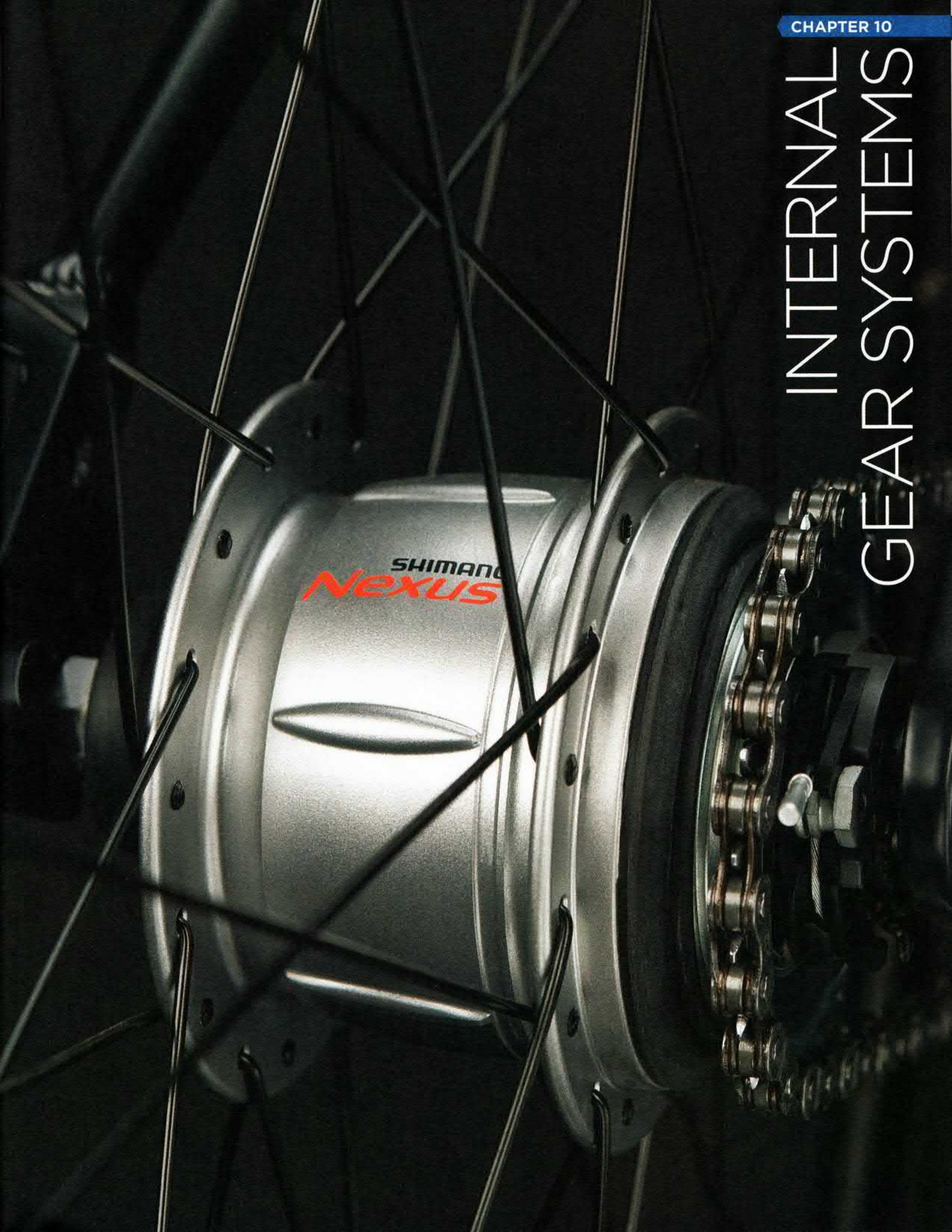
Campagnolo® designed the battery LED to be useful in diagnosing problems. Inspect for the color of the light at the LED window. If the solutions below do not return the system to working order, contact an authorized Campagnolo® Service Center.

- White: Battery system problem. Press mode-button once and attempt shift.
- Yellow: Front derailleur problem. Press mode-button once and attempt shift. Readjust front with zero-setting procedure if necessary.
- Green: Rear derailleur problem. Press mode-button once and attempt shift. Readjust rear with zero-setting procedure if necessary.
- Blue: Front derailleur switch problem. Press mode-button once and attempt shift. Readjust with zero-setting procedure if necessary.
- Purple: Rear derailleur switch problem. Press mode-button once and attempt shift. Readjust with zero-setting procedure if necessary.
- Red: Shift-interface problem. Press mode-button and attempt shift again.

See the Campagnolo® website for a useful troubleshooting chart. Campagnolo® recommends cleaning bikes with EPS® only by wiping with damp cloths. Full washing with water pressure may degrade the system.

CHAPTER 10

INTERNAL GEAR SYSTEMS



Internally-geared hubs allow for different gear ratio selections without a derailleur system. These hubs contain a series of gears called "planetary gears" that act as a transmission.

A center gear, called the "sun gear," is fixed to the axle and engages the outer gears known as the "planets." All planets are engaged into the "planet carrier" that drives the hub shell. Different planet gears engage or disengage the sun gear for a particular gear ratio. Internally-geared hubs use a special keyed washer and axles with flats that prevent the axle from rotating in the dropout (figure 10.1). Wheel installation, cable attachment, and gear adjustment are reviewed here. Internal hub service is best left to professional mechanics.

FIGURE 10.1

Keyed washer to prevent axle rotation

Internally geared hubs use one of the middle gears as the "neutral" or 100% of the front ring-to-rear cog ratio. This gear gives the same mechanical advantage as if the bike were a single speed. Gears on either side of this neutral gear will either reduce the gear ratio by some amount, or increase it. For example, the first gear of the SRAM® DualDrive™ hub reduces the gear to 73% of the middle position, and third gear increases it to 136% of the middle position.

SRAM® DUALDRIVE™

The SRAM® DualDrive™ hub offers three internal gear choices. The hub is also fitted with a freehub and cassette that is shifted by a derailleur. The internal hub gears can be viewed as a replacement of the three front chainring choices.

Internal hub gears are shifted through a small rod on the right side of the axle. The shift rod attaches to the "click-box," which pulls the shifting rod engaging different combinations of planetary gears inside the hub. The wheel can be removed to service the tire and tube, and the cable can be replaced.

Procedure for wheel removal:

a. Shift internal shift lever toward lowest gear range (to the left). Shift the external derailleur to smallest rear cog on derailleur.
b. Push button on click-box downward to release box from shifting rod. Pull box off of right side axle (figure 10.2).
c. Loosen left and right axle nuts. Shifting rod may remain in the right side of the axle, but use care not to bend or damage rod.
d. Remove wheel from bike.

Procedure for wheel installation:

a. Install wheel in frame and align. Use care to position special alignment washer in frame dropout.

FIGURE 10.2

Remove click-box to access axle nuts

b. Secure axle nuts fully.
c. If shifting rod was removed, reinstall and gently secure with screwdriver.
d. Push button downward on click-box and install box on axle by pushing box against axle nut.
e. Push click-box button upward from below to engage lever arm on to shifting rod. Test by pulling gently on click-box away from hub to ensure it is seated on the axle threads.

The rear derailleur is adjusted as any other derailleur system. See Chapter 9, Derailleur Systems, for rear derailleur adjustments.

The internal gears of the DualDrive™ are adjusted by changes in cable tension from the shift lever. To adjust the three internal gears, shift lever to the middle position. Inspect inside the window of the click-box for the lever with a yellow mark. Use barrel adjusters to change cable tension and move yellow

FIGURE 10.3

Adjust cable tension until yellow mark aligns between marks

FIGURE 10.4

Cable access of the SRAM® double control lever mark to adjustment mark on window of click box (figure 10.3). Test adjustment by shifting to all three possible positions.

The DualDrive™ system has two cables at the shift lever. One wire shifts the derailleur. A second cable shifts the rod at the click-box. The derailleur cable installs under a ring-cover, which is held by a screw. Disconnect cable from rear derailleur and remove screw-on ring-cover at lever. Pull cover outward to expose cable end and push out old shift cable. Lubricate new cable and install through hole left by old cable. Push cover to lever, install screw, and secure (figure 10.4).

Procedure for internal shift cable installation:

a. Remove click-box as described in wheel removal above.
b. Remove back end of click-box. Hold main body of box and push downward on corner end of click-box (figure 10.5).
c. Loosen cable pinch bolt inside click-box and pull cable from click-box.

FIGURE 10.5

Hold click-box and pry corner down and away

FIGURE 10.6

Remove and install cable at shift lever

FIGURE 10.7

Pull cable snug and secure pinch bolt

d. At shift lever, remove cover over internal shift cable (figure 10.6).
e. Push old cable from lever. Lubricate and install new cable and route though lever and housing back to click-box. Thread barrel adjuster fully into click-box.
f. Thread cable into pinch bolt mechanism. Push click-box to housing end cap, while pulling back on lever. Secure pinch bolt (figure 10.7).

SRAM® I-MOTION® 9

The I-Motion® 9 hub offers nine different gear ratios. The sixth position used for adjusting the hub gears. It is necessary to detach the shift cable when removing the wheel. Internal hub service should be left to professional mechanics.

Procedure for wheel removal:

a. Turn shifter to first gear.
b. Slide quick-disconnect sleeve on connecting tube and slide it away from hub.
c. Pull connecting tube down and away from hub fitting (figure 10.8).

FIGURE 10.8

Remove connecting tube

d. Loosen axle nuts. Remove coaster arm locking bolt if applicable.
e. Remove wheel.

Procedure for wheel installation:

a. Install washers with serrations toward frame. Washer lugs must fit into dropouts to prevent axle rotation.
b. Tighten drive side then non-drive. Check and correct chain tension as necessary.
c. Install and secure coaster arm locking bolt if applicable.
d. Move shifter to first gear.
e. Open quick disconnect sleeve and connect catch to shifting stud at hub.

Procedure for gear adjustment:

a. Shift bike to seventh gear, then shift to sixth gear.
b. View window at right side of hub for red and yellow marks.
c. Use barrel adjuster at the connecting tube and adjust cable tension until yellow marker on moving indicator aligns with red marker of hub (figure 10.9).
d. Test gears by shifting through gear range.

Procedure for cable change:

a. Shift to first gear.
b. Remove quick-disconnect sleeve from hub.
c. To remove old cable, pull at connecting tube away from housing and cut cable.

FIGURE 10.9

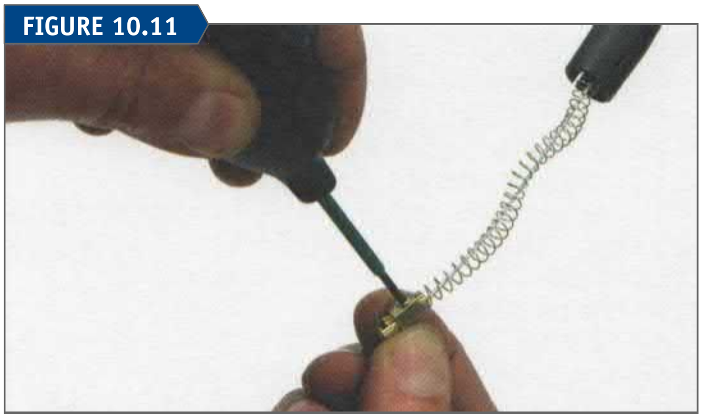
Align marks through window to adjust gears

d. Remove adjusting barrel from connecting tube.
e. Remove coil spring, remaining shift wire, and connection nipple from connecting tube. Loosen setscrew in connection nipple and remove old cable.
f. Using a small-tipped screwdriver, remove cable cap from shift lever. You may need the screwdriver to also help pull the head of the cable out. Push cable while engaging cable end with tip of screwdriver (figure 10.10).
g. Install new cable through shift lever. It can be helpful to slightly bend end of new wire to feed it through bend in lever.
h. Route new cable through housing. Ensure all end caps are fully pressed onto housing.
i. With shift lever in first gear and housing fully seated, cut cable a distance of 105 mm (4⅛ inches) past the housing end cap.

FIGURE 10.10

Remove cable from shifter

FIGURE 10.11



Secure shift wire setscrew

j. Install adjusting barrel and coil spring over wire.
k. Carefully compress coil spring over cable and install connection nipple onto end of cable. Secure setscrew to hold cable (figure 10.11).
l. Install connection nipple and cable into connecting tube. Asymmetrical shape of nipple will fit tube in only one orientation. Nipple should be visible at end of tube with open end facing hub connection stud.
m. Thread barrel adjuster fully on to connecting tube.
n. Install quick-disconnect sleeve to hub and adjust hub gears as described above.

SHIMANO® NEXUS INTER-7®, NEXUS INTER-8®, & ALFINE® HUBS

The Nexus Inter-7®, Nexus Inter-8®, and Alfine® hubs use a "cassette joint" on the right side to actuate the gears. When installing wheel, it may be easier to work with the bike upside down. This allows the use of two hands to manipulate parts.

Procedure for wheel removal:

a. Shift lever to first gear on the indicator.
b. Remove housing for housing stop at hub cassette joint. Pull at housing end and disengage from housing stop (figure 10.12).
c. Detach cable anchor from cassette joint. Rotate anchor and lift it from hook in joint.
d. Loosen axle nuts and remove wheel. The cassette joint consists of three pieces and is held to the hub by a lockring. The cassette joint may stay together for wheel service. Turning the lockring lever counter-clockwise releases the joint. To install the joint, align a series of

FIGURE 10.12

Release cable from housing stop to detach anchor from cassette joint

FIGURE 10.13

Cassette joint of Inter hub system

yellow dots on the assembly. Turn lockring clockwise 45 degrees to lock cassette joint (figure 10.13).

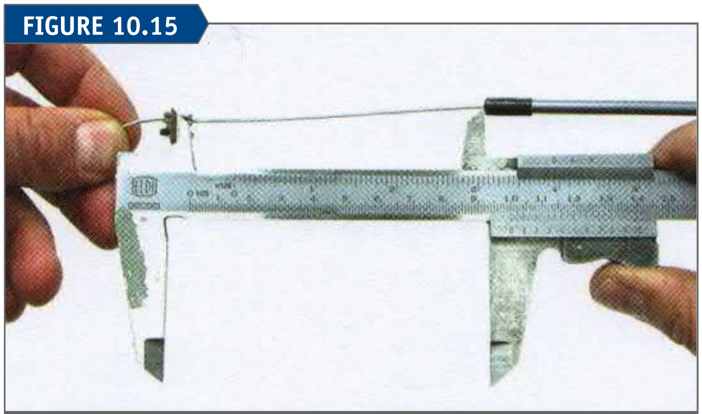
The hub axle uses special keyed washers to prevent the axle from rotating in the dropouts under load. Align the cable-housing stop of the cassette joint so it points toward the shift cable. For hub models with coaster or band brakes, secure left side braking arm to frame. Install wheel and adjust chain tension as on a single-speed system.

The common shifter for the Inter hub systems is the Revoshift® shifter. To install a new shift cable, remove the cover screw and lift cover from lever body. Turn shifter to gear seven or eight, whichever allows better access to cable end. Push on exposed cable adjacent to barrel adjuster to gain cable slack. Use a small-tipped screwdriver to remove cable end from lever (figure 10.14). Install new cable first through barrel adjuster and then route cable back into cable end anchor. Install cover and cover screw and shift lever to first gear.

FIGURE 10.14

Shift cable attachment in Revo shift lever

FIGURE 10.15



Measure approximately 100 mm between end cap and center of pinch bolt

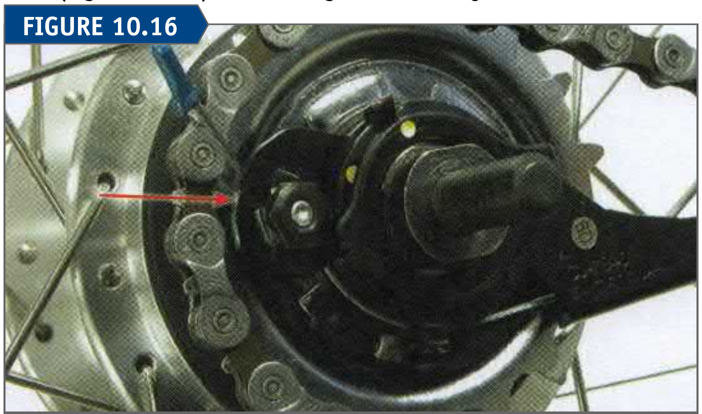
Route shift cable through housing to rear hub. A pinch bolt mechanism is used to attach cable anchor to cassette joint. Pull firmly on cable to ensure it is seated in the housing stops. Back out barrel adjuster approximately two turns from full engagement to allow adjustment. Secure pinch mechanism so there is a distance of approximately 100 mm from the end cap to center of bolt (figure 10.15). Secure nut; cable will flatten at pinch mechanism.

Gears are adjusted by alignment marks on the cassette joint. The marks are visible both from above and below the bike.

Procedure for gear adjustment:

a. If not already done, engage cable anchor bolt to cassette joint (figure 10.16).
b. For Inter-7® and Inter-8® hubs and shifters, shift to the fourth gear position. For Alfine® 11-speed, shift to the sixth position.
c. Use barrel adjust to align red marks on cassette joint (figure 10.17). Shift all gears after adjustment.

FIGURE 10.16



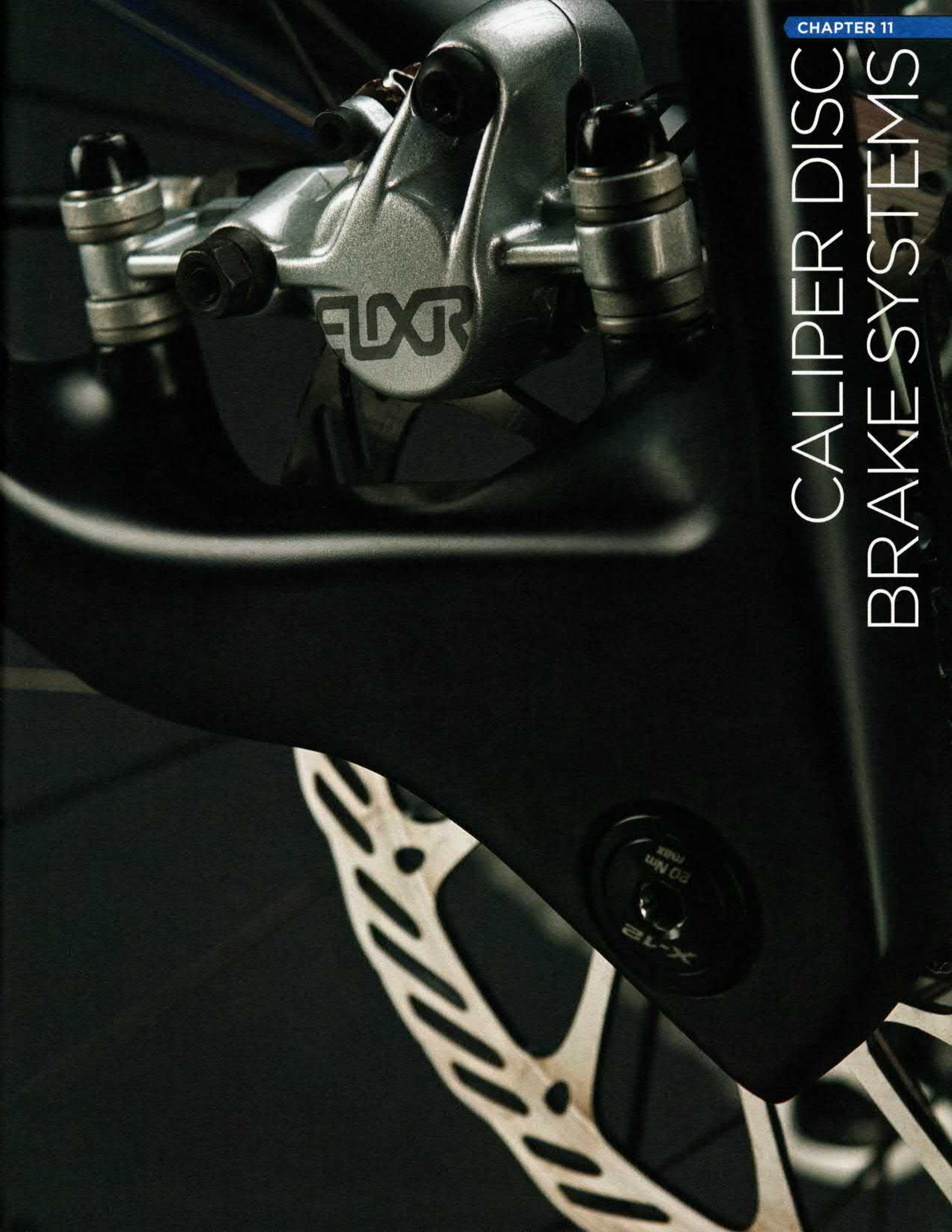
Engage pinch bolt into cassette joint

FIGURE 10.17

Align shifting adjustment marks at joint

CHAPTER 11

CALIPER DISC BRAKE SYSTEMS



Disc brake systems use a caliper brake mounted near the dropouts of the frame or fork end and rotor (disc) mounted to the hub. Disc brakes can be designed into many types of bikes including MTB bikes, road bikes, cyclocross bikes, hybrid, and road bikes.

Brake pads are housed in the caliper and are forced onto the rotor, which slows the bike by converting the speed of the bike into heat. Disc brakes can be effective in wet weather where mud, dirt, and water are a concern in braking. The system can generate significant heat from slowing the bike. Allow the rotor and caliper to cool before touching. The rotors are made of machined steel, and the edges can be sharp. Always use care when working with or around disc brakes and rotors. It can be also useful to move the skewer lever to the opposite side of the rotor to help prevent injury (figure 11.1).

FIGURE 11.1

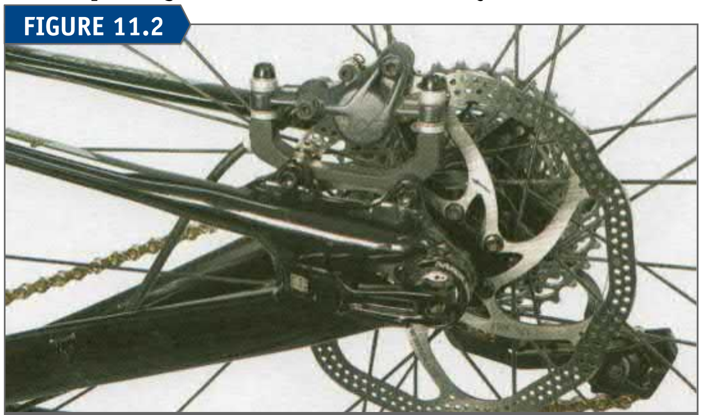
Front mechanical caliper and rotor

CALIPER TYPES

Disc brake systems can be either mechanical or hydraulic. Mechanical systems use calipers that are cable actuated, similar to rim caliper brakes, using brake cable housing and an inner brake cable pulled by the brake lever (figure 11.1).

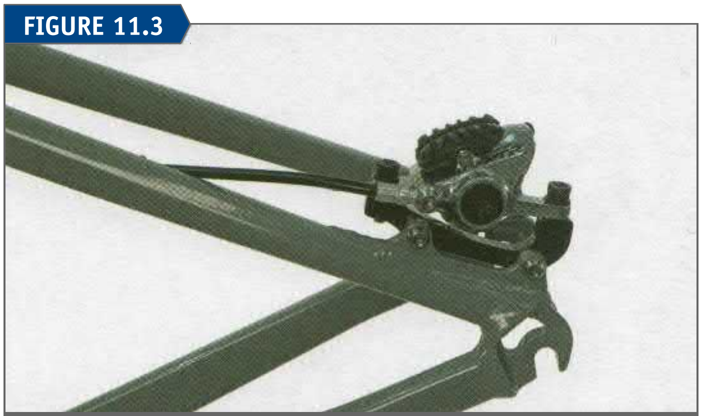
Hydraulic caliper systems use sealed tubing and pistons to move the brake pads (figure 11.2). Brake fluid travels from a piston at the lever to pistons behind the brake pads, which in turn push against the rotor. The brake system relies on the

FIGURE 11.2



Rear hydraulic caliper and rotor

FIGURE 11.3



International Standard (IS) disc brake caliper mountting system on rear seat stay

entire system being sealed and free of air bubbles when the lever is pulled.

Disc brake caliper bodies use two different mounting standards on the bicycle frame and fork. The International Standard (IS) uses two mounting tabs with unthreaded holes spaced 51 mm apart (figure 11.3). The caliper mounting bolts are positioned perpendicular to the face of the rotor. Calipers may be bolted directly to the mounting tabs, or the caliper may use an adaptor bracket that is secured to the tabs. Brackets are available in different sizes to allow for use of a larger or smaller rotor.

Another mounting system is the post mount (PM) (figure 11.4). Post mount systems allow most brake calipers to be directly mounted to the frame or fork without an adaptor bracket. Post mount caliper mounting bolts are parallel with the rotor. The mounting holes are spaced 74 mm apart with internal threading for M6 bolts. Adaptor brackets and spacers can be used to raise the caliper body, allowing the use of larger rotor sizes. Consult the frame or fork manufacturer if an adaptor is required.

FIGURE 11.4

Post Mount (PM) system on fork

BRAKE PADS

Each disc brake manufacturer designs pads compatible with their system. Pads do not interchange between most brands, although there are pad manufacturers making after-market pads for many different models.

Brake pads wear thin with use as they rub the rotor under pressure. Pads should never be worn down to where the metal holder is showing or contacting the rotor. Typically there should be a minimum of 3 mm pad thickness, but contact your brake manufacturer for their specifications.

Brake pads for both mechanical and hydraulic systems are available in various compounds (figure 11.5). Generally, a softer organic or resin material will tend to squeal less, which can be an issue in some systems. These will also offer the user more modulation. However, the resin type pads tend to also wear more quickly. The harder sintered or semi-metallic pads will last longer, especially in wet and muddy conditions, but also tend be noisier. Check the brake rotor before selecting pads. Some rotors are designed for resin pads only, and this will be printed on the rotor. Resin-only rotors will not hold up to the harder semi-metallic pads.

Brake pads should be kept clean of fluids, oil, and grease. Contaminated pads should be replaced. A light sanding with very fine emery cloth can help to clean marginal pads. Use isopropyl alcohol or acetone when cleaning dirt or oils from the rotor surface. Do not use a solvent or cleaner that contains oils or leaves an oily residue.

FIGURE 11.5

Left: Semi-metallic disc brake pad; Right: Resin disc brake pad

DISC BRAKE ROTORS

The rotor of the disc brake system secures to a disc-specific hub. The common system uses six bolts on a flange built into the hub shell. Rotor-mounting bolts are commonly M5 threading and use a Torx® T-25 size wrench (figure 11.6). Secure rotor bolts to manufacturer's torque specifications. Rotor design is commonly asymmetrical and directional. Inspect the rotor for rotational direction arrows before installing.

Disc hubs may also be designed with a splined fitting for compatible rotors. These are referred to as “center-lock”

FIGURE 11.6

Secure rotor bolts using the Torx® driver

FIGURE 11.7

Shimano® center-lock rotor lockring use the FR-5 lockring tool

FIGURE 11.8

Center-lock rotor on thru axle hub using the BBT-19

rotors and tighten to the hub with a lockring similar to a rear cassette lockring. Use the Park Tool FR-5 for lockrings with 12 internal notches sized like the cassette lockring (figure 11.7). Use the Park Tool BBT-9 for lockrings with 16 external notches, common on thru-axle hubs in both front and rear (figure 11.8).

Rotors are available in 140, 145, 152, 160, 180, 183, 185, 200, and 203 mm diameter sizes. The brake caliper, brake mount on the frame/fork, and rotor diameter must all be compatible. A larger rotor provides more leverage during braking, which results in a more powerful brake. Frame and fork design will limit the rotor size options. It is possible on some frames/forks to change rotor diameter by also changing the caliper mounting adaptor bracket. Different rotor brands are commonly interchanged between calipers, assuming the replacement rotor is the correct diameter.

FIGURE 11.9

An obvious step from pad wear requires rotor replacement

Braking will eventually grind and thin the rotors to where they must be replaced. A common manufacturer's minimum rotor replacement thickness is 1.6 mm. Measure caliper thickness and replace before it reaches this minimal tolerance. Replace the rotor if it has developed an obvious step at the braking surface where it is contacted by the brake pads (figure 11.9).

Rotors may become bent or warped with use and abuse. Some re-bending for alignment may be possible. The Park Tool DT-2 Rotor Truing Fork allows re-bending of the rotor (figure 11.10). It can be useful to number the rotor arms to better track the repair progress. Mount the bike in a repair stand and spin the wheel. Watch for a lateral wobble (runout) at the caliper pads, or hold the DT-2 close to the rotor as a truing indicator. Stop the wheel where it rubs and note the location and direction of the rub. Also note your reference number on the spider arm. Move the rotor out of the caliper body to permit bending, and use the DT-2 or adjustable wrench to bend this area slightly. Spin the wheel and check the rotor again. Repeat as necessary. If rotor true does not improve after several attempts, rotor replacement is the best option.

FIGURE 11.10

Move area to be re-bent away from the caliper body

Replacement rotors should match the intended brake pads. Some rotors are sold as "resin pads only." Do not use the sintered or semi-metallic pads with these rotors.

New rotors and new pads should be "burned in." The heat of burn-in helps remove solvents and any residue from the pads and rotors. Pad material is also transferred to the rotor face. To burn-in a new rotor, begin by cleaning it with alcohol or acetone. Under clean and dry conditions, ride the bike at speed on flat pavement and apply the brakes with force, as in a "panic stop," but do not skid the tires. Repeat this ten times for each brake. Use care when burning in the front brake that you do not flip the bike.

HYDRAULIC BRAKE SYSTEMS

Hydraulic brakes should be used with compatible lever and calipers. The designs of the primary and secondary pistons are proprietary. Do not mix brake levers and calipers between brands.

Hydraulic systems should be inspected at all fittings and hose connections for leakage and seepage on a regular basis. As in all hydraulic systems, it is important that there is no air in the tubing or lines between the caliper and the primary piston. Air bubbles in the line will compress and cause the brake to feel soft when the lever is pulled with force.

HYDRAULIC BRAKE LEVERS

Brake levers are positioned on the handlebar similar to conventional or non-hydraulic levers. Set the angle for comfortable reach when the cyclist is in the saddle. The lever reach from bar to lever is adjusted with a screw either behind or in front of the lever (figure 11.11). Turning the reach screw moves the lever relative to the handlebar. The reach adjustment screw does not move the pistons closer to the rotors. Set the lever reach for rider preference.

FIGURE 11.11

Brake lever reach adjustment screw on a Shimano® lever

FIGURE 11.12

Reservoir and bladder at brake lever

The hydraulic brake lever contains a piston called the "primary cylinder" (primary piston). When the lever is pulled, the primary cylinder pushes brake fluid down the sealed hydraulic line to a pair of pistons in the caliper body, and these push against the pads. The pads will press and rub against the rotor and this results in heat. The heat is dissipated at the rotor, but some heat will also transfer to the piston and fluid. Brake fluid expands as it picks up heat from the pads rubbing against the rotor. Hydraulic disc systems use a reservoir system that contains a bladder to allow for the expansion of the brake fluid. Some models use an "open system" while others use an enclosed bladder (figure 11.12). The primary piston is sealed from the reservoir when the lever is pulled but opens to the reservoir when the lever is fully open.

Some models of hydraulic brake levers can be rebuilt with new seals and primary pistons. This work is best left to professional mechanics.

HYDRAULIC DISC CALIPERS

Because the hydraulic fluid does not compress or flex under stress, hydraulic systems are considered more efficient and provide higher performance compared to mechanical disc systems. A spring inside the brake lever body pushes back the primary piston when the lever is released. This pulls the fluid back from the caliper pistons to retract them from the rotor face.

With use, dirt and moisture will gradually creep past the seals into the brake fluid, contaminating the brake fluid. Hydraulic systems should occasionally be bled and old fluid replaced, even if the braking is good and there is no air in the line. Changing fluid and bleeding once a year is typically an adequate fluid change interval.

When fluid change bleeding a brake it is critical to use the correct type of fluid when servicing brake system. Some manufacturers specify proprietary mineral fluids, while others use an automotive DOT brake fluid. The different types of brake fluid should never be mixed. Using an incompatible fluid may cause seals to fail and result in brake failure.

Automotive fluids are DOT (Department of Transportation) approved and are generally polyglycol fluids. The DOT fluids have different ratings, such as 3, 4, or 5. Contact the brake manufacturer for a specific recommendation. Automotive brake fluids are caustic and toxic. Work with care to avoid fluid contact with the outside of the lever, caliper, bike, and your skin. When available, use protective gloves, such as Park Tool MG-2 Mechanic Gloves. During any work with hydraulic fluid, clean spills on the bike, caliper, or lever with a rag and isopropyl alcohol or soapy water. DOT hydraulic fluids can damage paint finish. Bleeding tools and syringes for mineral fluid should not be used for automotive DOT fluid and *vice versa*.

When servicing hydraulic brakes, work in clean conditions. Use care to keep hydraulic pieces such as the bladder, bleed port screws, and any fittings clean and away from dirt.

The caliper pistons and piston seals will wear out with time and use and require replacement. Caliper body and piston overhaul is best performed by professional mechanics.

Hydraulic Brake Caliper Alignment

It can be difficult and awkward to view the caliper-to-rotor alignment because the pads are hidden inside caliper body. There are tight tolerances between pad and rotor. Work in well lit areas. It can help to place white paper, or equivalent, behind the area you are viewing. Shine a flashlight on the paper to backlight the pad and rotor (figure 11.13).

FIGURE 11.13

Use a white background to help in viewing pad to rotor alignment

FIGURE 11.14

The pad above is new, while the used pad below show signs of misalignment of caliper to the rotor.

Disc pads are designed to strike the rotor face flat or square. Inspect old pads when removed. If pads are worn unevenly, it may be a sign that the caliper is misaligned to the rotor (figure 11.14).

Caliper brake bodies commonly have a lateral adjustment and allow adjustment of the front and back edges of the pads to the rotor. The top and bottom edges of pad should also strike the rotor flat. Depending upon the design of the caliper, proper alignment will rely on the machining of the caliper mounts relative to the rotor. If no adjustment of the caliper will stop pad rubbing and allow pads to strike the rotor flush, the frame fork mounts may require machining (facing). Consult a professional mechanic.

Procedure for hydraulic caliper alignment:

a. Remove the wheel from bike. Push both pads back into caliper body using a piston tool such as the PP-1.2 or a plastic tire lever.
b. Fully loosen caliper-mounting bolts. This will allow the caliper to move sideways.
c. Reinstall the wheel.
d. Depress the brake lever to secure pads against the rotor and maintain pressure. This will move the caliper so pads are aligned to the rotor. Inspect caliper and brake pad pistons. Push caliper left or right until pistons appear centered over rotor. Maintain pressure on the rotor and tighten the caliper mounting bolts (figure 11.15).
e. Release lever and inspect this initial pad alignment. Ideally, the pads should clear the rotor with no rubbing. Fine-tune the pad alignment by fully loosening one

FIGURE 11.15

Align caliper pad to rotor and then tighten caliper-mounting bolts mounting bolt while keeping the other bolt snug. This will allow you to push the caliper while pivoting off the snug bolt. In some cases, however, a light rubbing may occur no matter the adjustment. This should not affect performance.

Disc brake calipers can also be designed to bolt directly to the IS mounts. This design has no built-in lateral adjustment, and it is necessary to use thin washers and shims to adjust the caliper alignment. A shimming washer can be placed between the frame or fork mount and the caliper body (figure 11.16). View pad-to-rotor alignment and then add or subtract washers as necessary. The upper and lower mounts may require different amounts of shimming.

FIGURE 11.16

Add a shim washer to move caliper and pads laterally

When a hydraulic brake lever is pulled, both the outer and inner pistons of hydraulic calipers are designed to move toward the rotor the same distance and at the same time. However, because of small differences in seals, pistons, and caliper bodies, it may be that one pad strikes the rotor first. This is not a problem because no pressure will be applied until the second pad reaches the rotor. One pad and piston may not retract as fully as the other into the caliper body as compared to the other pad when the brake lever is released. Consider this retracted position as the "normal" or resting position. Use the resting position when positioning the caliper body laterally over the rotor, instead of trying to adjust the caliper so the pads hit the rotor at the same time.

HYDRAULIC BRAKE FLUID SERVICE

The procedures to change brake fluid vary between manufacturers. There may also be different techniques for the same model. In all hydraulic brakes, the concept is to inject new fluid and remove any air bubbles.

The required service tools for brake bleeding can vary with each brand. The basic component parts of a bleed kit are: a sealed plastic bottle or syringe to pump fluid into the system, a mechanism or system to catch waste fluid as it exits, and hoses and threaded fittings to attach hoses to the caliper and levers. Acceptable syringes are also available from pet supply retailers and farm and ranch suppliers. However, if the system requires threaded fittings, these are often proprietary and it is best to use the manufacturer's bleed kit.

SHIMANO® HYDRAULIC BRAKES

Shimano® hydraulic brake systems use a proprietary mineral fluid. Never use an automotive DOT brake fluid in a system requiring mineral fluid. Shimano® offers bleed kits for their brakes based on two different systems. The common Shimano® design uses a reservoir at the lever with a removable cover. This can be bled from the lever downward to the caliper. A second type is used on XTR levers, which do not have a removable cover at the lever. This system requires the use of a bleed kit from Shimano®, part number TL-BT03-S, and is not covered in this book.

Brake Pad Removal and Replacement

For Shimano® pads, replace when pad material (not including pad holder) is less than 0.9 mm thick. As the pads wear, the pistons reposition closer to the rotor. It will be necessary to remove the rotor and push the pistons away from the center before installing new pads.

Procedure for pad replacement:

a. Mount bike in repair stand and remove wheel.
b. Push pads back into calipers using a piston press such as the Park Tool PP-1.2. **Note:** If no piston press is available, remove pads and use a plastic tire lever to push pistons back into caliper body.
c. Remove pad fixing bolt clip and unscrew pad fixing bolt (figure 11.17). Shimano® also uses a cotter pin as a retaining device. Use needle nose pliers to bend cotter pin straight and pull cotter pin from caliper body (figure 11.18).
d. Remove pads by pushing them outward and away from hub axle. Note orientation of pad return spring between pads. This spring assists pad release from rotor during braking.

FIGURE 11.17

Remove bolt clip and unthread pad fixing bolt

FIGURE 11.18

Cotter pin acting as pad retainer

FIGURE 11.19

Pad return spring is placed between pads

e. If not already done, use a plastic tire lever to push both pistons into the caliper body.
f. Place pad return spring between new pads (figure 11.19).
g. Install pads into caliper. Orient eyehole of pads with caliper pad fixing bolt hole.
h. Install and secure pad fixing bolt and any bolt clip. If a cotter pin, install pin and bend longer end of the pin end upwards 90 degrees.
i. Install wheel and test brake by squeezing lever with force. Pull lever repeatedly to push pads to rotor. If lever feels soft, system will require bleeding.
j. Check pad alignment and adjust as necessary.

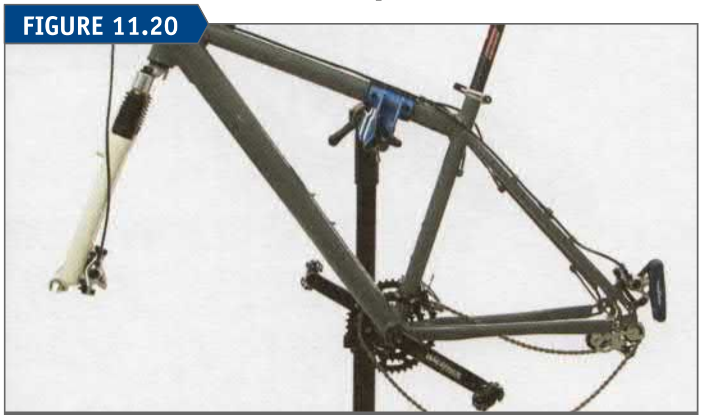
Brake Bleeding

The procedure below outlines a complete fluid change for levers with removable reservoir covers. It uses gravity to pull fluid through the system and out the caliper. It will be necessary to arrange a waste collection bottle or bag at the caliper.

Procedure for fluid change and brake bleed:

a. Mount bike in repair stand and remove wheels.
b. Remove brake pads to avoid contamination by brake fluid.
c. Rotate bike as necessary until tubing has a continuous upward slope from the brake caliper to the reservoir (figure 11.20). Caliper may also be removed from the frame, as necessary, to achieve as much of a vertical line as possible from caliper to lever.
d. Install Shimano® caliper block Y8CL18000 in place of pads. Block provides a stop to pistons when lever is operated. If this part is not available, substitute a clean 10 mm hex wrench between pistons.

FIGURE 11.20



Rotate bike and lever for continuous upward slope

FIGURE 11.21

Caliper is blocked with 10 mm hex, bleed bottle is in place, and wrench is attached to nipple

e. Attach bleed tubing to end of bleed nipple at caliper. Attach bleed bottle or bag to end of tubing to catch waste fluid (figure 11.21). **Note:** It is useful to attach box end of wrench over bleed nipple. Then attach bleed hose. This holds wrench to nipple during process of bleed.
f. Rotate brake lever on handlebar until top surface of reservoir is parallel with the ground.
g. Clean dirt from lever and wipe around reservoir tank cover. Unthread screws at reservoir tank cap. Remove reservoir cap and bladder.
h. Loosen bleed nipple at caliper body by ⅛–¼ turn. Gravity will drain fluid from lever down through caliper and out to bleed nipple. Fluid will be captured in bottle or bag.
i. Maintain fluid level at reservoir as it drains out bleed nipple (figure 11.22). When clean fluid with no bubbles appears at bleed hose and reservoir is full, close bleed nipple. Air may remain trapped in caliper body. Encourage any air trapped in caliper or line to rise toward the reservoir by operating lever repeatedly while tapping caliper and line with a non-metallic lever.

FIGURE 11.22

Keep reservoir filled with fluid at all times

j. Test lever by pulling. Piston should extend but be stopped by brake block. Lever will eventually become stiff and firm when pulled. If there is no resistance to lever, open bleed screw and continue to operate handle. This will pump more fluid into the system. Maintain fluid level at reservoir.
k. When lever resistance stiffens, close bleed nipple. Hold lever closed and maintain pressure. Loosen bleed

nipple to open system. Open and close system within one second, and take notice if any of the expelled fluid contains an air bubble.

l. Release lever. Check reservoir tank and add fluid.

m. Operate lever repeatedly. If lever feels stiff with resistance at the end of its travel, line contains no air and is fully bled. If lever feels soft, repeat steps “j” through “m.”

n. Check that reservoir tank is filled to top. Install reservoir bladder and cap. Expect some excess fluid to spill from lever. This is normal and ensures no air is below bladder. Tighten cap screws.

o. After bleeding, disconnect hose and bleed bottle or bag from bleed nipple. Clean the lever and caliper of any fluid.

p. Install brake pads and wheel. If the brake lever appears soft, it is possible to bleed air without a full fluid change. Air must be purged and fluid level maintained in the reservoir.

MAGURA® HYDRAULIC CALIPER BRAKES

The Magura® hydraulic disc calipers use a proprietary mineral oil called “Magura Royal Blood™.” Do not use DOT fluids for brake fluid. Do not use syringes or tubing that have been used with DOT fluids.

Magura® brake pads should be changed when measured less than 2.5 mm including pad holder. To change pads, remove wheel with rotor from frame. Use a piston press such as the Park Tool PP-1.2 to push pistons back into caliper body (figure 11.23).

Remove pad-fitting screw. Pads sit on magnetic studs. Remove pads from caliper and install new pads (figure 11.24).

FIGURE 11.23

Press piston back into caliper body

FIGURE 11.24

Remove pads by pushing out of caliper body

Install pad-fitting screw and secure. Install wheel and squeeze lever to bring pistons to rotor.

The Magura® caliper brakes bleed from the caliper upward to the lever. Magura® offers a bleed kit with a two syringe system. The first syringe uses flexible tubing with a proprietary barbed fitting to push fluid from the caliper to the lever. A second syringe is used for fluid collected at the lever bleed port (“EBT™” screw).

Procedure for fluid change and brake bleed:

a. Mount bike in repair stand and remove the wheel of brake being bled.

b. Set pistons back into caliper body using the Park Tool PP-1.2 Piston Press or a plastic tire lever.

c. Remove pads from caliper to avoid oil contamination.

d. For front fork calipers, rotate bike so caliper mounting tabs are vertical. For rear brake, unbolt caliper brake from frame and allow caliper to hang vertically. This places caliper bleed port screw in its most vertical position.

e. Install a Magura® transfer block inside caliper. Substitute a 10 mm hex wrench for this block. Hold block in place with a rubber band or zip tie as necessary. This prevents any movement of the piston during the bleed.

f. Prepare injection syringe with mineral oil. Pull 25–30 cc of brake fluid into syringe, then hold syringe vertically with fitting upward to allow air to excape. Push plunger slowly until only fluid remains in syringe.

g. Remove caliper bleed port screw from caliper. Thread and secure barbed fitting of syringe filled with fluid.

h. Remove bleed port screw (EBT™ screw) from brake lever using T25 Torx® driver. Pull plunger from second syringe and insert syringe without plunger into brake lever port (figure 11.25). Open syringe will act as a brake fluid catch during bleed.

FIGURE 11.25

Install syringe into bleed port at lever

i. Push fluid syringe at caliper until nearly empty (figure 11.26). Do not fully empty syringe as this may introduce air into the system. Watch for bubbles appearing in fluid at lever in the open syringe (figure 11.27).

j. Pull backward on caliper syringe slowly to draw a vacuum in the brake system. This helps remove any internal air

FIGURE 11.26

Push fluid from caliper upward to lever

FIGURE 11.27

Bleed syringe collects fluid at the lever

FIGURE 11.28

Alternately push and pull brake fluid to remove air from caliper

bubbles. Partially squeeze and quickly release lever to encourage any bubble to dislodge and leave system. Do not completely drain syringe at brake lever (figure 11.28).

k. Push fluid back through system a second time from caliper syringe toward the lever.
l. Pull back one last time on the syringe at the caliper to draw a vacuum. Do not completely drain fluid from the syringe at lever.
m. Remove syringe at lever. Use a rag to catch fluid as syringe is pulled. Install the bleed port screw (EBT™) at lever and secure.
n. Unthread syringe fitting from caliper and install caliper bleed port screw.
o. Wipe caliper and lever clean of fluid using alcohol.
p. Remove the block from caliper. Install pads and pad screw.
q. Install wheel and pull lever to move pads to rotor.
r. Lever should feel firm when pulled repeatedly with force. Repeat bleed as necessary.

HAYES® HYDRAULIC CALIPER BRAKES

The Hayes® hydraulic brake calipers are designed for Post Mount (PM) systems. Adaptor brackets are used to mount the caliper to IS (International Standard) mounts. Calipers are aligned as described in "Hydraulic Brake Caliper Alignment."

Hayes® hydraulic brakes use only DOT 3 or DOT 4 brake fluid. Never use a mineral oil for this system. The brakes bleed from the caliper upward, and the excess fluid exits at the lever. The Hayes® bleed kit includes bleed fittings for the lever, small pieces of plastic tubing, and a squeeze bottle. The bottle permits fluid to be pushed into the system and then to be sucked back out. This system of pressure followed by a vacuum helps to clear the system of air. A syringe can be substituted, but it is necessary to occasionally pull back on the plunger to flush the system of air. It is necessary to rig a bleed waste fluid collection bottle at the lever to catch the DOT fluid.

Hayes® brake pads are held to the pistons with a spring clip. Inspect caliper body for pad mounting type. If there are tabs at end of pads, use these to pull pad from body.

To replace pads, remove wheel. Use a piston press such as the Park Tool PP-1.2 to push pistons back into caliper body. Use a needle nose pliers when possible (figure 11.29). **Note:** Do not use a piston press without the pads in place. Pistons use a stud to hold the pads and the press may break this stud.

FIGURE 11.29

Use pliers to remove the Hayes® pads

If the pads use a tab on the pad plate, use tab to push pad toward center of caliper and then pull pad out of caliper body. If no tabs are present, inspect for a pad-holding screw. Remove screw and push pads from caliper.

Pads are not symmetrical and are marked "inner" and "outer." Replace outer pad first, using tab to engage spring on to piston stud. Install inner pad. Install wheel and squeeze lever repeatedly to bring pads to rotor.

The Hayes® bleed kit contains a bottle for fluid input and tubing with threaded fittings to fit the various brake lever models. Find an empty bottle or can to collect waste fluid. A bent spoke and zip ties can be used to hang bottle from handlebars during your work. Before beginning the bleed process, fill the bleed bottle approximately half with Hayes® brake fluid. Attach the tubing onto the spout of the filling bottle. It can be useful to use a small zip tie to help secure tubing to bottle spout. Cut the bleed hose short to maintain control of bottle during bleed.

Procedure for fluid change and brake bleed:

a. Remove wheel and remove brake pads to avoid contamination.
b. Rotate bike and or bars as necessary so there is an upward flow from the caliper to the lever bleed screw. Remove caliper from frame if necessary.
c. Inspect the lever for the bleed screw. Loosen and rotate lever on the bar as necessary until screw points directly upward to assist any air bubbles to escape. Leave lever clamp bolts loose enough to rotate lever.
d. Remove bleed screw from lever and insert bleed hose fitting. Arrange bleed hose and waste bottle to catch fluid. Use rags around lever to prevent fluid from getting on frame or other components.
e. The Hayes® caliper brakes require the pads be removed before setting the pistons. Use the box end of an 8, 9, or 10 mm wrench over the stud in the piston and push each piston fully into caliper body (figure 11.30).

FIGURE 11.30

Push piston back using box end of wrench placed over piston stud

f. Locate bleed nipple on caliper body and remove rubber cover. Use a 6 mm box end wrench and fit over bleed nipple.
g. Attach tube from brake fluid squeeze bottle to bleed nipple. Loosen bleed nipple ¼ turn. Squeeze bottle firmly for approximately 5 seconds to force fluid into caliper and out the lever bleed port. Relax bottle to draw any air out of the caliper body. Continue to alternate between squeezing bottle for 5 seconds and releasing bottle until no air bubbles come back out of caliper (figure 11.31). If using a syringe, push fluid in, then draw back slightly to draw any air out of the caliper.
h. When no more air bubbles appear to exit at the caliper, continue to squeeze and release the bottle while inspecting the exit tubing at the lever. Snap lever closed and open to encourage any trapped air to exit (figure 11.32).
i. Rotate lever on bar slightly upwards while continuing to push fluid through the system. Next rotate lever slightly downward and repeat. Continue until the fluid exiting the lever appears clear with no bubbles.

FIGURE 11.31

Alternately squeeze and release bottle to draw out air bubbles from caliper

FIGURE 11.32

Pull slightly on lever and allow it to snap forward to release bubbles

j. Close bleed nipple at caliper. Remove caliper bottle carefully and avoid fluid dripping on the bike or parts. Clean any spills immediately with soapy water or isopropyl alcohol.
k. Remove exit hose from lever. Install and secure the lever bleed screw. Return lever to normal position and secure. Clean any spilled fluid all parts with soapy water or isopropyl alcohol.
l. Remove piston block and install brake pads.
m. Install wheel and rotor and test lever. The lever will feel loose for a few pumps until the pistons move toward the rotor. Lever should then feel firm when pulled with force.

AVID® HYDRAULIC CALIPER BRAKES

Avid® caliper brakes are designed for direct mounting post mounts on fork or frame. Adaptor brackets are used when mounting to IS mountings. The caliper will mount directly to post mounts.

Brake pads should be replaced when less than 3 mm or if the pads become contaminated with oils or brake fluid. To replace pads, remove wheel. Use a piston press such as the Park Tool PP-1.2. Push the pads open to set the pistons back into the caliper body. Squeeze tabs at end of pad together and pull pads outward and away from caliper. If pad return spring

FIGURE 11.33

Return spring is placed between pads

remains in caliper, push spring out from the top using hex wrench. Place new pads over pad return spring. Spring should be sandwiched between new pads (figure 11.33).

Avid® hydraulic disc brake calipers use DOT 4 or DOT 5.1 fluids. Do not use a mineral oil in this system. All models share the same concept and procedure for bleeding. The Avid brakes are bled from the caliper up to the lever. It's best to use the Avid® bleed kit with their hydraulic brakes. It includes two syringes with special threaded fittings, a bottle of DOT fluid, and an 8 mm crow's foot in ⅜ inch drive. Store syringes with tubing clamps open. One syringe is used to push fluid, and the second is used to catch fluid at the lever.

Before beginning the bleeding procedure, prepare the two Avid® syringes. Open tubing clamp on the syringe and fill about ½ full with only Avid® DOT 5.1 fluid. Never substitute mineral oil. Clamp tubing clip shut. Fill the second syringe only ¼ full and close tubing clip. Hold syringe vertically with tip upward and pull gently back on the plunger. This reduces pressure in the syringe and will cause any air bubbles to appear in the fluid (figure 11.34). Allow these to rise to the top and tap the side gently to help dislodge them. Unclamp tubing and push bubbles out the top. Close clamp and repeat process until fluid appears mostly clear on bubbles. This is called "degassing" the fluid. Some very small bubbles will always be present and will not be a problem in the system.

Avid® has several models of hydraulic brakes that share the same bleed kit and will be bled with a similar process. The Avid® kit is needed to effectively bleed their system. Do not use other syringes and tubing.

FIGURE 11.34

Degassing the DOT fluid by purging air

Procedure for fluid change and brake bleed:

a. Remove wheel of brake being bled and remove pads. Install Avid® brake block. Substitute a 10 mm wide block such as a hex key if necessary.
b. Check the reach adjustment. Levers set for a long reach may have the reservoir closed and will not permit bleeding. Measure from center of handlebar to end of brake lever tip for no more than 80 mm (figure 11.35).

FIGURE 11.35

Adjust reach screw until lever end to bar center is no more than 80 mm

FIGURE 11.36

Adjust contact adjusting knobs

c. If present on lever, set the volume of the caliper system with the adjusting knobs. Right-hand lever: turn knob completely counterclockwise, then back clockwise one turn. Left-hand lever: turn knob completely clockwise, then back counter-clockwise one turn (figure 11.36).
d. Rotate the bike and brake levers as necessary so there is an upward flow from the caliper to the lever bleed screw.

FIGURE 11.37

Remove bleed port screw at caliper to attach syringe

Loosen brake lever bolts just enough to allow you to rotate the levers to different angles.

e. Install Avid® caliper piston block. This keeps the pistons in position. If pistons were to move, the system would become overfull of brake fluid. If no block is available, substitute a 10 mm hex key.

f. Select the syringe that is ½ full. Double-check that it is free of bubbles, and leave tubing clip closed. At the caliper, remove bleed port screw using a T10 Torx® driver (figure 11.37). Screw is located in the center of the banjo bolt that attaches the hose to the caliper. Remove port screw and secure the syringe into the fitting.

g. Inspect for location of bleed port screw at brake lever. Remove screw and thread in bleed syringe (¼ full). This syringe will accept the overflow from the caliper syringe during the bleeding process.

h. Open tubing clamp clips on both syringes. Hold lower syringe upright to help prevent any air from entering caliper body (figure 11.38). Push lower syringe plunger to move fluid through the system and out at lever syringe (figure 11.39). Inspect for air bubbles. Inspect for dirty or contaminated fluid. Push lower syringe plunger until at least empty of fluid, but do not fully empty syringe.

i. Close tubing clip on lever syringe. Leave caliper syringe tubing clip open.

FIGURE 11.38

Push fluid through caliper toward brake lever

FIGURE 11.39

Excess fluid is accepted at the syringe at the lever

FIGURE 11.40

Pull and hold lever to handlebar after closing lever syringe clip

j. Pull brake lever to handlebar and secure to bar with toe strap or rubber band (figure 11.40).

k. At lower caliper syringe, push plunger gently to pressurize the system, and then pullback on the plunger. Repeat this process three or four times to pressurize and then apply a vacuum to the caliper (figure 11.41). Inspect for any air coming back up into syringe. Leave caliper syringe open.

l. Remove strap holding lever, but keep lever to bar by hand pressure (11.42). Push caliper syringe plunger and allow lever to slowly return to relaxed position as fluid is pushed at caliper.

FIGURE 11.41

Pull back on plunger to create a vacuum

FIGURE 11.42

Release brake lever slowly while pushing caliper syringe

m. Close the tubing clip at caliper syringe. Unthread caliper syringe and reinstall bleed port screw. Clean off any fluid with alcohol or soapy water.
n. Open tubing clamp of syringe at lever. Pull back on plunger to create a vacuum, then push plunger. Pull lever slightly and allow it to snap back to help purge any bubble remaining in lever body (figure 11.43). Repeat this process 10 times or until no more bubbles appear in the tubing.

FIGURE 11.43

Push and pull repeatedly at lever to clear lever of air

o. Push the plunger gently as lever syringe is unthreaded from lever. Remove the syringe and install the bleed port screw. Clean up any spilled fluid with alcohol or soapy water.
p. Install pads and install wheel.
q. Pull lever to bring pistons to the rotor. Lever should feel firm when pulled with force. Repeat bleed if necessary. Empty syringes into appropriate container and store syringes with clamps open.

TEKTRO® HYDRAULIC CALIPER BRAKES

Tektro® offers several brake models and all share common bleeding procedures. Tektro® uses a mineral oil as the brake fluid. Never use a DOT fluid or syringes used for DOT fluid with this system. The Tektro® bleed kit includes a syringe to push fluid from the caliper to the lever. The fluid exits at a port screw at the lever. Tektro® provides a hollow M6 threaded fitting on a hole to for the waste fluid to cleanly exit. Flexible tubing that is 3⁄16 inch diameter can be substituted for the threaded fitting, however, expect some spillage of the fluid at the lever. The caliper fitting uses 1⁄4 inch tubing.

While the system can be bled with brake pads in place, it is best to remove pads to avoid any chance of contamination with the brake fluid.

Procedure for pad removal:

a. Remove rear wheel.
b. Reset piston back into caliper body using the Park Tool PP-1.2 or a thin tire lever.
c. Remove piston retaining screw from outside side of caliper body. Screw passes through both brake pad plates and the pad return spring (figure 11.44).

FIGURE 11.44

Remove pad fixing screw

FIGURE 11.45

Remove pads from caliper body

d. Push pads from the top of the caliper body (figure 11.45). Pads will exit on opposite side of body. Note position of pad return spring between pads.
e. Install the brake pads with the reverse procedure. Place pad return spring between pads. Push pads up into caliper and install pad-retaining screw. Secure screw.

Procedure for fluid change and brake bleed:

a. Hold bike in repair stand and rotate bike so there is an uphill path from caliper body to lever. Remove wheel and remove brake pads from caliper.
b. Rotate brake lever so lever reservoir is parallel with ground (figure 11.46). Use the split below the reservoir lid as a reference line when aligning. Aligning level will put the port screw at the highest point.
c. Remove bleed port screw from top of reservoir lid using a T15 driver (figure 11.47).

FIGURE 11.46

Adjust lever so reservoir cap is flat to the ground

FIGURE 11.47

Remove bleed port screw

FIGURE 11.48

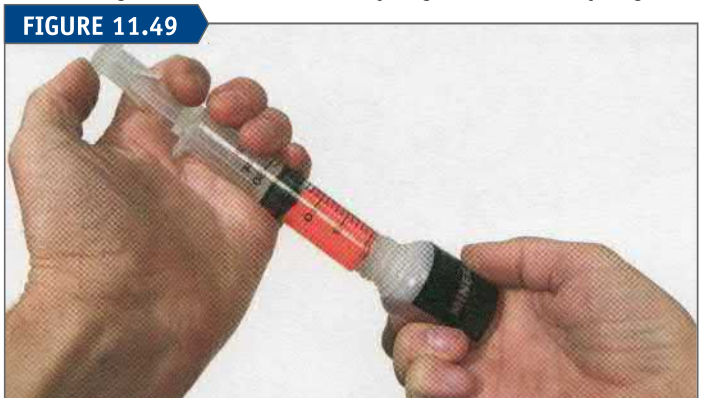
Brake fluid will bleed into waste bottle

d. Attach bleed tubing to lever reservoir lid. Tektro® bleed fitting will screw into lever (figure 11.48). Alternatively, insert $\frac{3}{16}$ inch tubing into hole. Place other end of waste tubing into a bottle or can fitted to hang off handlebars.

e. Attach hose to syringe and fill syringe with approximately 15 ml of mineral based brake fluid. **Note:** Excess hose at syringe makes bleeding difficult. Trim hose to about 3–4 cm in length. Fill syringe at least half full of fluid (figure 11.49).

f. The caliper has a bleed screw fitting that uses a 7 mm wrench. Place the box end of a 7 mm wrench over the fitting and then attach the syringe hose. Hold syringe upward to allow any small bubbles in the syringe to float to the top.

FIGURE 11.49



Pull brake fluid from bottle, filling syringe half full

g. Open the bleed fitting counter-clockwise $\frac{1}{8}$–$\frac{1}{4}$ turn and press syringe to flow brake fluid upward to the lever and waste bottle. Push slowly and evenly. Keep syringe upright to prevent any bubbles in the syringe from entering the caliper (figure 11.50).

FIGURE 11.50

Push fluid after opening up bleed nipple

FIGURE 11.51

Push fluid after opening up bleed nipple

h. Continue pushing until the syringe is near empty. Watch at the exit hose for any signs of air bubbles, debris or discolored fluid (figure 11.51).

i. Retighten the bleed fitting at the caliper body. Secure fitting to equivalent of 4–7 Nm. Remove syringe from bleed nipple. Replace any rubber cover on the bleed nipple.

j. Remove bleed hose from lever. Drip a drop or two of fluid into the hole at the reservoir cover and install screw. Secure until snug, only to 2–4 Nm.

k. Clean any excess fluid on caliper or lever with isopropyl alcohol or soapy water.

l. Reinstall brake pads. Reinstall wheel and test caliper brake. One first pull lever may depress more as the pads move to the rotor. Repeated pulling should feel firm with no softness. Any air in the line will show as a mushy feeling in the lever pull.

MECHANICAL DISC BRAKE SYSTEMS

Mechanical disc calipers use a wire brake cable from the hand lever that attaches to a lever arm on the caliper body. This lever arm is rotated to push the brake pads to the rotor. The most common mechanical designs have one pad fixed (non-moving) and one pad moving. The moving pad is the outboard pad (the pad furthest from the spokes), and it pushes the rotor to flex it over until it contacts the non-moving inboard pad (the pad close to the spokes). Mechanical calipers typically operate with wider clearances between pads and rotor. Because there is flex in the housing and brake cable, the mechanical caliper brakes are not as efficient as the hydraulic systems.

BRAKE LEVER

Flat handlebar brake levers used with mechanical disc calipers are compatible with the linear-pull rim caliper brakes. The lever should be set for a comfortable reach from the saddle. Prepare brake housing and cable as with rim caliper brakes.

Drop bar brakes typically do not pull the same amount of cable as the disc-compatible flat bar lever. The common drop bar lever requires the use of road compatible calipers. If drop bar levers are used with calipers designed for the linear-pull lever, it will require a mechanical pulley system, such as the Travel Agent™, which leverages the amount of cable pull (figure 11.52). These devices allow the use of non-long travel levers, such as many road levers, with mechanical disc brakes.

FIGURE 11.52

Travel Agent™ pulley system

CALIPER PAD ALIGNMENT AND CLEARANCE

Most mechanical disc calipers share a common alignment procedure. The caliper body is mounted to either post mounts on the frame/fork or to an adaptor bracket. On most mechanical calipers, only one pad moves to the rotor. The rotor is flexed as it spins and is pushed over to press against a non-moving pad. The caliper body can be adjusted laterally over the rotor (figure 11.53).

FIGURE 11.53

Lateral adjustments on caliper body

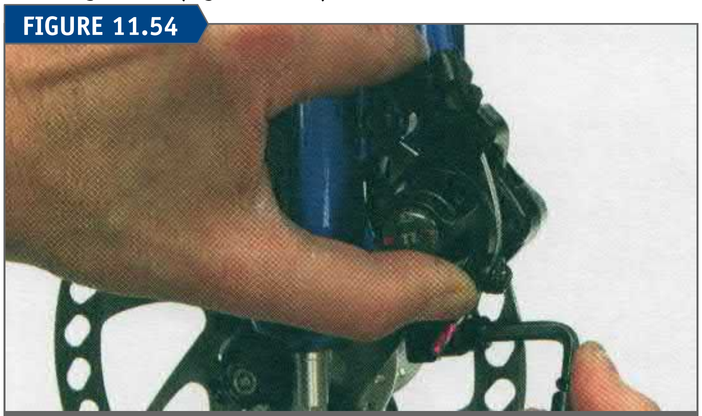
Procedure for mechanical disc caliper alignment:

a. Install and route inner wire and housing to caliper. Pull slack from cable and secure cable pinch bolt. Cut cable end short enough so that is does not contact frame, caliper, or adaptor.
b. Loosen caliper mounting bolts to permit lateral movement of caliper body.
c. Inspect caliper body for pad adjusting screws that move pads in caliper body. There may be an adjusting screw or knob on inner or outer faces of body. However, some models have only one pad adjusting screw at the inner pad.

   Calipers with outer and inner pad adjusting knobs: Turn outer pad adjustment clockwise one turn from being fully out. Turn inner pad adjusting screw in clockwise until pads lock against rotor. Secure each mounting bolt. Loosen each adjustment screw/knob ¼–½ turn and check pad. Turn adjusting screw(s) in or out to adjust pad clearance for 0.2–0.4 mm on each side of the rotor. This is approximately the thickness of the average business card.

   Calipers with only inner pad adjusting knob: Turn inner pad adjust clockwise until it locks against rotor, then turn back approximately ¼ turn. Squeeze lever to lock rotor. This moves outer pad to rotor and positions body laterally (figure 11.54). Secure each caliper mounting bolt and release lever.
d. Inspect pad alignment to rotor. Pads should appear parallel to rotor. To fine-tune, loosen one bolt at a time to allow the caliper to move slightly to fine-tune alignment (figure 11.55).

FIGURE 11.54



Position caliper and pads over rotor

FIGURE 11.55

Caliper must rotate counter-clockwise over rotor for better alignment

e. Test brake by pulling lever. Adjust feel by adjusting both pad adjustment screws in or out, if present. For models with only inner pad adjustment, use barrel adjuster on cable housing to move outer pad in or out.

As pads wear with braking, use both pad adjusting screws, if available, to move pad pistons closer to rotor. If both pads have an adjusting screw, tighten both sides. If only one adjusting screw is available, tighten that screw. However, use care when using the adjusting barrel or cable pinch bolt to account for pad wear. Caliper arm may bottom out on caliper body as it articulates and prevent the pads from pressing on rotor.

SHIMANO® MECHANICAL DISC BRAKES

The Shimano® mechanical calipers align laterally as described above in “Caliper Pad Alignment and Clearance.” Shimano® recommends pad clearance of 0.2–0.4 mm on each side of the rotor.

The pads of the Shimano caliper are held in place with a pad fixing screw. Replace pads when pad material is less than 0.5 mm thick, not including pad holder. To replace pads, remove wheel and then remove any clip at end of pad screw and remove screw (figure 11.56). Push pads and pad return spring out from caliper body. Install new pads with new pad return spring into caliper body. Install and secure pad fixing screw and install clip if present. Install wheel and adjust new pads to rotor.

TEKTRO® MECHANICAL DISC BRAKES

Tektro® mechanical calipers align laterally as described above in “Caliper Pad Alignment and Clearance.” Tektro® recommends a 0.3 mm clearance from each pad to the rotor.

FIGURE 11.56

Remove pad fixing screw to remove pads

FIGURE 11.57

Tektro® pads and pad fixing screw

Tektro® brand pads are made with a wear indicator. A circular hole in the pad will appear as the pad thins and requires replacement. Pads are held in place with a pad fixing screw (figure 11.57). Remove wheel and pad fixing screw. Push pads and pad return spring from caliper. Some models will use a magnet in the piston and have no return spring. To remove these pads, use tab on pad and lift pad away from stud on piston. Pull pad out.

HAYES® MECHANICAL DISC BRAKES

Hayes® recommends a pad to rotor clearance of about 0.4–0.5 mm. To replace pads, remove wheel. Use tab on pad plate and pull outer pad first toward center and pull outward from caliper body. Pads are not symmetrical. Match replacement pad to old pad from caliper. Replace outer pad first, using tab to engage spring onto piston stud (figure 11.58). Install inner pad. Loosen pad adjusting screw(s), install wheel, and set clearance to rotor. Some models use a magnetic pad holder without stud or clip system.

FIGURE 11.58

Hayes® pad and pad tabs used for removal

AVID® MECHANICAL DISC BRAKES

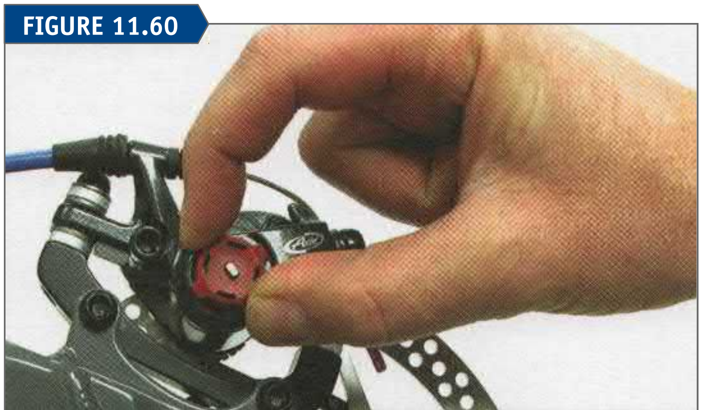
Avid® disc caliper brakes use a ball-and-socket system for the caliper mounting bolts. This fixing system is similar to many brake pads on linear-pull caliper rim brakes (figure 11.59). The caliper body can move laterally as other brands but will also allow vertical rotation of the pad face to the rotor.

Both the inner and outer pads of the Avid® brake can be adjusted for clearance with pad adjusting knobs (figure 11.60). The moving outer pad flexes the rotor toward the fixed inner pad when the brake is operated. The dials use an

FIGURE 11.59

Ball and socket system for caliper alignment to rotor

FIGURE 11.60



Pad adjusting knob move pad position relative to rotor

indented "click" system, with one complete revolution moving the pad approximately 1 mm.

The Avid® caliper design is to have the inner pad-to-rotor gap about twice as large as the outer pad-to-rotor gap (figure 11.61). It can be difficult to measure and achieve this ratio, but the brake will still perform even if the ratio does not achieve this exact proportion.

FIGURE 11.61

Gap from fixed pad to rotor should be larger than gap from moving pad to rotor

Procedure for pad alignment:

a. If the caliper is attached to an adaptor bracket, check that the bracket is fully secured to the frame or fork.
b. Loosen caliper-mounting bolts so the caliper is loose on bracket or post mounts.
c. Slacken cable with adjusting barrel or loosen brake wire pinch bolt if it is secured.
d. Check that both pad adjusting knob dials are turned fully counter-clockwise to move pads fully away from rotor. Turn the outer pad adjusting knob approximately ½ turn clockwise.
e. Turn the inner pad adjusting knob clockwise until inner pad fully secures and locks rotor. This aligns caliper body and pads to rotor face.
f. Snug each caliper-mounting bolt. Alternate turns to tighten one bolt and then the other until both are fully secure.
g. Draw slack from the brake wire and secure pinch bolt. Do not allow caliper arm to move upward when drawing slack from brake (figure 11.62).
h. Set pad clearance. Loosen outer pad adjusting knob approximately ¼ turn counter-clockwise. Loosen inner

FIGURE 11.62

Pull slack from cable but do not move caliper arm

pad adjusting knob approximately ½ turn counter-clockwise. Inner pad (fixed pad) to rotor gap should appear larger than the outer pad to rotor gap.
i. Squeeze lever to test caliper brake. Adjust lever modulation setting by moving pads inward or outward from rotor by using both pad adjusting knobs. To maintain the 2:1 ratio, turn the fixed pad adjusting knob twice as many clicks as the moving pad adjusting knob. For example, if a looser modulation is desired, turn the inner pad adjusting knob counter-clockwise four clicks and the outer pad adjusting knob counter-clockwise only two clicks.

The caliper-actuating arm is designed to operate from a fully open position. Set cable tension at the adjusting barrel so actuating arm is fully opened or returned. Do not use the brake lever adjusting barrel or cable pinch bolt to account for pad wear. Caliper arm may bottom out on caliper body and prevent the pads from pressing on rotor.

As pads wear, use pad adjusting knobs to move pads closer to rotor. Turn the fixed pad adjusting knob clockwise twice as many clicks as the moving pad adjusting knob to maintain the 2:1 ratio of pad-to-rotor spacing. For example, if the inner (fixed) pad adjusting knob is turned clockwise two clicks, turn the outer (moving) pad adjusting knob clockwise one click.

Brake pads should be removed and replaced if the pad thickness, including the metal holder, is less than 3 mm.

Procedure for pad removal and replacement:

a. Remove the wheel.
b. Loosen each pad adjustment knob an equal amount.
c. Squeeze tabs at end of pad together and pull pads

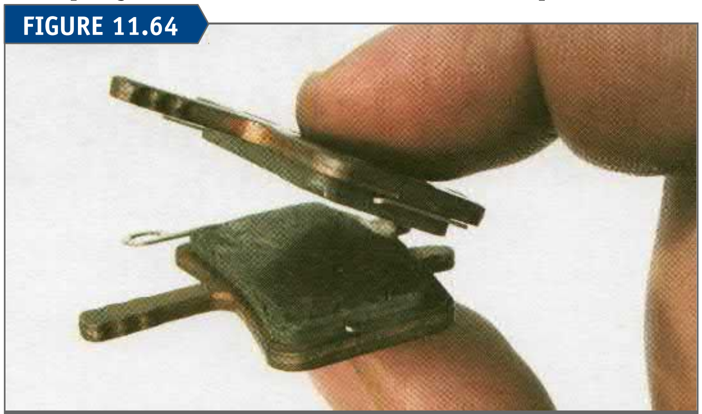
FIGURE 11.63

Push pad tab to center of caliper body and lift to remove outward and away from caliper (figure 11.63). If pad return spring remains in caliper, push spring out from the top using hex wrench.

d. Note orientation of pad return spring and remove spring from pads.

e. Place new pads over pad return spring (figure 11.64). Spring should be sandwiched between new pads.

FIGURE 11.64



Place spring between pads

Installation lever is set asymmetrically on pad. Align bridge of spring with caliper boss locators.

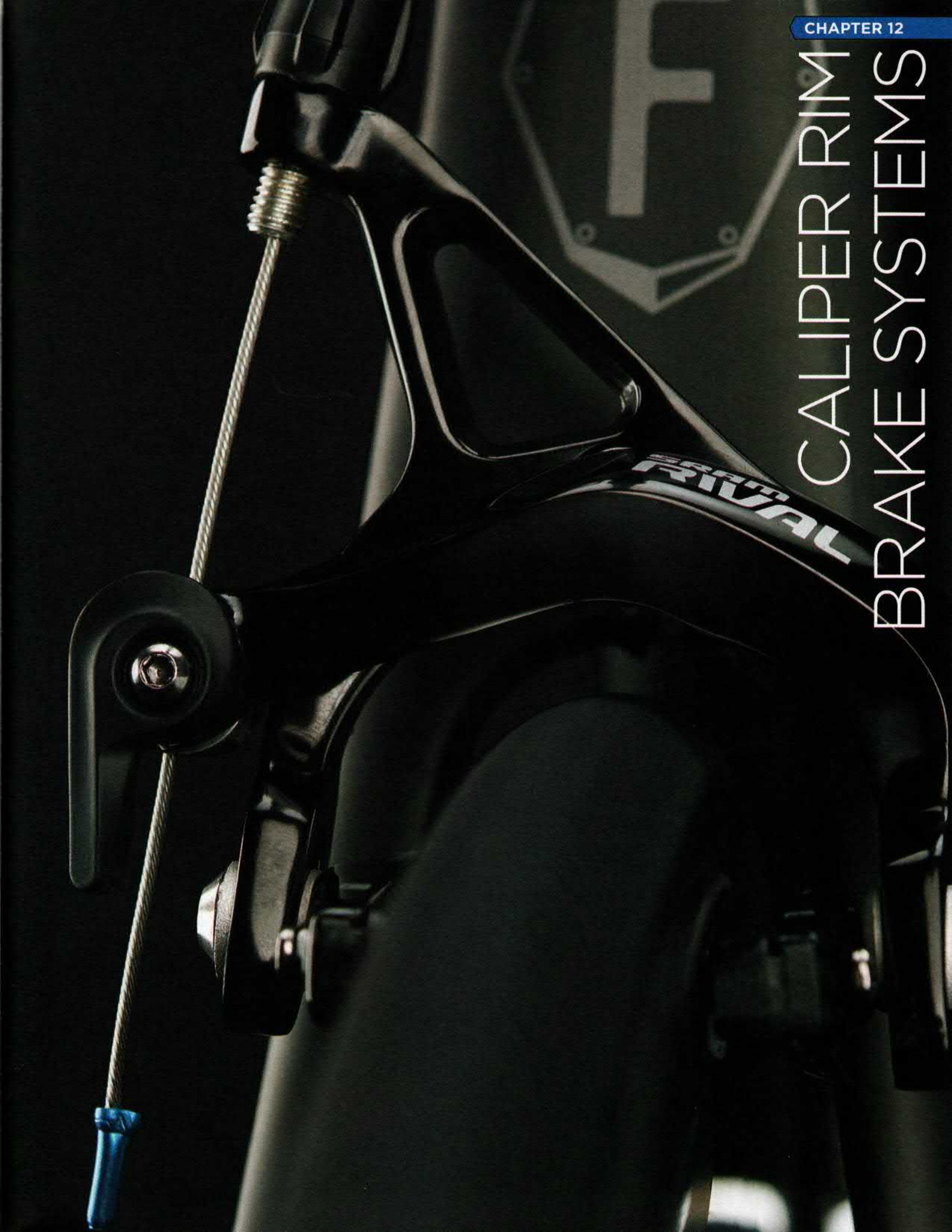
f. Gently squeeze return spring and pads. Engage pads into caliper body. Pad installation lever orients away from brace bolts. Push return spring and pads into place (figure 11.65). Pad locator will engage bosses in caliper boss.

g. Install wheel.

FIGURE 11.65

Push pads into caliper body

CALIPER RIM BRAKE SYSTEMS



Caliper rim brakes are mechanisms attached to the frame and fork that apply pressure to the wheel rim. Force is applied to the rim by the pads, which converts the momentum of the bicycle and rider to heat and slows them. The caliper rim brake system includes the brake lever, cables and housing, brake caliper, brake pads, and wheel rim.

Disc brake systems use a rotor attached to the hub and a caliper attached to the frame or fork. These brakes are discussed in Chapter 11, Caliper Disc Brake Systems.

Braking systems should provide more than an emergency stop. Properly adjusted brakes give the user subtle control and modulation of speed and bike handling. Many small details affect the control of the bike, including the placement of the levers, how the cable system is installed, and the alignment of the brake pads.

This chapter will review "cantilever," "linear-pull," "dual-pivot," and "side-pull" rim brakes. For service of other systems, such as "U-brakes" and center pull calipers, see Repair Help at www.parktool.com.

BRAKE LEVERS

There are two basic types of brake levers: the upright bar brake lever and the drop bar brake lever. Brake levers are fitted to handlebars with a clamp. The muscular force of the hand is leveraged by the lever to pull the cable and transfer this force to the brake pads. It is a common error for newer riders to want an overly tight brake setting. Rim brake calipers generally should not be set so tight that a mere touch of the lever results in the pads striking the rim. The hand is not in a good position to apply power to the lever when the brakes are set too tight at the rim.

UPRIGHT HANDLEBAR BRAKE LEVERS

Upright compatible brake levers are designed for a 22.2 mm flat handlebar end diameter. Position upright handlebar brake levers so they are easy and comfortable to reach. Levers will also move laterally along the handlebar. They are commonly positioned close to the grips and outboard of separate clamp type shift levers.

Upright handlebar (flat bar) brake levers should be rotated so they are aligned with the rider's arms as the rider sits on the saddle and holds the bar grips. A common standard is to set the lever at 45 degrees downward slope from horizontal (figure 12.1). This avoids excessively bending the wrist to apply the brakes. Brake levers may be rotated on the bar by loosening the clamp-fixing bolt.

FIGURE 12.1

Rotate levers for comfortable reach

Upright bar levers commonly have a setscrew in the lever body that controls the lever's position relative to the handlebar grip, which may be called lever reach. Lever reach is set according to the rider's hand size and riding style. Tighten the setscrews to bring the levers toward the grip to accommodate smaller hands or shorter fingers. Changing this setting will cause a change in the brake cable adjustment.

Upright bar levers typically allow for easy installation of the cable end into the cable anchor of the lever. Pull the lever and inspect for the cable end anchor, which is typically a hole for the cable end with a slot for the cable to exit to the cable housing. Inspect also for slots in the adjusting barrel. Align the slots and then slip the cable end into the anchor hole. Engage the brake cable between the slots in the barrel adjuster (figure 12.2).

FIGURE 12.2

Use slots in lever body to engage and disengage cable end

Brake levers are designed to pull a certain amount of brake cable as the lever is squeezed. The distance from the cable head pivot and anchor to the lever pivot determines the amount of brake cable pulled. Linear-pull or "long travel" brakes require more cable be pulled by the lever, and compatible brake levers will have a greater distance between cable end and lever pivot (approximately 30 mm or more). Cantilever caliper levers will have a relatively shorter distance (29 mm or less). Although levers for linear-pull type brakes pull more cable, they pull with less force compared to levers for cantilever brakes.

DROP BAR BRAKE LEVERS

Drop bar brake levers may be moved up or down the curve of the bar for easier reach. Moving the lever down on the bar curve makes the levers easier to reach while riding in the drops. Moving the lever upward on the curve allow for an easier reach when riding on the top portion of the bars. Handlebar tape must be removed to move the levers up or down.

Drop bar brake levers usually use a metal strap to pull the brake lever body tight to the handlebar. The handlebar diameter of drop bars is larger than the diameter of flat bars, and brake levers are not compatible between the two.

The bolt or nut to tighten the brake lever strap may be inside the lever body or hidden under the rubber hood covering of the body. It may be necessary to pull the cover up in order to insert the hex wrench when tightening the strap

FIGURE 12.3

Adjust lever height along hook of drop bar

(figure 12.3). The drop bar brake lever should be tight to the handlebar. The user effectively uses the lever body as a "bar extension" when riding on the tops of the levers. If the levers were to move during use, it could result in a crash.

The brake cable ends interlock with the cable anchor in the lever. Pull the brake lever fully down and inspect inside. The anchor will have a socket fitting for the cable. The common aero-style lever will have a hole in the lever for the cable end (figure 12.4). Feed the cut end of the cable into the socket first and route it out the back of the lever body. Pull the cable and check that the end is fully seated into the anchor. The brake housing is fitted through the back of the lever body.

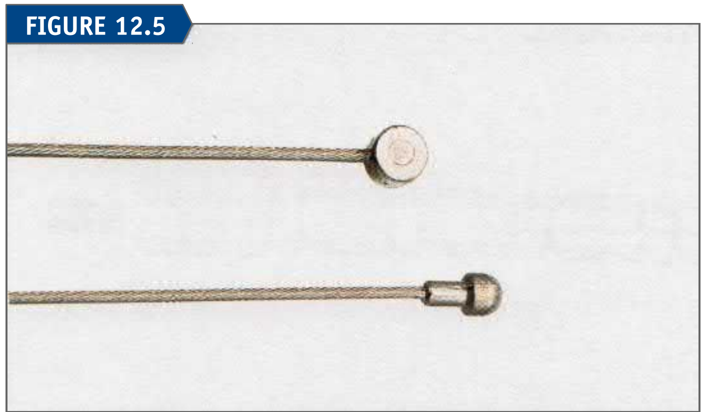
FIGURE 12.4

Insert brake cable from front of lever

CABLE SYSTEM

The cable system is made of the brake cable and cable housing, connecting the brake lever to the caliper. The brake cable is made of multiple strands of wire and a metal fitting, usually called a "cable end," on one end that sits in the lever. Brake cables are often sold with two ends, and the type of cable end not required is cut off. The brake cable end sits in the brake lever, and the other end of the cable is bolted to the caliper arm. Upright bar levers use a round, disc-shaped end about 7 mm (9/32 inch) in diameter. Drop bar levers use a "mushroom" or "tear-drop" shaped end (figure 12.5). Brake cables have a minimum diameter of 1.5 mm (1/16 inch), which is larger than derailleur cables.

FIGURE 12.5



Top: brake cable end for upright bar lever
Bottom: brake cable end for drop bar lever

FIGURE 12.6

Common brake housing, with cut away to show inner support coiled wire

Brake housing connects the brake levers to the bike and allows the cable to bend around corners on the way to the brake caliper. Wound-type brake housing is made of a plastic liner tube around which support wire is wound like a coil. It is then covered by plastic to help prevent rust (figure 12.6). Wound housing differs from the compressionless shift cable housing used on derailleur systems. Compressionless shift housing will not hold up to the higher stresses of braking.

"Braided" or "woven" housing is acceptable for either brake or indexing shift housing (figure 12.7). The outer support wires are woven in a mesh around the liner. This housing is especially effective on systems that seem to have excessive amounts of flex from coiled housing. Housing flex is felt as "sponginess" or "softness" in the lever pull.

FIGURE 12.7

Braided or woven housing used for both braking and shifting

FIGURE 12.8

Articulated housing used for both braking and shifting

"Articulated housing" uses small tubular segments strung together over a plastic liner (figure 12.8). Articulated housing may be used for both brake housing and indexing shift housing. The pieces of housing are pieced together much like beads on a string for the correct length.

Replace housing if it has become twisted, rusty, split, or if it is too short. It is a good idea to replace housing if it is simply old, as there is a plastic tube inside the wound housing which becomes dirty and worn with use.

CABLE LUBRICATION

To prevent rust and to ensure smooth operation, apply a light lubricant to the brake cable where it passes through the housing. If the frame housing stops have a split, the housing and brake cable can be released from the stops for easier lubrication.

Release the brake caliper quick-release to relax the cable tension. Pull the housing back and out of the stop. Slide the housing back to expose the cable. Wipe the cable clean with a rag and lubricate. Reinstall housing into the stops. Close the caliper quick-release.

If removing the housing from the stops is not possible, rotate the bike so lubrication can be dripped down the brake cable into the housing. Some housing systems use an external liner to cover the entire length of cable from lever to caliper. Do not lubricate the cable in these systems.

CABLE HOUSING LENGTH

When replacing housing, consider the housing length. Generally, housing should be as short as possible yet still enter straight into the housing stops (figure 12.9). If the housing is too long, it will bend past an imaginary line created by the housing stop (figure 12.10). If it is too short, it will create kinks or severe bends. If it is likely the stem and bars are to be raised in the future, leave the housing somewhat longer than the ideal length at the brake levers.

FIGURE 12.9

Housing enters stop in a straight line, indicating a good length

FIGURE 12.10

Housing passes housing stop, indicating housing is too long

If the old housing was an acceptable length, cut new housing to the same length. If in doubt, cut housing longer and insert into stops, then inspect and cut shorter as required. For wound housing, cut with diagonal pliers (preferred) or with cable cutters. Bend brake housing where you wish to cut to open the wound coil (figure 12.11).

Wound housing is made of a single coiled wire. Cutting this wire tends to leave a sharp end or burr. The burr should be filed or ground smooth so the housing end is perpendicular to the length of housing (figure 12.12).

FIGURE 12.11

Flex the wound-type housing to open coils for side cutters

FIGURE 12.12

File brake coil smooth to eliminate burr from side cutters

FIGURE 12.13

Various styles of housing end caps

Woven or braided housing is cut with cable cutters as is compressionless shift housing. However, articulated housing is shortened similar to shortening a beaded string. Pieces are removed and the inner plastic liner cut with scissors.

Housing end caps should be used whenever they fit. The end cap will only improve the fit into a cable stop. However, if an end cap will not fit into a brake cable stop, the cap is not necessary. End caps are available in different designs (figure 12.13). The end diameters vary to better mate with frame fittings, and some may have extensions for protective liners.

After a brake cable is installed and the brake adjusted, the excess cable should be cut using a cable cutter, such as the Park Tool CN-10. The cutting jaws surround the cut, and shear the wires. Leave approximately 3–4 cm (1.5–2 inches) wire length past the pinch bolt. After cutting the brake cable, use a cable end cap crimped to the end to prevent fraying (figure 12.14).

FIGURE 12.14

Use a cable end cap to prevent fraying of wires

FIGURE 12.15

Pinch bolt and flattened brake cable

The brake cable is fixed to the rim caliper arm by a plate and bolt. The brake cable is pulled with great force by the hand lever and must not slip in the pinch bolt (figure 12.15). The brake cable will flatten with proper torque on the pinch bolt.

Brake housing is often routed through a "barrel adjuster," fitted either at the brake lever or at the caliper arm (figure 12.16). This is a hollow threaded bolt that is turned in or out to effectively shorten or lengthen the housing. Unscrewing the barrel out of, or away, from the lever body or caliper will effectively lengthen the housing and draw the brake pads closer to the rim. Screwing the barrel into, or toward, the lever body or caliper arm will shorten the housing and allow the pads to come away from the rim.

If the brake cable is frayed or sliced anywhere between the lever and the cable pinch bolt at the derailleur, it should be replaced. Even the failure of a single strand of wire will eventually lead to a complete cable break (figure 12.17).

FIGURE 12.16

Adjusting barrel on a dual-pivot rim brake

FIGURE 12.17

Inspect and replace cables with broken wire

CALIPER RIM BRAKES

Note: When rim calipers are discussed in this chapter, "right" and "left" will be from the mechanic's point of view, not the rider's point of view. In other words, the left caliper arm of the front brake is the left one as seen when standing in front the bike. On the other hand, the left caliper arm of the rear brake is the one on the left side of the bike while standing behind the bike.

The design of the brake caliper will determine how the brake pads are adjusted. Most caliper arms swing the pad on an arc as it approaches the rim. Certain caliper types swing the pad downward as it moves toward the rim. Other types move the pad

FIGURE 12.18

This pad moves in a downward arc as it swing toward the rim

upward as it moves toward the rim. Before adjusting pads, begin by determining the basic type of caliper used. Move the caliper arm and watch how the pads move toward rim (figure 12.18).

BRAKE PADS

Brake pads wear with use and will require replacement. Some pads are made with a "wear line," which indicates the need for replacement. Age will also harden pad material and make it less effective. It is not uncommon for small amounts of aluminum from the rim-braking surface to become embedded in the pad. Inspect the brake pad and remove pieces of grit and foreign material as necessary using a pick or small screwdriver. Pads that are aligned too low on a rim, toward the hub, will develop a lip or edge. This lip makes correct alignment impossible (figure 12.19).

FIGURE 12.19

Worn pad showing signs of low placement on rim

Replacement pads should be compatible with the type of caliper. There are many after-market pads available from all-around use to pads for wet conditions or specific rim compounds. Choose a pad set that meets your needs as a rider. A relatively soft pad, for example, will generally give high performance but will wear quickly.

Brake pads may be replaced as an entire unit with the pad material and pad holder and fastener in one piece. Some pad systems use a "cartridge pad" holder that allows for the pad material to be changed. The pad holder and fastener are reused in these systems. To replace cartridge pads, inspect for and remove any screw or clip retaining the pad. Pull on the pad backwards, away from the rim rotation direction (figure 12.20). Install new pad by pushing it into holder and reinstall any retaining screw or clip.

FIGURE 12.20

Pull cartridge pad toward back to remove pad from holder

FIGURE 12.21

Off-center brake pad mounting stud

It is common for some cantilever and linear-pull caliper brake pads to have the mounting stud placed off-center, so one end of the pad is longer (figure 12.21). Look for the manufacturer's marking for direction of rim rotation or marking for "front" or "back" pad.

Brake Pad Alignment

Rim caliper pad adjustments depend upon the wheel being centered in the frame. A misaligned wheel will affect both pad centering and pad placement on the rim, and it is important that the wheel be centered before beginning pad adjustments (figure 12.22).

A wheel can be misaligned from simply being placed in the frame incorrectly. Loosen quick-release or axle nuts and pull wheel fully into dropouts. It is also possible the wheel rim is not properly centered over the hub. As a test, flip the wheel

FIGURE 12.22

Misaligned wheel off to mechanic's left

around left to right and inspect again. If the centering is good, wheel centering will look the same either way. A wheel may be purposely "misdished" to correct for minor frame or fork misalignment. It is also possible the frame or fork was made with the left and right dropouts at slightly different heights.

An effective solution for an off-center fork or frame is simply to hold the wheel centered when installing it, and then close the skewer tightly (or tighten axle nuts) to hold the wheel in place. Some frames have dropouts that have enough material to allow filing to effectively raise one dropout. Consult a professional mechanic.

Brake pads are mounted to the caliper arms and are adjustable in several directions. There are four basic aspects to pad alignment: vertical height alignment, tangential alignment, vertical face alignment, and pad toe. Not every brand or model of brake caliper has every adjustment, and sometimes it is necessary to compromise when setting pads.

Vertical Height Alignment

This is the alignment up and down relative to the rim-braking surface, which is the flat vertical section of rim. View caliper face-on and move the arms while watching the pads move to the rim. If the pad moves on an arc moving down, set pads near the upper edge of the rim-braking surface (figure 12.23). If the pad travels upward toward the rim, set pads near the lower edge of the rim-braking surface. As the brake pad wears, it gets thinner and tends to move further upward or downward along its arc. Do not set pads so high that they strike the tire at any time or so low that they are below the braking surface.

FIGURE 12.23

Pad on left is set at top of rim braking surface, while pad on right is at bottom of rim braking surface

Tangential Alignment

This is the alignment of the pad tilt viewed from the side. The front and back of the pad should be even on the rim. One side should not be higher or lower than the other side (figure 12.24). Use care when tightening the pad fixing bolt and hold the brake pad to keep it from rotating.

Vertical Face Alignment

This is the alignment of the brake pad face relative to the rim's vertical surface. The vertical face of the pad should be set parallel to the face of the braking surface as it strikes the rim (figure 12.25). Most cantilever and linear-pull calipers have an adjustment for vertical face alignment. Many side-pull and dual-pivot caliper pads do not allow for vertical alignment. These pads will simply wear in with use or they can be sanded or filed to shape.

FIGURE 12.24

Top image showing proper tangent alignment. Front and back edges of pad are square with rim. Lower image is improperly set with rear edge too low.

FIGURE 12.25

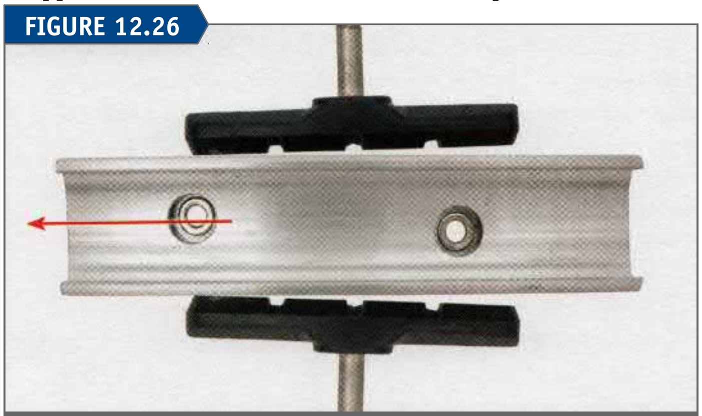
Vertical faces of both pads are misaligned to rim braking surface

Pad Toe

This is the alignment of the pad angle as it touches the rim viewed from above the rim. Toe, often called "toe-in" or "toeing," refers to setting the pad so its front or leading edge strikes first, with a slight gap of 0.25 mm to 1 mm at the back or trailing edge of the pad (figure 12.26). Toe helps to reduce squeal during braking.

Caliper arms have play in the pivots. Additionally, the brake caliper flexes with the wheel movement when the brake is applied. This creates a back and forth "slip and stick"

FIGURE 12.26



Toe seen in the pad adjustment (arrow shows direction or rim rotation) phenomenon as the pads are first pulled forward and then spring backward. The effect is much like that of a bow on a violin string. The result is "harmonic resonance" or squealing if the vibrations are within the range of human hearing. Caliper systems that are more rigid tend to flex less and that results in less audible squealing. Generally, less toe angle is better than more for brake performance. Too much angle will exacerbate brake caliper flex without providing braking force to the pads.

Some brake pad systems allow toe adjustment in the pad-fixing bolt. Side-pull and dual-pivot caliper arms can sometimes be bent slightly for pad toe. However, if the caliper arm is relatively thick or difficult to bend, toe may be cut into the pad with a file. It is simplest to first test ride the bike and see if toe is even required.

LINEAR-PULL CALIPER ADJUSTMENT

Both linear-pull and cantilever caliper arms attach to separate frame or fork pivots located below the rim surface on either side of the wheel. Pivot studs are commonly bolted to the frame or fork. For steel frames and forks, the studs may be "brazed-on" to the tubing. The studs are nominally 16 mm long and 8 mm in diameter, with an internal thread for a M6 mounting bolt. Grease the surface of the stud before installing the calipers. The cantilever should pivot freely when the mounting bolt is secure. Overtightening may damage the stud fitting and cause the caliper to stick.

There may be several spring hole options in the brake caliper as well as in frame braze-on (figure 12.27). Mount left and right caliper springs into mirror image holes. Spring hole options allow changes in spring tension. Generally, select the middle option and move both sides symmetrically if changing tension.

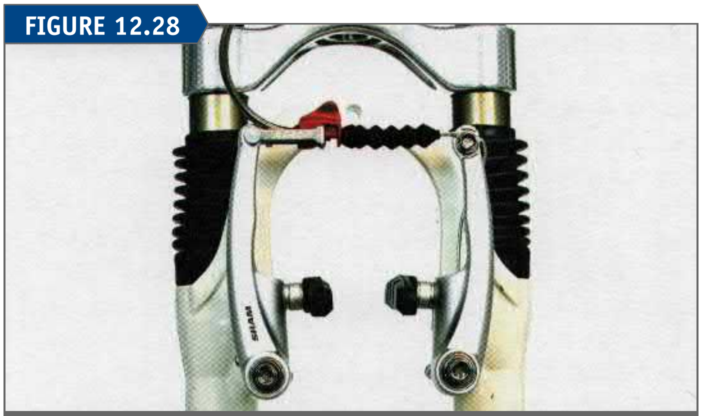
FIGURE 12.27

Brake stud and spring mounting holes for linear-pull or cantilever brake

Linear-pull brakes share many similarities with cantilever brake designs. The caliper arms pivot on frame- or fork-mounted studs at one end and are pulled by the brake cable at the other end. However, there is no straddle wire as with cantilevers. The primary cable from the brake lever passes through a metal cable-housing stop called a "noodle." The noodle is fitted to one arm, and the cable attaches to the second arm. Pulling the brake lever pulls the arms together and forces the pads onto the rim-braking surface.

Linear-pull brakes and Shimano® V-Brakes® are common on many mountain bikes and hybrid bikes (figure 12.28). The caliper arm shares the same frame mounting system with cantilevers.

FIGURE 12.28



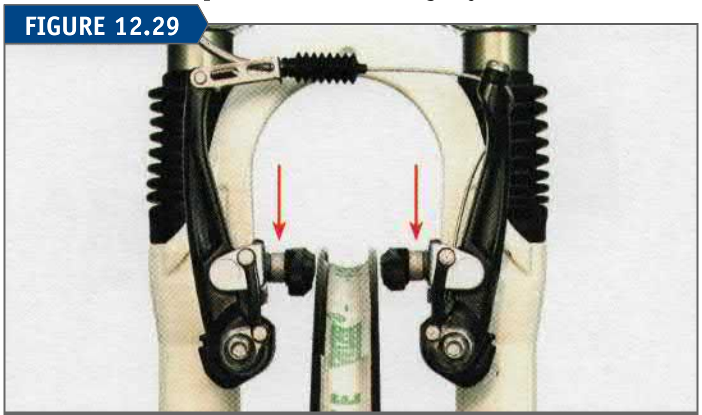
The linear-pull caliper brake

Linear-pull calipers move the pads in an arc moving downward toward the low side of the rim. Pads should be set high vertically on the rim but without interfering with the tire. Pad height will lower as pad face wears.

Linear-pull brake pads often use a washer system to set caliper arm position to the rim. Push both arms together until pads are touching rim and view caliper arms. Arms should be close to parallel with one another. If arms are forming a wide "V," swap the wide spacers inside the caliper for the narrower spacers outside the caliper. If the arms tilt inward when the pads are striking the rim, swap the narrow spacers inside the calipers for the wider spacers outside the calipers (figure 12.29).

Some models of the Shimano® XTR®, Deore XT®, and Deore LX® brakes use a moving parallelogram for the pad-to-rim motion. These are called V-Brakes® and differ in pad placement from other linear-pull models. A linkage system allows the

FIGURE 12.29



Move wide spacer to outboard side of caliper to narrow arms

FIGURE 12.30

Linkage system of Shimano® V-brake system pads to move straight toward the rim, not on an arc. The pad is mounted to a moving plate attached to the caliper arm with a linkage system (figure 12.30). Set pad height to strike in the middle of rim braking surface for these caliper brakes.

Linear-pull calipers, like cantilevers, are attached to the frame or fork at the braze-ons. Grease the outer surface of each braze-on before installing the calipers. Secure mounting bolts. The caliper arm should pivot freely. Overtightening may damage the fitting and cause the caliper to stick.

Most models of linear-pull calipers use a threaded stud brake pad. A threaded bolt is fixed into the pad. The bolt is located in the caliper arm by a series of convex and concave washers. This "ball and socket" system allows the bolt and pad to move in the caliper arm for toe and vertical face alignment (figure 12.31). To change pad angle, loosen the bolt and move pad to desired position. Hold pad while securing nut/bolt.

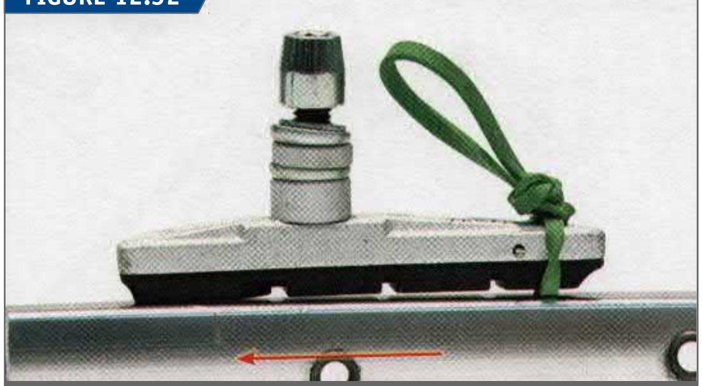
FIGURE 12.31

Ball and socket system of threaded brake pad

Procedure for linear-pull caliper and pad adjustment:

a. Attach brake cable to brake lever and feed through barrel adjuster and housing. Feed cable through frame fittings, through the "noodle", and through the protective rubber boot, if available. Finally, feed brake cable through pinch mechanism.
b. Check barrel adjuster position. Unscrew barrel adjuster two turns from fully threaded into lever body.
c. Push both arms together until pads are touching rim and inspect caliper arms. Arms should be close to parallel with one another. Move washers as necessary to position arms as described above.
d. Adjust one pad position relative to the rim at a time. Loosen pad nut/bolt and lubricate curved washers and thread. Install rubber band shim at back edge of pad (figure 12.32). This creates a temporary shim to add toe to back edge of pad.

FIGURE 12.32



The linear-pull caliper brake (arrow shows direction or rim rotation)

e. Push caliper arm to rim and view pad alignment. If practical, unhook spring from arm to make alignment easier. Set pads for correct position relative to rim in four basic alignments:
   Height: with pad close to top edge of braking surface.
   Tangent: with front and back edge even to rim.
   Vertical face: with pad face and rim parallel.
   Toe: with slight gap at trailing edge of pad. A rubber band can act as a shim to hold the back of the pad out slightly.
f. Tighten pad nut and remove rubber band. Inspect pad alignment again.
g. Repeat pad adjustment on other side of caliper.
h. Pull cable slack through pinch bolt mechanism. Do not pull cable overly tight if using a fourth hand tool such as the Park Tool BT-2. Secure cable pinch bolt fully. Cable should flatten when pinch bolt is tight.
i. Squeeze lever hard several times to test pinch mechanism and to settle cable and housing. Set pad clearance at lever for rider preference by using the barrel adjuster. If barrel adjuster is screwed all the way into lever body and brake lever is still too tight, loosen brake cable pinch bolt and allow slack to feed through pinch plate. Tighten pinch bolt and test again and adjust as necessary.
j. Inspect pad centering to rim. Use setscrew on sides of caliper to center pads to rim. Tighten setscrew on arm with pad that is closest to rim (figure 12.33).
k. Inspect to ensure that pads are not rubbing tire. Readjust if necessary.

If the linear-pull caliper uses smooth stud brake pads, the procedure is similar to cantilever calipers. Adjust the cable tension to set arms close to parallel and then adjust pads. Use the barrel adjuster to back pads off rim for clearance.

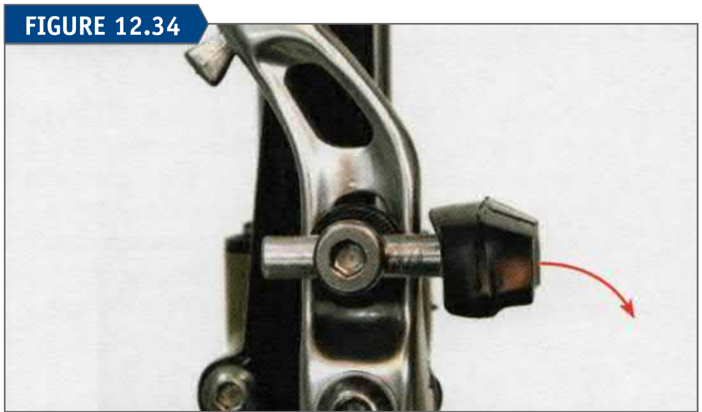
FIGURE 12.33

Use screw to change spring tension when centering pads to rim

CANTILEVER CALIPER ADJUSTMENT

Cantilever calipers may be found on mountain bikes, cyclo-cross bikes and touring bikes. Cantilever caliper pads move downward on an arc as they travel to the rim (figure 12.34). Because of the downward arc, pads should be set high vertically on the rim but without interfering with the tire. Pad height will lower as pad face wears and the caliper arms get closer to the lower edge (or hub side) of the rim.

FIGURE 12.34



Cantilever pads travel downward as they move toward rim

FIGURE 12.35

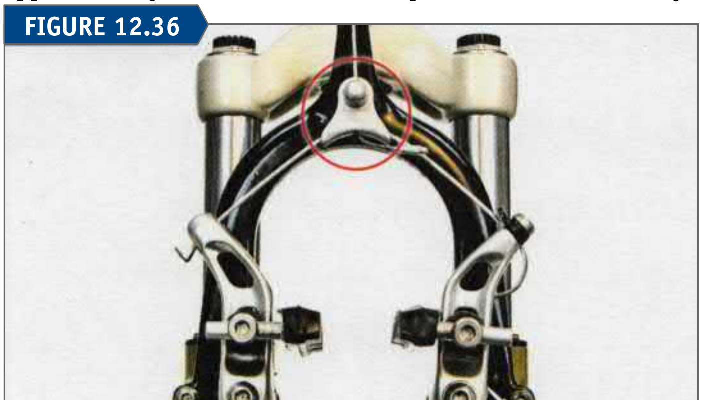
Smooth stud pad with curved washer system

Cantilever calipers may use either the “smooth stud” or “threaded stud” brake pads. Smooth stud brake pads are secured by pressure from a “pad-fixing bolt.” A system of curved washers allows the brake post to rotate for setting toe (figure 12.35). The pad can be bolted into a range of positions, closer to or further from the rim.

There are two basic systems that link the primary brake cable from the brake lever to the cantilever caliper arms: the straddle wire carrier and the “link unit.”

A straddle wire carrier is centered over the wheel and uses a pinch bolt to secure the primary brake cable (figure 12.36). The carrier pulls up on a straddle wire, a separate wire connecting the two caliper arms. Place the straddle wire carrier as low as practical for the best mechanical advantage to the brake pads. The bottom of the carrier should be approximately even with the lowest part of the rear seat stay

FIGURE 12.36



Straddle wire carrier for cantilever calipers

FIGURE 12.37

Straddle wire link unit

bridge or front fork crown, or clearing the top of the fender, if any.

A link unit uses housing and a head that is a fixed distance above the tire (figure 12.37). The height of the link unit determines the arm position. A longer link unit will allow more clearance above the tire. The primary wire attaches to one caliper arm, and the link unit attaches to the opposite arm. The center head does not pinch the wire. The arms are drawn together when the cable is pulled and the head is lifted upward.

Procedure for cantilever pad and caliper adjustment:

a. Mount bike in repair stand.

b. For calipers using link units, attach cable to lever. Feed cable through all housing pieces and the link unit to the caliper arm pinch bolt. For straddle wire carriers, feed cable through housing and attach cable to straddle wire carrier. Position the carrier above the tire even with the lower part of the frame or fork, clearing the top of the fender, if any. Fully secure carrier pinch bolt.

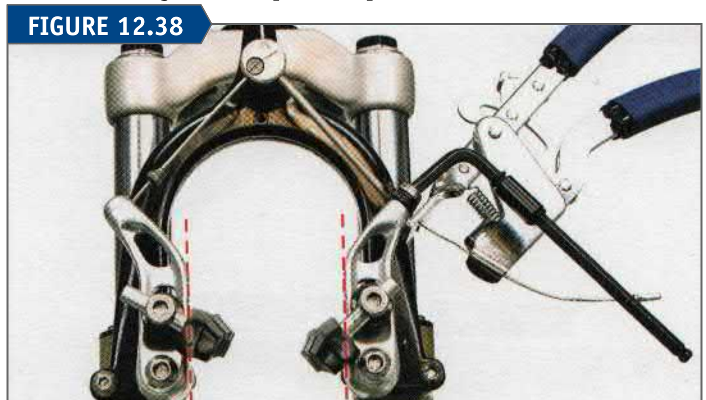
c. Turn brake lever barrel adjuster fully clockwise into lever body, then unthread approximately two complete turns. This allows adjustment after setting pad placement.

d. Loosen brake pad fixing nuts on both sides of cantilever and lubricate threads, curved washers, and washer-to-arm contact points.

e. Point pads down, away from rim, and gently snug nuts. This allows proper alignment of caliper arms before adjusting pads.

f. Position caliper arms parallel to one another (figure 12.38). For saddle wire carriers or link wires, adjust cable length at caliper arm pinch bolt. Use the Park Tool

FIGURE 12.38



Adjust brake cable at pinch bolt until arms are close to parallel

BT-2 Cable Stretcher to help adjust cable length. Secure pinch bolt.

g. View centering of caliper arms to rim. Most calipers use a centering setscrew on the caliper arm. Turning the setscrew changes spring tension. For example, to move both arms right, turn right side setscrew clockwise. To move both arms left, turn right side screw counter-clockwise. Squeeze lever to work calipers and check centering again. Do not center pads to rim at this stage; consider only the position of the caliper arms relative to rim.

h. Attach a rubber band around backside of pad. This is used in pad alignment only and is later removed (figure 12.39). The rubber band creates a shim to give toe to the brake pad. Some pads may have a built-in toe feature at the back end of the pad. Do not use a rubber band on these pads. Simply align the built-in toe feature flush to the rim.

FIGURE 12.39

Adjust the pad at a time, using a rubber band to create toe

i. Adjust pad alignment to rim. For smooth stud pads, push one pad through fixing bolt assembly until it is contacting rim. Use care not to move caliper arm. Set pads for correct position relative to rim in four basic alignments:

  Height: with pad close to top edge of braking surface.
  Tangential: with front and back edge even to rim.
  Vertical face: with pad face and rim parallel.
  Toe: with slight gap at trailing edge of pad. A rubber band can act as a shim to hold the back of the pad out slightly.

j. Hold mounting bolt with hex wrench and tighten mounting nut. Pad should contact rim after adjustment.

k. Remove rubber band from rear and view toe. There should be a slight gap at back of pad. Double-check pad alignment by viewing from top, bottom, front, and side.

l. Loosen other pad and repeat steps “h-k.” Both pads should be contacting rim when pad adjustments are completed.

m. Squeeze lever multiple times to seat brake cable and test brake cable pinch bolt. Cable should not slip either at cable carrier or caliper arm.

n. Set clearance at lever for rider preference. If brake feels tight, turn barrel adjuster clockwise to shorten cable housing and loosen brake cable tension. If brake feels loose, turn barrel adjuster counter-clockwise to tighten brake cable tension.

o. If barrel adjuster is all the way engaged at lever and brake lever is still too tight, loosen brake cable pinch bolt and allow slack to feed through pinch plate. Tighten pinch bolt and test again. Adjust at brake lever.

FIGURE 12.40

Use spring tension to center pads to rim

p. View pad centering to rim. If not adequately centered, use centering setscrew on arm (figure 12.40).

q. Inspect to ensure that the pads are not rubbing the tire. Readjust if necessary. For smooth stud pads, use care not to move brake pad stud in or out from caliper arm as this changes centering. Move pads only up or down.

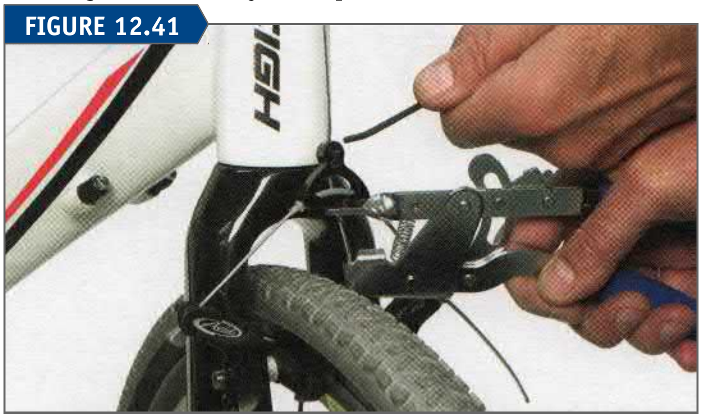
Some brands and models of cantilever calipers have no centering setscrew or other system of pad-to-rim centering. In this case, move smooth stud pads laterally as necessary in pad fixing bolt. Another option on some brands utilizes an adjustable spring tension nut on each caliper at the mounting bolt. Spring tension can be changed on either arm.

The cantilever caliper may be designed for use with a threaded stud brake pad that uses a series of convex and concave washer as a ball and socket system to allow the pad to rotate for toe and vertical face alignment (figure 12.41). The position of the pad to the arm can be changed laterally by moving the wider spacer to the inner or outer side of the caliper arms. The washer must be arranged with the convex and concave surfaces facing one another. Because there is a washer system on either side of the caliper, the threaded stud can be secured in various positions other than square to the caliper arm.

Procedure for cantilever threaded stud pad adjustment:

a. Use straddle wire to bring pads to rim and secure pinch bolt. Pads should be just touching rim-braking surface. Do not close pads to rim with force, as final pad alignment is not yet completed.

FIGURE 12.41



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b. Set pads for correct position relative to rim in four basic alignments:
   Height: with pad close to top edge of braking surface.
   Tangent: with front and back edge even to rim.
   Vertical face: with pad face and rim parallel.
   Toe: with slight gap at trailing edge of pad. A rubber band can act as a shim to hold the back of the pad out slightly.
c. Screw adjusting barrel into lever to clear pads from rim. Squeeze lever and set lever clearance as desired.
d. View pad centering to rim. If not adequately centered, use centering setscrew on arm.

DUAL-PIVOT CALIPER ADJUSTMENT

Dual-pivot calipers are popular on many road bikes. They appear visually very similar to side-pull brakes (figure 12.42). However, the left side and right side dual-pivot brake caliper arms move on separate pivots, and the two arms arc in different directions. As seen from the mechanics point of view, the left pad swings downward toward the rim while the right pad swings upward. As with other calipers, the swing of the arm determines initial pad height.

FIGURE 12.42

Dual-pivot caliper brake

FIGURE 12.43

Mounting nut of a dual-pivot or side-pull caliper brake

Dual-pivot and side-pull brake calipers secure in mounting holes in the frame and fork. These calipers secure to the frame with a single nut centered above the wheel (figure 12.43). The front brake-mounting bolt has longer threads, while the rear brake bolt has shorter threads. When mounting a dual-pivot or side-pull caliper, hold it centered to wheel and tighten nut.

Some dual-pivot brakes allow for only height and tangent alignment adjustments to rim. Toeing or vertical face alignments are possible with pads using a ball and socket system only. Dual-pivot caliper arms can sometimes be bent slightly for pad toe. If the caliper arm is relatively thick or seems difficult to bend, however, then toe may be cut into the pad with a file. If the brake does not squeal on a test ride, toeing is not required.

Tools & Supplies:

- *Box or open end wrenches (Park Tool CBW-1 and CBW-4)*
- *Hex wrenches (Park Tool – various models)*
- *Fourth hand (Park Tool BT-2)*

Procedure for dual-pivot caliper and pad adjustment:

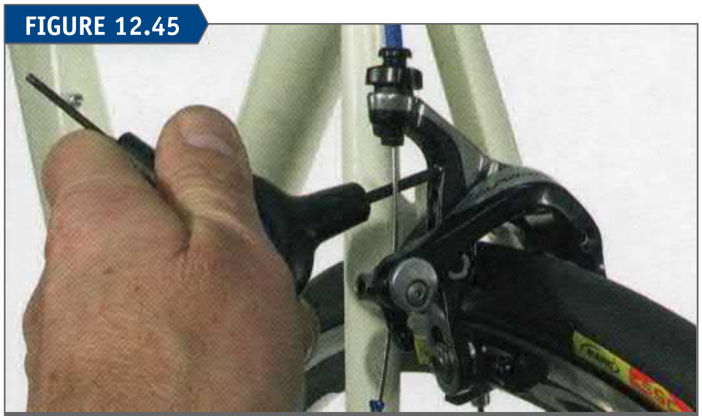
a. Feed brake cable through brake lever and through housing.
b. Attach brake cable to pinch bolt and secure.
c. Loosen and lubricate threads of pad bolt/nut.
d. Squeeze both pads to rim and adjust pads for height and tangent. Right pad should be set to lower edge of braking surface. Left should be set to upper edge of braking surface. Vertical face alignment to rim and toe alignment are not typically adjustable on dual-pivot calipers. If desired, toe may be set by slightly bending arm. Grasp arm with small adjustable wrench and bend arm as needed. Use rag on caliper arm to protect finish if surface scarring is a concern.
e. Fully tighten pad-fixing bolts.
f. Squeeze lever to test pad clearance.
g. Use barrel adjuster to adjust pad clearance. Set clearance for approximately 3–4 mm ($\frac{1}{8}$ inch) on each side from pad to rim or set for rider preference. Draw slack from system using brake cable pinch bolt if barrel adjuster is unscrewed to its limit.
h. View pad centering to rim. If left pad appears closer to rim, tighten setscrew. If right pad appears closer, loosen setscrew (figure 12.44).

There are brakes that require different methods of centering. The Shimano® BR-9000™ uses a centering screw located in the caliper arm that holds the adjusting barrel (figure 12.45). Use this screw to move the arms left to right when centering to the rim.

FIGURE 12.44

Center pads to rim with setscrew in brake bridge.

FIGURE 12.45

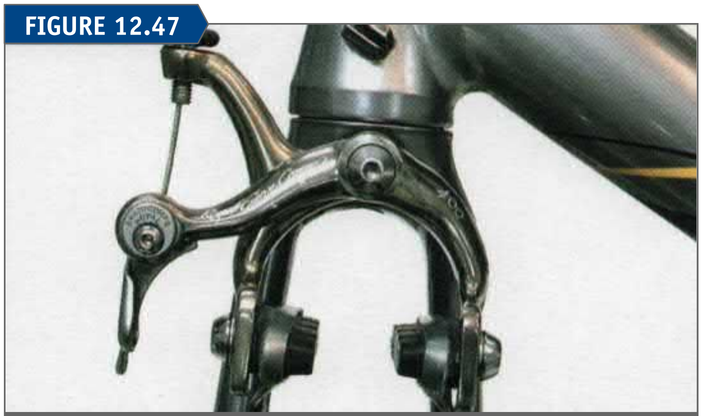


Centering screw for Shimano® BR-9000

FIGURE 12.46

Rotate mounting nut and wrench flats the same direction to move calipers over rim

FIGURE 12.47



Side-pull caliper brake

SRAM® has wrench flats behind the caliper arms. Use a hex wrench in the mounting nut behind the brake and a brake-centering wrench such as the Park Tool OBW-4 at the same time, moving them in the same direction (figure 12.46).

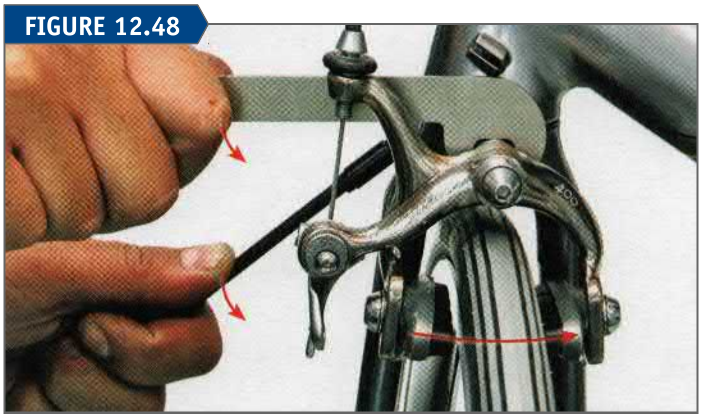
SIDE-PULL CALIPER ADJUSTMENT

Road-type bikes can also use a side-pull brake (figure 12.47). Side-pull calipers at first glance look like dual-pivot calipers. Each arm, however, shares a single pivot bolt in the middle of the brake. The bolt for mounting the brake and for the arm pivot is centered over the rim. Both pads swing downward on an arc toward the rim and should be set high on the braking surface.

Procedure for side-pull caliper and pad adjustment:

a. Feed brake cable through lever and through housing.
b. Loosen each pad-fixing nut and lubricate threads.
c. Push one arm to rim and set pad alignment. Adjust pad to strike upper edge of braking surface. Pad front and back edges should be level. Most side-pull pads adjust only for height and tangent. Vertical face alignment is not typically adjustable. Tighten pad-fixing bolt.
d. Repeat adjustment with other pad and tighten pad-fixing bolt.
e. Insert brake cable in pinch bolt mechanism. Squeeze pads to rim and draw slack from cable. Secure brake cable pinch bolt.
f. Squeeze lever hard several times to test brake cable pinch bolt torque.
g. Check lever clearance to handlebar. Use adjusting barrel to change lever clearance to rider preference.
h. Check brake pad centering to rim.
i. If pads are not centered to rim, hold caliper arms with one hand while loosening rear nut. Move caliper so pads are centered to rim and tighten rear nut. Some models are fitted with a wrench flat in the center bolt. Use one wrench on the stud and another wrench on the mounting nut and move wrenches the same direction and the same amount (figure 12.48). One pad may contact the rim before the other when squeezed to the rim. This is not an issue with side-pull calipers. It is only important that the pads are centered to the rim when they are fully open.
j. Set toe if necessary. Test ride bike and apply brakes. If brakes do not squeal, toe is not necessary. If desired, toe may be set by slightly bending arm. Grasp arm with small adjustable wrench and bend arm as needed. Use rag to protect arm if surface scarring is a concern.

FIGURE 12.48



Centering side-pull with centering flats on brake stud

CHAPTER 13

HANDLEBARS, STEMS, SADDLES, & SEATPOSTS

Handlebars connect the rider to the stem, which connects to the bicycle fork. The handlebars are one of the three contact points between the cyclist and the bicycle, along with the saddle and pedals. All of these components should be fitted and adjusted to the rider's body and riding style to maximize comfort and performance. Different models, sizes, and styles of handlebars and stems can be changed for individual positioning needs. There are two basic handlebar types: the upright bar and the drop bar.

UPRIGHT HANDLEBARS

Upright style bars are commonly used on mountain bikes, hybrid bikes, BMX bikes, and cruisers. These bars can be tubular steel, aluminum, or carbon fiber and are made with a bend or curve to each side. Generally, these bars should be aligned to point straight back with the bar bend level to the ground (figure 13.1). When the bars are rotated, it will affect the reach to brake and shift levers.

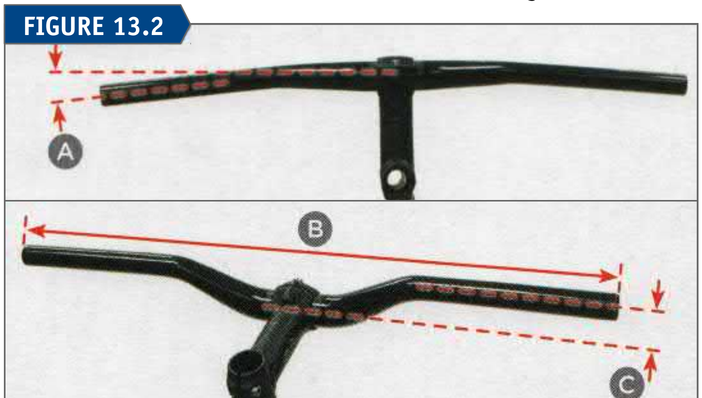
FIGURE 13.1

Upright handlebar rotated to a level or flat position

Standard upright bars use a 22.2 mm outside diameter at the ends for securing brake levers, shift levers, bar grips, and bar-end extensions. The stem tightens on the handlebar center. Upright handlebars are made with center diameters of 22.2 mm, 25.4 mm, 26.0 mm, 26.4 mm, 31.8 mm, and 35 mm. (Note: 31.7 mm is considered the same as 31.8 mm and interchanged without issue). Shims are available for oversized stems to fit smaller bar center diameters.

Upright bars are available in different designs and can vary in width, bend, and/or rise (figure 13.2). Bar width is measured end to end. The bars may bend or sweep back toward the rider. The amount of bend is measured in degrees from the bar center to the grip. The bar may also rise up from the bar center, and bars may vary from no rise to several centimeters.

FIGURE 13.2



(A) Bend (B) Width (C) Rise

Bar-ends are optional extensions attached to the end of upright bars and give the rider more hand position options. There are designs that mount internally or externally on the ends of the handlebars (figure 13.3). Bar-ends may be stressed with nearly the entire body weight of the rider during use and should be tight and very secure on the bar. However, external bar-ends may crush the ends of very thin-walled handlebars. If the inside diameter of the bar is greater than 19 mm, a plug is required to provide internal support to prevent bar damage. Consult a professional mechanic or the manufacturer if in doubt.

FIGURE 13.3

Secure bar-ends so they do not move under load

BAR GRIPS

There are two types of grips: the slide-on grip and the lock-on grip. Slide-on grips are made to push on the bar ends with force and rely on tension from the rubber gripping the bar. Lock-on grips use external collars at each end of the grip. Small setscrews in the collars are tightened to prevent the grip from moving.

Grips vary in shape, color, compounds, size, and length, but all are designed to fit a 22.2 mm bar diameter. Grips should not slip or move during the ride. With extended use, grips may loosen and should be replaced.

When installing new grips make sure the levers are positioned to allow the grips to slide fully onto the bar. For slide-on grips, it can help to lubricate the inside of the grip with non-oily liquids, such as rubbing alcohol, hair spray, window cleaner, or a fluid which will quickly evaporate. Do not use oil of any type in the grip, as this will prevent the grip from holding fast.

If the old slide-on grips are worn out and are being replaced, they may be cut off the bar. It is also possible to remove and re-use the grips if they are in good condition. Use a long, flat-tipped screwdriver worked gently under the inside edge of the grip. Drip or spray liquid such as window cleaner, hair spray, or rubbing alcohol in the gap (figure 13.4). Work the solvent around the grip to loosen the bond and slide the grip off the bar.

If the grip has a sealed end, it can be removed with compressed air. Use a blow tip and place inside end of grip. Wiggle the grip while pulling as blown air loosens grip from bar. It is necessary to have someone plug the exposed bar end to remove the second grip.

FIGURE 13.4

Move levers inward, then lift grip to inject liquid spray

If the grips are slipping, it may be possible to improve the bond to the bar with glue. Contact cements and tubular tire cements are good choices. Use a thin layer inside the grip rather than on the bar to avoid having to clean up excess exposed glue.

Lock-on grip setscrews should hold the grip tightly to the bar (figure 13.5). Test the grip by turning with force. The grip should not rotate. The center rubber section of lock-on grips will wear and eventually require replacement.

FIGURE 13.5

Secure setscrews on the lockring grips

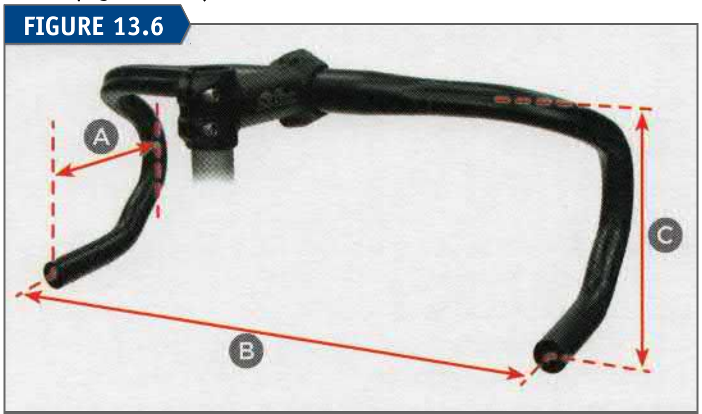
DROP STYLE HANDLEBARS (ROAD BARS)

Drop style bars curve forward and downward to form hooks for the hands. Drop bars may be made of steel, aluminum, or carbon fiber and will vary in width, reach of the drop, and shape of the bar. Select a bar for comfort. There are currently center diameter standards of 25.4 mm, 25.8 mm, 26.0 mm, 26.4 mm, 31.8 mm (31.7 mm is considered the same as 31.8 mm), and 35 mm. When in doubt, measure the bar center diameter with a caliper. Stems sized for larger bar can be shimmed down for the small bar standards.

The stem should match the standard of the bar center. For example, using a stem made for a 26.0 bar center with a 25.4 bar will mean the bar will not properly secure in the stem. This combination will slip and move, resulting in a very dangerous situation for the user. However, a difference of 0.1 mm between stem and bar is considered acceptable.

Drop bars are made with different designs and shapes. The common method for measuring bar width is from center to center at the bar ends. The amount of handlebar drop is measured center-to-center from the bar top downward to the lowest section. Bar reach is measured from bar center, where it clamps in a stem, forward to the center of the bar at the curve (figure 13.6).

FIGURE 13.6



(A) Reach (B) Width (C) Drop

Drop style bars can be rotated at the stem for comfort. There are rotational limits (figure 13.7). Too far up or down sacrifices performance and safety. Drop bars experience a significant amount of stress at the stem clamp, and it is important that the drop bar be fully secure. Refer to Appendix C and with manufacturer's specifications for torque values.

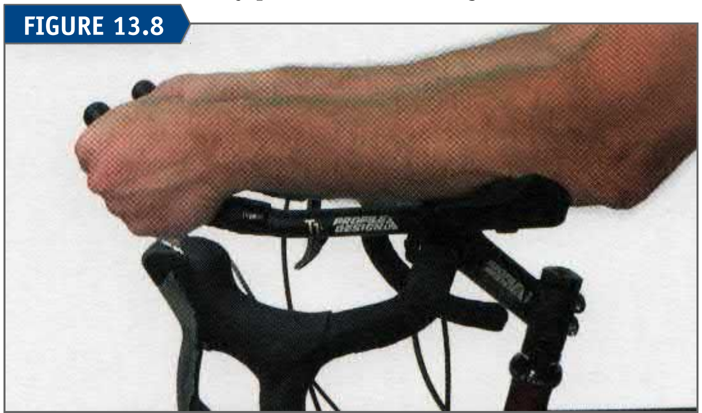
FIGURE 13.7

Upper and lower limits of drop bar rotation

CLIP-ON AND AERO HANDLEBARS

"Clip-on aero bar" attachments are available for drop or flat handlebars (figure 13.8). These bars secure to the existing bar, and are intended to improve the aerodynamic position of the cyclist. However some cyclists use them simply to allow a different body position for a change in comfort. It

FIGURE 13.8



"Clip-on" handlebars mounted to drop handlebars

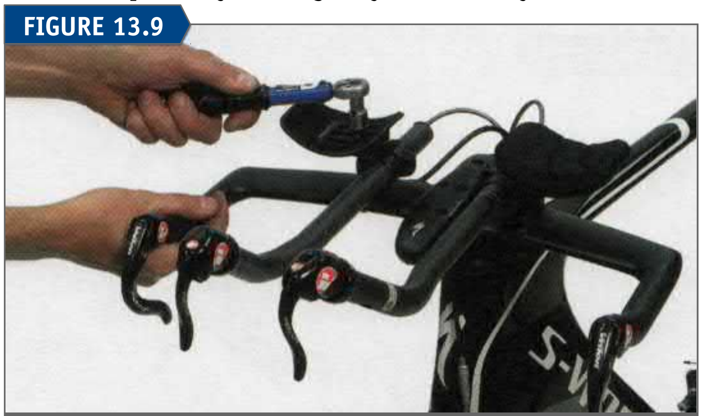
Tech Note:

Road handlebars are wrapped in a padded tape for comfort. Alternatively, long foam rubber grips are slid on to the bars. Wrapping is a skill that takes practice and patience. For the procedure to wrap handlebars, see www.parktool.com/blog/repair/help.

is important that the primary bar and clip-on attachments are fully secure before riding. Loose bars may result in a cyclist losing control, should they slip during use. Check manufacturer's specifications for torque and compatibility.

Unlike the supplemental clip-on bar attachments, the integrated aero handlebar is a complete bar assembly (figure 13.9). Aero handlebars have fittings made to rest the elbows and extensions for the hand controls. The extensions are usually adjustable forward and back, and the elbow rests are usually adjustable side to side. Special purpose brake and shift levers are fitted to the aero handlebar. Aero handlebars are considered primarily a racing-only handlebar system.

FIGURE 13.9



Secure all fittings on integrated aero bar systems

STEMS

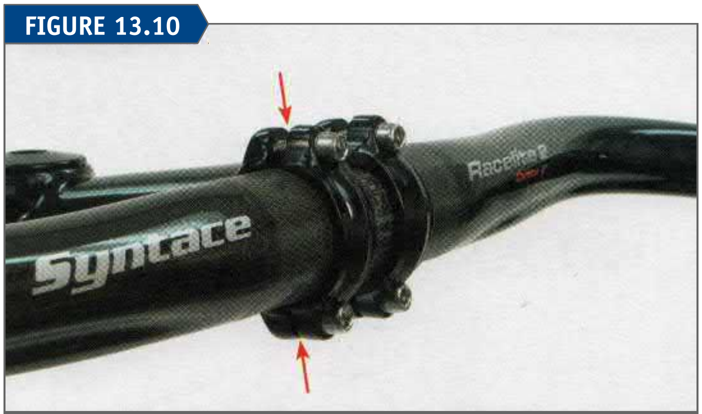
Stems connect the handlebars to the fork column. Bikes with threaded columns use "quill stems" and threaded headsets, and bikes with threadless columns use threadless stems and threadless headsets.

A stem binds and holds the bars using either a faceplate or a one-piece pinch clamp. All binder bolts in the stem should be lubricated and secured tightly. Do not, however, get grease or oil in the area where the bar meets the stem or column. The stem/bar interface may creak or even slip and move if not properly secured.

The removable faceplate of a faceplate clamping stem presses against the bar center when the stem binder bolts are tightened. It is important that each bolt be tightened the same amount and the top and bottom gaps between the faceplate and the stem body are the same. If the gap size is different, the heads of the faceplate bolts will be stressed as they rotate during tightening (figure 13.10).

Stems are designed for specific uses. There is some interchangeability, if the column and handlebar diameters match, but riding style must dictate stem selection. For example,

FIGURE 13.10



Gap between faceplate and stem body must be even between top and bottom plates

stems designed for downhill riding tend to be short, heavy, and very strong in order to take the punishment of DH riding. Stems designed for road riding tend to be longer and lighter, but are not as strong. Handlebar and steering column diameters may match between two stems, but a less strong stem should never be substituted when the riding calls for a stronger stem.

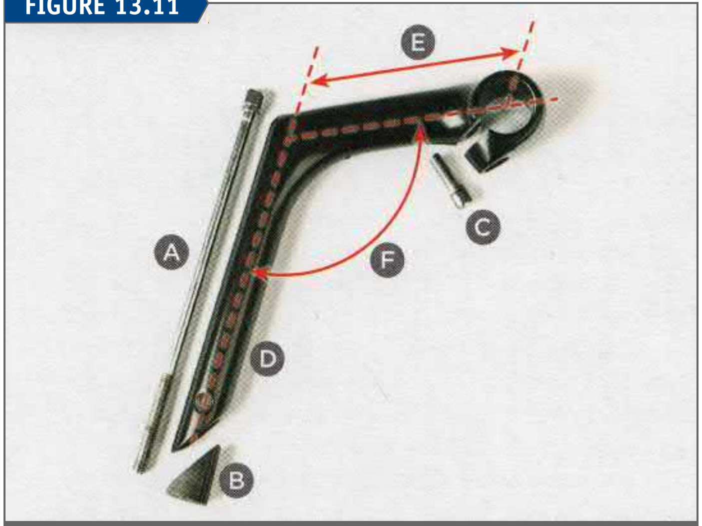
Both threadless and quill stems are available in adjustable angle versions. An adjustable angle stem has a built-in pivot that allows changes to the angle relative to the steering column. These stems allow the rider to try different positions without installing a new stem. The pivot fastener must be fully secured before the stem can be safely used.

QUILL STEMS

The "quill" refers to the vertical post of the quill stem that inserts into the inside of the threaded steering column. A bolt draws up a wedge or cone to jam the stem tight inside the column. The stem binder bolt, bolt head, wedge, and outside of the quill should have a layer of grease or anti-seize before installing and tightening (figure 13.11).

Quill stems are available in different stem angle and extensions like threadless stems. Quill stems are also specified for length of the quill. The stem angle is measured from the quill to the extension (figure 13.11).

FIGURE 13.11



Quill type stem: (A) Stem binder bolt, (B) Stem wedge, (C) Handlebar binder, (D) Quill section, (E) Stem length, (F) Stem angle

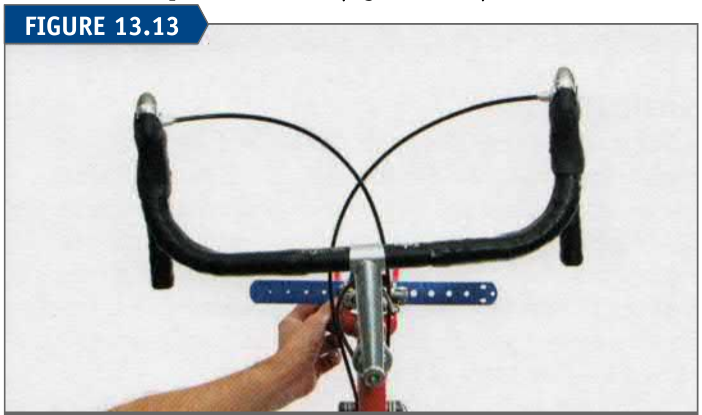
It is important that the stem's quill diameter is a correct match for the inside diameter of the steering column. The quill should be slightly smaller than the inside of the column. There are several different steering column sizes found on bikes. Quill stems of 22.2 mm are used inside a 1 inch (25.4 mm) steering column. Quill stems of 25.4 mm are used inside a 1⅛ inch (28.6 mm) column, and a 28.6 mm quill is used inside a 1¼ inch (31.8 mm) column.

FIGURE 13.12

Example of stem set too high. "Max height" line must not be visible.

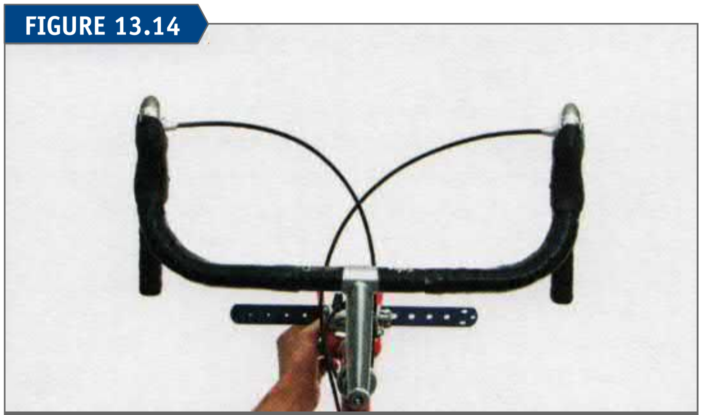
To change stem height on a quill stem, loosen the stem binder bolt at the top of the quill. Do not loosen the headset locknut to move the stem. Attempt to move the stem by twisting after loosening the binder bolt. If it will not move, strike the top of the stem binder bolt with a hammer or mallet to free the wedge. The stem must not be raised too high. Inspect the stem for a "max height" line and do not raise the stem past this mark (figure 13.12). As a rule, have at least 2.5 times the diameter of the quill inserted into the column. For 1 inch diameter quill stems, leave 2½ inches of quill inserted. Large changes to stem height may also require adding longer shift or brake cables and housing.

FIGURE 13.13



Straight edge shows bars and stem are not aligned

FIGURE 13.14



Straight edge is parallel to bar, which makes stem aligned

The stem should be aligned with the front wheel. However, it is often easier to align the handlebars to the front axle or the dropouts. Handlebars provide a visual straight edge to align the bars parallel to the front hub. It is useful to place a straight edge on the fork blades. Compare this line to the handlebar near the stem. If the two lines appear parallel, the stem is straight (Figure 13.13 and Figure 13.14).

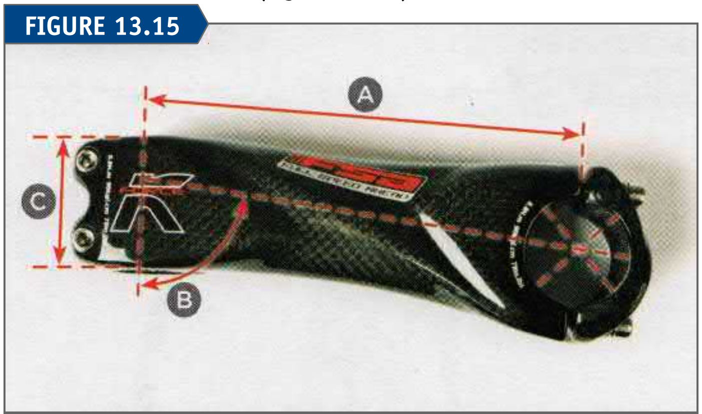
THREADLESS STEMS

Threadless stems clamp around the outside of the steering column. A threadless stem also acts to lock the threadless headset's bearings' adjustment. Look for the adjusting cap at the top of the steering column. Do not confuse this cap for part of the stem. A threadless stem should be mounted only to a threadless steering column; never secure a threadless stem over the threads of a threaded fork.

Threadless stem standards are determined by the outside diameter of the steering column. There several standards in use: the 25.4 mm stem for 1 inch steering columns, 28.6 mm stems for 1⅛ inch columns, 31.8 mm stems for 1¼ inch columns, and 38.1 mm stems for 1½ inch columns. A larger stem may be shimmed down to a smaller steering column standard.

Threadless stems are available in many different angles and lengths. Stem length or extension is measured from the center of the bar clamp to the center of the steering column. Stem angle is measured between the steering column to a line through the stem extension. The fork clamp stack height is measured along the steering column. The clamp stack height is a consideration when sizing and cutting the steering column to fit the bike (figure 13.15).

FIGURE 13.15



Threadless stem measurements: (A) Stem length,
(B) Stem angle, (C) Stem stack height

Threadless stem height adjustability is limited by the number of extra spacers used along the steering column. To lower threadless stems, remove extra spacers that are below the stem and stack them above the stem. It is important to keep at least one spacer between the stem and headset. This helps reduce stress on the steering column. If, after lowering the stem, there is an excessive amount of steering column extending above the stem, the column may be cut and shortened. See Chapter 14, Headsets, Threadless Steering Columns.

To raise a threadless stem, look for any spacers above the stem. Move these to below the stem, leaving enough of a gap for the top cap to allow for headset adjustment. Simply adding additional spacers below the current stem and column arrangement to raise the bars may compromise stem-to-steering column engagement and make the bike unsafe. The steering column must have good contact with the inside of the threadless stem. However, the steering column should be slightly recessed below the stem top (figure 13.16).

FIGURE 13.16

Threadless steering column recessed below threadless stem

Aluminum, steel, and carbon fiber steering columns have limits for how many spacers can be between the lower edge of the stem and the headset top cap. See page 203, Threadless Steering Columns.

If there are no spacers above the stem, consider installing a different stem with a steeper upward angle. Another option for more height is to add a threadless stem extension to further raise the handlebars (figure 13.17). These mount over the steering column and extend a post upward where the threadless stem clamps. It is important that the extension fully engages the steering column. Consult the manufacturer for height limits.

FIGURE 13.17

Threadless column extender

Align the stem with the front wheel. If this proves difficult, use a straight edge to extend the line of the fork blades (figure 13.18). See the procedure described above for quill stems. Fully secure stem binder bolts.

FIGURE 13.18

Stem is misaligned when bars are not parallel to fork blades

It is critical for safety, when the steering column is made of carbon fiber, to not over-tighten bolts as this may crack the carbon material (figure 13.19). Consult the manufacturer for acceptable torque limits.

FIGURE 13.19

Cracked steering column from stem binder bolts

SADDLES

The saddle is straddled by the cyclist and offers support for his/her weight. Saddles are available in many different shapes, widths, and padding options. Saddles are made in both “men’s” and “women’s” specific designs. However, saddle selection is a personal choice and it is best to find a retail bike shop that will allow you to try different models. There are also designs specific to BMX, time-trial racing, cyclo-cross, as well as other types of riding.

Bicycle saddles have a rail system mounted beneath a saddle shell, which in modern saddles is usually molded plastic resin. Padding and a leather or synthetic cover then covers the shell. The rails are secured to the seatpost by saddle rail binder clamps (figure 13.20).

Common saddles use two parallel 7 mm round rails. The rails allow the saddle to be positioned forward or back relative to the seatpost as desired by the cyclist. Seatposts allow options in saddle tilt or angle. There are also proprietary mono-rail saddle designs that require a unique seat post made by the saddle manufacturer.

A common problem in this area is a creaking noise in the saddle or seatpost. This is typically resolved by properly tightening the saddle rail binder bolts. However, if the saddle shell has loosened from the rail, it cannot be effectively repaired. Hard use and crashing may bend the saddle rails.

FIGURE 13.20

Secure saddle rail binder bolts by alternating tightening when two bolts are used

Riding with a bent rail may lead to breakage of the rail. Replace saddles with cracked shells, bent rails, or rails that have separated from the shell.

To change the saddle, begin by noting the position of the current saddle. Place a straight edge on the saddle and measure the saddle tilt or angle using an angle finder. It is useful to use a long straight edge on the saddle to extend the top when setting the saddle angle (figure 13.21). Note the forward/rearward position of the saddle on the rails. Unbolt the old saddle from the seatpost cradle. Lubricate saddle rail binder bolts with a light lubricant. Install the new saddle on the post clamp and secure binder bolts. Using an angle finder, measure and adjust the saddle angle, and secure the saddle on the rails in the same position as the previous saddle. Change the position as necessary after a test ride. Generally, begin with the saddle in a level position, and then make changes in small increments upward or downward as necessary for rider comfort.

FIGURE 13.21

Use straight edge to extend saddle line when adjusting tilt

SEATPOSTS

The seatpost connects the saddle to the frame. Seatposts are available in different lengths, diameters, and even shapes. Better quality seatposts have a saddle rail binder clamp integrated into the top of the post.

Seatposts vary in "offset" or "setback" which is the distance from center of the post to the center of the rail binder system securing the saddle. More offset allows the rider to sit further back relative to cranks and away from the handlebars (figure 13.22).

FIGURE 13.22

Post on the left has no offset; post on the right has 32 mm offset

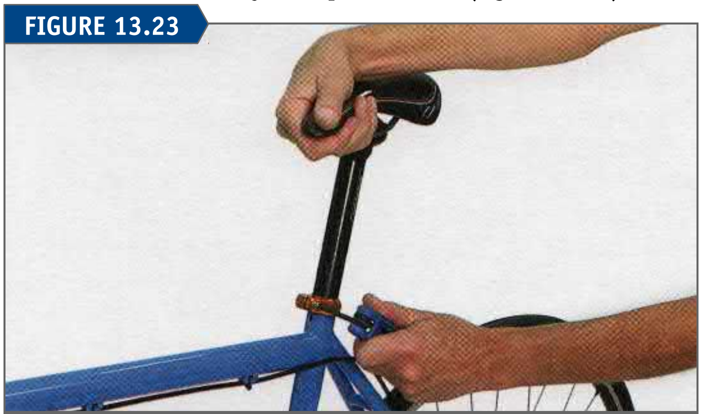
Less expensive and older bikes may use a simple seatpost without built-in clamp. These are basically a simple tube swedged down to a ⅞ inch diameter top. A separate clamping bracket secures the saddle rails to the top of the post.

There are many different sized seat tubes used on bicycles, and seatpost diameters are available to match. Seatpost diameters range from 22.2 mm to 32.4 mm. The post diameter should be approximately 0.1 mm smaller than the inside seat tube diameter. There are shims available to allow a smaller post to fit into a larger seat tube. Cutting "homemade" aluminum shims does not typically provide an adequate fit.

If the frame is steel, titanium, or aluminum, use grease or anti-seize inside the seat tube to prevent corrosion from seizing the post. If the seatpost or frame is made of carbon, use a special assembly compound such as Park Tool SAC-2. These compounds contain both a gritty substance for more friction and a carrier that helps prevent corrosion. If you ride in an area with much rain or are often riding near salt water, remove the post every 3 to 4 months to clean inside the seat tube and reapply the grease, anti-seize or assembly compound.

Various methods are used to secure a seatpost into the bicycle frame. Frames that use round seatposts typically have a compression slot cut into the top of the seat tube. A seatpost binder bolt pinches the seat tube at the top to hold the post secure in the frame. Lubricate the seatpost binder bolt before tightening. The binder bolt does not require a great deal of tension to hold the post from slipping downward. Generally, only tighten the binder until the saddle will not rotate when pressed with one hand. If it will not rotate with one hand, it is unlikely to slip downward (figure 13.23).

FIGURE 13.23



Test saddle rotation by twisting with one hand, not two

Tech Note:

Seat posts can seize to the frame. For details on seized post removal, see www.parktool.com/blog/repair/help.

Bike frames may use a seatpost binder mechanism with a bolt built into the frame. However, some frames use a separate collar that slides over the top of the seat tube. The collar holds the seatpost binder bolt to squeeze the collar around the seat tube and hold the post.

Another option for securing the seatpost is a quick release cam system. This permits the post to be raised and lowered without using wrenches. The cam is similar to a wheel skewer quick release in design. However, less tension is required for a seatpost compared to a wheel quick release skewer. Adjust for only enough tension on the cam to prevent the saddle from easily twisting sideways.

Seatposts are usually marked with a "maximum extension" or "minimum insertion" line (figure 13.24). Do not raise the post above this line, or the post may break. Generally, always keep the end of the post inserted below the frame lug or joint of the seat tube and top tube. Seatposts often flex under use and can bend permanently from impact and heavy use. A bent post is not repairable and should be replaced immediately.

FIGURE 13.24

Post is too high; insert post so "max line" is not seen

Some bike frames are designed for flat or aero shaped seatposts. These posts cannot be rotated in the frame because of the non-round shape of both frame and post. The shapes are proprietary and are made for a close fit to particular frames. These posts do not interchange between frame manufacturers. Some frame designs hold the aero post using a seatpost backing plate, similar to the faceplates of stems. Bolts press a specially shaped plate to back side of the seatpost to hold it tight in the frame. Other frame designs use a compression slot and a binder bolt system. The frame is pinched tight at the compression slot to hold the aero post.

FIGURE 13.25


Trim integrated seat tubes using saw guide SG-7.2

When possible, secure seatposts using a torque wrench using the manufacturers' torque recommendation.

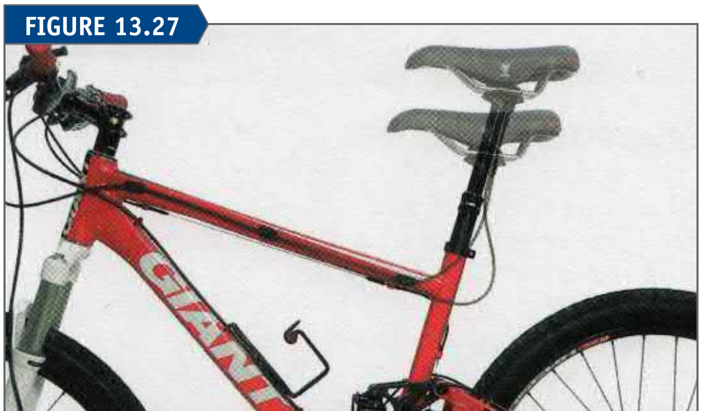
The "integrated seatpost" is a frame design using an extended seat tube built into the frame. A long seat tube extends upward past the top tube and holds a seat rail clamp mechanism. The frame acts as the seat post extension for the saddle. The seat tube is cut down to fit the rider with a saw guide such as the Park Tool SG-7.2 (figure 13.25).

Suspension seatposts are made to allow for rider and saddle movement up and down relative to the frame (figure 13.26). A spring system allows the bicycle to move up and down under the rider to help minimize bumps. With much use, the

FIGURE 13.26

Suspension seatpost

FIGURE 13.27



Range of height option for an adjustable height seat post bushings and linkage of the system may develop play. Contact the manufacturer for service procedures.

"Adjustable height" posts are made of telescoping tubing and can be quickly moved and then locked to different saddle height options (figure 13.27). These posts do not provide suspension for the rider, but can be useful when a lower height is desired for extreme off-road descents. Adjustable height posts are commonly fitted with handlebar control mechanisms to adjust the height without getting off the bike while riding.

Tech Note:

A bent saddle rail or a saddle that is not centered may result in pain or discomfort. Inspect saddle after any crash or impact.

HEADSETS

The headset is the bearing system that connects the bicycle fork to the head tube of the frame. A properly maintained and adjusted headset permits two-wheeled vehicles such as bicycles to make small self-corrections in steering. These small corrections in handling allow us to ride a relatively straight and smooth line.

The fork column is supported by bearings in the upper and lower areas of the frame head tube. If these support surfaces are not machined parallel, the bearings will bind as the fork is rotated. This can lead to premature bearing wear and poor adjustment. The head tube can become deformed by welding or by inadequate manufacturing techniques. If necessary, the head tube can be machined ("faced") so the surfaces are parallel by using a head tube reaming and facing tool (figure 14.1). The base of the fork steering column should also be cut square to the fork. If it is not properly machined, the fork crown race will not sit square to the steering column and will add to the binding effect. The fork can be machined with a crown race cutter. Facing the head tube and fork crown is best left to professional mechanics. Generally, the headset is first installed and then simply adjusted. If it adjusts well, with no binding, then the machining is considered adequate and there is no problem.

FIGURE 14.1

Facing the head tube surface to improve bearing alignment

HEADSET TYPES

The two basic headset types are threaded and threadless. Threaded headsets use a threaded top-bearing race that screws onto a threaded steering column. A locknut is used above the threaded race to lock and hold the bearing adjustment. A quill stem inserts down inside the steering column but is not part of the bearing system (figure 14.2).

FIGURE 14.2

External cups of a threaded headset with quill stem installed

The threadless headset is used on steering columns with no threading. The adjustment is performed with a non-threaded adjusting race that slides along the steering column. The race is pushed against the bearings by pressure from an adjusting cap at the top of a threadless stem (figure 14.3). Pinch bolts on the stem secure the stem on the steering column and also lock the bearing adjustment.

FIGURE 14.3

Threadless headset with external pressed cups, threadless stem, and top cap

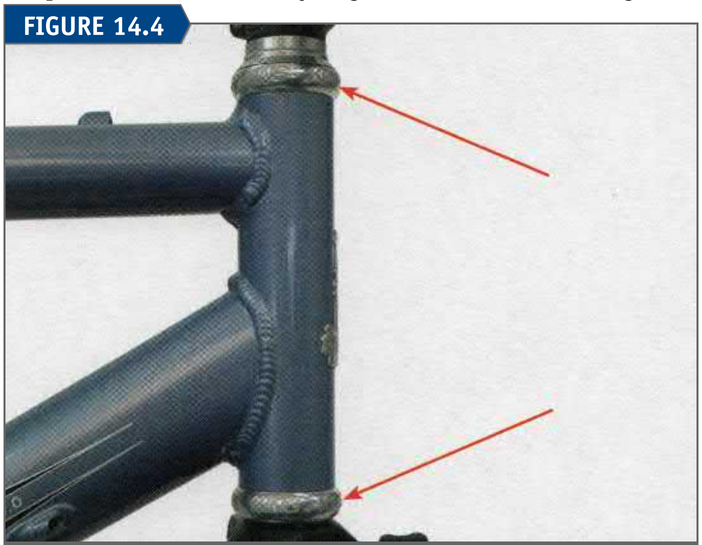
There are currently many different headset standards. When replacing a headset it is important to select a compatible model. The cycling industry is making an attempt to be more consistent in describing and naming the different headset standards by implementing the "Standardized Headset Information System," or "SHIS," a code system that describes the headset style and sizing diameter of the bike. Appendix D is a table of SHIS terms, the common legacy names, and sizing dimensions.

The first part of the SHIS is a two-letter code defining the headset fit into the frame. This may be "EC," "ZS," and "IS."

"EC" is an abbreviation for "external cup." Both the threadless and threaded headsets can use this design. The bearing cups and bearings sitting outside (above and below) the head tube faces. This would be considered a traditional or conventional headset design (figure 14.4).

"ZS" refers to the internal headset designs, also known as "zero-stack" or semi-integrated. Headset cups or adaptors are pressed into a relatively large head tube. The bearings sit

FIGURE 14.4



The "EC" or external cup style headset

inside these pieces with the bearings being nearly level with the head tube faces, rather than outside the head tube as with the EC design. A new replacement ZS headset will include the cups or adaptors that press into the frame as well as the bearings. The ZS compatible bikes tend use a relatively large diameter head tube of approximately 50 mm. This allows the bearings to sit hidden inside the tube (figure 14.5).

FIGURE 14.5

The ZS or "zero stack" headset type

"IS" is the "integrated headset" design (figure 14.6). IS headsets use cartridge bearings that are a slip-fit into the frame. The frame is made with a head tube profile that holds the cartridge bearings. Bearings are dropped into place without pressed-in cups or adaptors. The cartridge bearings use an angular contact to mate with a concave fitting in the frame. The ZS headset is not considered an integrated design because the bearings sit inside cups or adaptors that are pressed into the frame. For IS headsets, the headtube of the frame acts as the adaptor and is effectively part of the headset system. A replacement IS headset will include only cartridge bearings, a crown race, and top cap.

FIGURE 14.6

IS headset type

In the SHIS system, the letter code is followed the nominal size of the intended frame bore. For example, EC34 is the external cup style for a nominally 34 mm bore head tube. The sizing number is not intended to be the actual OD of the cup or ID of the head tube. It is an abbreviated code system to simplify the labeling of headsets. The older legacy name for this was the "1⅛ inch conventional pressed headset." A ZS44 headset is the zero-stack (internal) with a nominal 44 mm bore diameter in the frame. The IS42 headset is an integrated headset using the 42 mm bore, known previously as the "1⅛ integrated Italian Standard."

The SHIS system provides for separate designations of upper and lower headset bearing configurations. This is because a bike can use different standards for the upper and lower faces of the headtube. The two-letter code and bore number are followed by a backslash and numbers providing information about the steering column size. For example, one configuration could have an upper headset of EC34/28.6 and a lower headset of EC34/30. Both upper and lower are external cup (EC) headsets for a nominally 34 mm frame bore. However, the upper designation indicates a steering column of 28.6 mm (1⅛ inch), while the lower headset designation indicates a larger diameter of 30 mm (the fork crown race size). This headset would fit a 1⅛ inch steering column that uses a 30 mm fork crown.

Bikes may also have mixed standards with a "tapered headtube." One such system might have a designation of ZS44/28.6 for the top bearing assembly and ZS56/40 for the lower. The fork in this example would have a tapered steering column, with a base of 40 mm at the fork crown. It would then taper upwards to a size of 28.6 mm, allowing for a threadless stem (figure 14.7).

FIGURE 14.7

Mixed headset standards with the lower headtube is ZS56/40, and the upper headtube is ZS44/28.6

There are also several proprietary designs unique to some manufacturers. It is important to know which standard the bike uses to find the correct replacement parts. When in doubt, consult a professional mechanic.

HEADSET SERVICE

The front wheel throws dirt and water directly up at the lower headset bearings, causing them to become contaminated with grit and dirt. Riding also stresses the bearings, especially the lower races, and the bearing surfaces will become scored. To determine if a headset needs service, pick up the front wheel and turn the bars left and right. If it feels gritty or sticky, it should be overhauled. If the headset seems to stick and stop in

Tools & Supplies:

- *Hex wrenches*
- *Headset wrenches, for threaded headsets only (Park Tool HCW-15)*
- *Large adjustable wrench, for threaded headsets only (Park Tool PAW-12)*
- *Grease (Park Tool PPL-1)*
- *Solvent (Park Tool CB-2)*
- *Rags*

a pattern as it rotates, then the races are pitted. Replace these headsets. During any overhaul, taking notes regarding parts orientation during disassembly will help during reassembly.

Depending upon the design, headsets may use caged (retainer) ball bearings, loose ball bearings, or cartridge bearings. Cartridge bearing headsets are serviced by simply replacing the entire cartridge. Caged bearing and loose ball bearings ride on curved bearing races.

When overhauling, inspect bearing races for pitting and damage. Look for gouging and small evenly spaced pits (figure 14.8). Use a ballpoint pen to trace the bearing path. Roughness and wear will be felt as the small ball of the pen passes over bad areas. Wear in the races will not become smooth with new grease. Replace worn parts or the entire headset. Ball bearings that have been cleaned and have a shiny silver color and appear smooth may be reused. The ball bearings are generally the last part of the system to wear out. Ball bearings that appear discolored or "cloudy" after cleaning should be replaced.

FIGURE 14.8

Inspect the cups for pit marks

Pressed races may be left in the head tube and on the fork unless the headset is being replaced. Clean all bearings and races with a solvent. Use care on suspension forks not to get solvent into lower sliding legs.

Remove or disconnect handlebar-mounted computer wire and/or electronic shift wires to avoid damage before removing the stem from the fork. The handlebars are often in the way when servicing the headset. It is best to disconnect the cables from the brake calipers and derailleurs and completely remove the bars. This will also help prevent damage to housing and inner wires. Alternatively, use toe straps and rags to pad and bind the handlebars to the frame so they are out of the way.

THREADLESS HEADSET SERVICE

The threadless EC, ZS, and IS headset standards share the same basic service procedures. If the headset uses a cartridge bearing rather then caged ball bearings, simply replace the cartridge bearing as a unit. However, it is sometimes possible to use a seal pick and remove the seals of some cartridge bearings after removal from the bike. These can than be cleaned and re-greased. However, new grease will not repair and make smooth a pitted or rough bearing surface.

The cartridge bearing is common in the ZS and IS standards. The bearings are a slip fit and will install and remove by hand. Grease the outside of the cartridge to prevent corrosion. Cartridge bearings for headsets have a concave and convex

FIGURE 14.9

Cartridge bearing orientation

side. The concave side will face a cone shaped race on the fork crown, or it will face the adjusting race. The convex side will face toward the headtube, either top or bottom (figure 14.9).

Procedure for threadless headset disassembly:

a. Loosen stem binder bolts.
b. Loosen and remove top cap bolt and cap.
c. Note location and orientation of any washers or spacers on steering column. Remove stem and all spacers from steering column.
d. Pull fork from bike. It may be necessary to use a mallet and tap the top of the steering column, driving fork downward (figure 14.10). Once the fork is driven down a little, lift it back up and remove center cone from adjusting race.

FIGURE 14.10

If necessary, drive fork column down using a mallet

e. Remove fork from frame and note orientation of cage bearing retainers, cartridge bearings, or any rubber seal as they sit in headset.
f. Unless headset is to be replaced, leave pressed parts on the frame or fork.
g. For caged-ball or loose-ball bearing headsets, clean and inspect parts. Any worn parts should be replaced. For cartridge headset, simply replace cartridges.

If the headset uses caged ball retainers, check the orientation of the retainers in relation to the races before installing. Retainers have only one correct orientation. The metal wire of the retainer forms a “C” shape between the balls. The open side of this “C” should face the cone shaped race, not the cup-shaped race (figure 14.11). If in doubt as to retainer orientation you can test it by placing the bearing between the race and cup without the fork. Press downward on the mating bearing surfaces with your hand. Rotate the race and note the feeling. If the bearing orientation is incorrect, the metal retainer will cause a rubbing feeling as it rotates and pushes against the race. If the orientation is correct, the race rotates only on the ball bearings, not the retainer cage, and the race will rotate freely.

FIGURE 14.11

Open side of cage should face cone-shape of race

Procedure for threadless headset assembly:

a. For caged-ball headset, thoroughly pack grease into bearing retainers and bearing race cups.
b. Install bearing retainers into upper and lower cup shaped races. For cartridge bearing headsets, drop cartridges in place, with concave side facing to cone shape of races.
c. Install fork steering column through head tube.
d. Install top adjustable race, centering-washer, and bearing cap onto column. Press centering-washer and bearing cap down to contact adjusting race.
e. Install any spacers and accessories on steering column as appropriate.
f. Install stem on column. Push stem against spacers and race. Snug stem bolts to hold fork.
g. Check for acceptable clearance from top of column to top of stem and install top cap with cap bolt (figure 14.12).

FIGURE 14.12

Steel and aluminium steering columns should be recessed below top of stem

Note the height of the steering column relative to the stem. Steel and aluminum columns can be approximately 2–3 mm (⅛ inch) below the level of the stem. The stem needs to press down on the bearing race below in order to adjust the bearings. If the top cap presses on the steering column rather than the stem, there will be no load put on the adjusting race and bearings. It will be impossible to remove bearing play. The column can be cut shorter, or alternatively, spacers can be added either above or below the stem to achieve a gap between top cap and steering column (figure 14.13).

FIGURE 14.13

Spacer added to increase clearance between top cap and column

Carbon fiber columns should protrude past the stem rather than be recessed. This permits the stem to secure as much column as possible and reduces the chance of cracking at the top of the column (figure 14.14). A spacer must then be used on top of the stem as described above to allow the top cap to perform the bearing adjustment.

FIGURE 14.14

Recessed carbon columns are susceptible to cracking from stem binder bolt pressure

For headsets using caged bearings, it is possible to replace retainer ball bearings with loose ball bearings of the same diameter. Loose balls, especially in the lower race, can move about in the race and this helps prevent the pitting that commonly ruins headsets. Installation and assembly with loose bearings is more difficult. It is important that the bearings stay aligned in the cup as the headset is assembled.

To use loose ball bearings, grease cups to hold bearings. Place balls into cup-shaped races. Leave a gap equal to two to three ball bearings (figure 14.15). Do not attempt to fully fill cup with ball bearings. If possible, rotate bicycle upside down in the stand to assist assembly before installing fork. After assembly with loose ball bearings, rotate fork to check smooth

FIGURE 14.15

Loose ball bearings in the headset cup with gap so balls can move freely

rotation. Any popping or sudden change in feeling indicates a bearing out of place. Dismantle the headset, reposition the bearings to line up in the cup, and reassemble.

THREADLESS HEADSET ADJUSTMENT

Threadless headsets, including EC, ZS, and IS types, operate on the same principle and share adjustment procedures. The bearing races must press against the bearings to remove play. The bolt in the top cap puts pressure on the stem. The stem presses on washers below the stem and the washers put pressure on the bearing races and bearings (figure 14.16). The stem binder bolts then secures the stem to the steering column to maintain the bearing adjustment and keep the stem in place and aligned.

FIGURE 14.16

Threadless stem with (A) Top cap, (B) Adjusting bolt, (C) Star nut in column

If not already inspected during assembly, remove the top cap to inspect the star nut or compression plug inside the steering column. No bearing adjustment can occur if the top cap is pressing on top of the steering column. Add an additional spacer if the column is too long for the stem and spacer combination.

Procedure for threadless headset adjustment:

a. Remove top cap bolt to inspect steering column length relative to cap. Lubricate bolt and reinstall cap and bolt gently. Do not tighten cap bolt.
b. Loosen stem bolt(s) that secure stem to the steering column. Lubricate these bolts if they are dry.
c. Wiggle the stem side to side to ensure it is loose. If the stem is jammed, rusted, or frozen to the steering column, no adjustment can be made.
d. Straighten stem to front wheel and gently secure the top bolt inside top cap. Stop when resistance is felt (figure 14.17).

FIGURE 14.17

Make bearing adjustment at top cap *only* when stem bolts are loose

e. Tighten stem bolt(s) and check for play by pulling back and forth on fork blades. Turn the handlebar in different directions while checking for play. There may be play at this early setting. Grab the upper portion of suspension forks because the lower legs may have play in the bushings.
f. If play is felt in headset, loosen stem bolt(s).
g. Turn adjusting bolt in center cap ⅛ to ¼ turn clockwise only.
h. Re-secure stem bolts, check fork for play again.
i. Repeat adjustments as above until play disappears. Remember to loosen stem bolts before turning adjusting bolt in cap.
j. Check alignment of stem and tighten stem binder bolts fully.

Another test for play is to place the bike on the ground and grab the front brake tightly. Press downward on the handlebars and rock the bike forward and back. A knocking sensation may indicate a loose headset. In effect, this does the same thing as grabbing and pulling on the fork. However, play in the brake caliper arms may cause a knocking. Front suspension forks may also have play in the legs, which can also cause knocking. Place one hand at top race and feel for movement to confirm headset bearing play.

If a bearing adjustment cannot be found to be acceptable, there may be other problems in the headset. Bearing surfaces may be worn out; the ball bearing retainers may be upside down; or a seal may be improperly aligned. If play always seems present no matter the adjustment, the steering column may be too long and may be pressing into the top cap. Another source of play can be a loose press fit in either in the head tube or on the fork crown race. A loose press fit may be improved with a retaining compound. In extreme cases, the headtube of the bike can become elongated from abuse and impact. Consult a professional mechanic for options with damaged headtubes.

THREADED HEADSET SERVICE

Threaded headset bearing adjustment is held by two threaded pieces locked together. A threaded top locknut is tightened down on a threaded bearing race. The bearing race often requires a narrow headset wrench such as the Park Tool HCW-15. The top locknut is taller and will accept wider wrenches such as a large adjustable wrench. 30 mm, 32 mm, and 36 mm are common headset wrench sizes for threaded headsets.

FIGURE 14.18

Drive stem binder downward to free stem from column

Procedure for threaded headset disassembly:

a. Leave front wheel in fork to act as a lever.
b. Loosen stem binder bolt. Attempt to move the stem by twisting. If stem will not move, strike the top of the stem binder bolt with a hammer or mallet to free the wedge (figure 14.18). Attempt to twist stem again.
c. Pull stem and handlebars from fork.
d. Stand in front of bike and hold the wheel between your knees while working with the locknut and race.
e. Hold lower threaded race with thin headset wrench. Loosen and remove top locknut with a second wrench.
f. Remove front wheel.
g. Remove spacers or brackets from under the locknut after noting location and orientation.
h. Unthread and remove the threaded race. Note orientation of top bearing retainers.
i. Pull fork from bike and note orientation of lower bearing retainer, if any. Work with care as bearings may unexpectedly fall from lower race.
j. Clean and inspect parts.

Threaded headsets commonly use a spacer with a tab or "tooth" on the inside diameter. This notch is designed to sit inside a groove running vertically in the column. However, these types of spacers will often rotate when the top locknut is tightened, resulting in thread damage as the washer rotates and the tab cuts into the threads. This is especially the case when the spacer is made of steel and is relatively thin. Inspect the threads of the fork. If any damage in the threads is present, file off the spacer tab or get a new spacer without a tab.

For non-cartridge bearing headsets, it is possible to replace retainer ball bearings with loose ball bearings of the same diameter. Loose balls, especially in the lower race, can move about which helps prevent the pitting that commonly ruins headsets. Installation and assembly with loose bearings is more difficult. It is important that the bearings stay aligned in the cup as the headset is assembled.

To use loose ball bearings, grease cups to hold bearings. Place balls into cup shaped races. Leave a gap equal to two to three ball bearings. Do not attempt to fully fill cup with ball bearings. If possible, rotate bicycle upside down in the stand to assist assembly before installing fork. After assembly with loose ball bearings, rotate fork to check smooth rotation. Any popping or sudden change in feeling indicates a bearing out of place. Dismantle the headset, reposition the bearings to line up in the cup, and reassemble.

Procedure for threaded headset assembly:

a. Grease bearing retainers and bearing race cups. Grease threads of steering column.
b. Install bearing retainers into upper and lower cup-shaped races.
c. Install fork steering column through head tube.
d. Thread on top race.
e. Install spacers and accessories as appropriate.
f. Thread on locknut. Inspect that steering column does not touch inner lip of locknut. Add spacers as necessary to allow locknut to press on washers.

THREADED HEADSET ADJUSTMENT

Threaded headsets are adjusted using a top locknut and threaded race. The stem has no effect on the bearing adjustment and does not need to be installed in order to adjust the bearings. Attempt to adjust the bearings so they are as loose as possible but without play or knocking. To achieve this, the following procedure will first create play in the adjustment. Proceed to incrementally tighten the race until play is gone.

Procedure for threaded headset adjustment:

a. Install front wheel. Front wheel will act as a lever to hold steering column.
b. Make sure headset locknut is loose. Use a headset wrench to hold threaded race.
c. By hand, turn threaded race clockwise until it contacts ball bearings. Turn race back counter-clockwise at least ¼ turn from this setting. Hold threaded race with headset wrench and tighten locknut. Tighten locknut fully (figure 14.19).

FIGURE 14.19

Hold adjusting race while tightening locknut

d. Check for play by pulling back and forth on fork. A knocking sensation indicates play. Turn fork in different directions while checking for play. There should be play in this early setting. If headset feels tight, loosen adjustment further until play is found.
e. Grab front wheel between knees and hold it in line with top tube. Threaded race will need to be adjusted slightly clockwise. Use a headset wrench to hold race and note orientation of wrench relative to front wheel.
f. Loosen locknut and rotate threaded race clockwise 1⁄16 to ⅛ turn relative to wheel.

g. Hold threaded race securely with wrench and tighten locknut fully. Check for play by rotating fork and moving fork forward and back at different positions.
h. If play is present, repeat steps "e" and "f" above until play disappears. Adjustment is finished when there is no play in any position, the fork rotates, and locknut is fully secure.
i. Reinstall stem, align, and tighten.

Another test for play is to place the bike on the ground and grab the front brake tightly. Press downward on the handlebars and rock the bike forward and back. A knocking sensation may indicate a loose headset. In effect, this does the same thing as grabbing and pulling on the fork. Play in the brake caliper arms may also cause knocking. Front suspension forks may also have play in the stanchion and sliding legs, which can cause knocking.

If an acceptable bearing adjustment cannot be found, there may be other problems in the headset. Bearing surfaces may be worn out; the ball bearing retainers may be upside down; or a seal may be improperly aligned. Another source of play can be a loose press fit, either in the head tube or on the fork crown race. If the headset seems well adjusted at one position but binds when rotated to another position, the head tube may require facing to improve bearing alignment. Consult a professional mechanic.

HEADSET REPLACEMENT & INSTALLATION

Headsets may be replaced when worn or when upgrading to a better model. After installing the new headset, the procedure for assembly and adjustment is the same as the procedures above.

There are several standards for headsets found on bicycles. A new headset must match the design of the bike. There are many headset standards that do not interchange. Appendix D, Headset Standards, reviews some of these standards. The table is not exhaustive, as some unusual and proprietary standards exist. It often necessary to remove the headset to know exactly what standard is being used. If in doubt, consult a professional mechanic for the correct standard for your bike.

It is sometimes possible to use a smaller steering column than the head tube was designed to use. Reducing rings are available and are pressed into the head tubes of the larger standards. Reducers are available to size the EC56 head tube down to the EC34 standard or to reduce the EC34 standard down to the EC30. However, it is not possible to convert a bike upward. The head tube cannot accept a steering column larger than it was designed to accept.

FIGURE 14.20

Stack height is composed of: (A) lower stack height, (B) upper stack height & (C) any spacers. Stem height (D) not included by headset manufacturers.

HEADSET STACK HEIGHT

Stack height is the amount of steering column length the headset will occupy (figure 14.20). Headsets vary between brand and model in amount of required stack height. The steering column is always longer than the head tube length, and the stack height of the headset must be compatible with the frame head tube and steering column.

Replacement headsets in both threaded and threadless models will have the stack height listed on the box or instructions. The manufacturer's stated headset stack height does not include the stem of threadless headsets, nor any sizing washers used to give extra rise to the stem. Generally, when replacing a headset, select one of equal or smaller stack height then the original headset. Using a headset with more stack height than the original may result in the steering column being too short for the bike.

PRESSED HEADSET REMOVAL

Both the EC and ZS headset designs use pressed races or adaptor cups in the headtube. These are removed when the headset is replaced. The IS headset designs use cartridge

FIGURE 14.21

Removing the slip fit integrated bearing from an IS headset

FIGURE 14.22

Draw the Race Tool RT-1 or RT-2 through headtube small side first bearings that slip fit directly into the frame, and bearings are simply removed by hand (figure 14.21).

Begin pressed headset replacement by removing the wheel, handlebars and fork as described in Headset Service. To remove pressed races, use a race removal tool such as the Park Tool RT-1 Race Tool for EC29 to EC44 and ZS41 to ZS44 standards. Use the larger RT-2 for the EC49 to EC56 and ZS44 to ZS56 headset cups. Install tool with smaller end first through the headset cup (figure 14.22). Squeeze sides of prongs and pull tool fully into head tube. Do not press prongs with hand as prongs will close and pinch flesh. A clicking sound will be heard as tool prongs engage head tube cup. Inspect that tool prongs are engaged only against headset cups.

Use a steel hammer at the small end of the tool and drive cup from head tube (figure 14.23). Place removal tool with small end first through remaining cup and repeat process to remove second race. A long punch can also be used to remove the head tube races. Alternate tapping left to right to "walk" out the race.

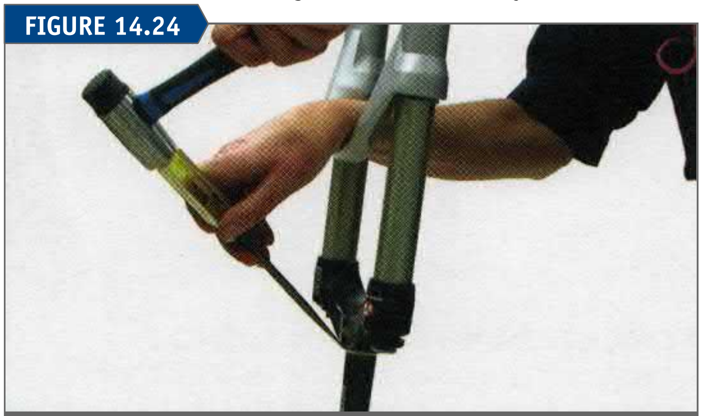
FIGURE 14.23

Drive the race from the headtube with the race tool and a hammer

The old fork crown race must be removed from the fork. Professionals will use the Park Tool CRP-2 Crown Race Puller. An alternative is to use a punch or other tool that will engage race. In some cases this may scar the fork and crown race. Place the fork column downward on soft material such as wood to protect top of column. Using a hammer, tap race alternately first on one side, then the other side, driving the race off the crown seat (figure 14.24).

There are designs of carbon forks that have the fork race molded directly into the fork. There is no removal or service of the fork crown with these designs. The fork is ready to install as is.

FIGURE 14.24



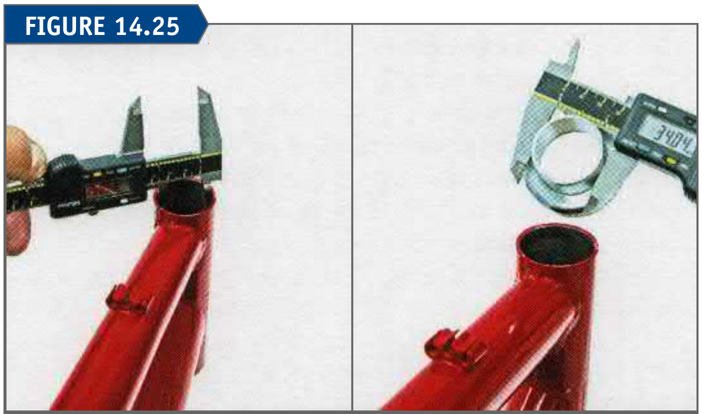
Carefully tap alternate sides repeatedly to remove

PRESSED HEADSET INSTALLATION

The EC and ZS headset bearing races or adaptor cups require a press fit into the frame. The press fit is called also an "interference fit" and occurs when a part with a slightly larger outside diameter is forced into another part with slightly smaller inside diameter. This creates tension between the parts and holds the parts tight. Generally, the difference in the headset press fit should be between 0.05 mm and 0.2 mm.

Use a caliper to measure and note the outside diameter of the cups. Next measure the inside diameter of the headtube in two places; each 90 degrees from the other. Average the two ID readings (figure 14.25). The difference between the outside diameter and inside diameter is the amount of interference fit. See Table 14.1 Interference Fit Guidelines.

FIGURE 14.25



Measure and compare the inside diameter of the headtube to the outside diameter of the headset cup or adaptor

If interference fit differences are too small, the headtube cups or bearing adaptors will move in the frame. The difference between the OD and ID might be zero, or even worse, the ID may be larger then the OD. One solution is to use a "retaining compound" in the press fit. This compound will expand and harden to increase the strength of the press fit. Retaining compounds require clean, dry surfaces. For removal, it is sometimes necessary to apply mild heat, such as from an air gun or hair dryer, to soften and weaken the compound. Retaining compounds are available from better home improvement centers, automotive part stores, and some bicycle retailers.

TABLE 14.1 *Interference Fit Guidelines*

DIFFERENCE BETWEEN RACE OUTSIDE DIAMETER AND HEAD TUBE INSIDE DIAMETER	RESULT AND ACTION REQUIRED
0.26 mm or greater	Too great of press fit difference. Ream head tube inside diameter to improve fit.
0.1 mm to 0.25 mm	Acceptable tolerances for press fit.
0.01 mm to 0.09 mm	Unacceptably small interference. Get a new race with larger diameter. It is also possible to use a retaining compound.
0 mm or any negative number	No interference fit at all, headset is smaller than head tube. Use a different race if possible. Retaining compound may be tried if no other option is available.

Significant force is normally required to press headset races into the head tube. Additionally, the races should be pressed square to one another. It is best to use a bearing press (Park Tool HHP-2 or HHP-3 Bearing Press) for the head tube races. The HHP-2 Bearing Press comes with a pair of cup guides (#530-2) to help maintain cup alignment during pressing. The cup guides fit most 1 inch and 1⅛ inch conventional headset races. If no guides are used press one part at a time into the frame.

Procedure for pressing of headtube races or cup adaptors:

a. Determine the acceptability of the headset press fit as described above.
b. For HHP-3, remove one handle and pressing washer. For HHP-2, remove sliding press plate.
c. When available, install headset cups onto guides. Press only one cup at a time if guides are unavailable or if guides do not closely fit cups.
d. Place upper headset cup on top of head tube and insert headset press through cup and headtube. If pressing one cup at a time, install pressing washer and handle (for HHP-3), or install sliding pressing plate (for HHP-2).
e. For cups fitting headset cup guides, install lower cup and install pressing washer and handle (for HHP-3), or install sliding pressing plate (for HHP-2) (figure 14.26).
f. Turn handle of headset press slowly and inspect alignment of cups as they enter headtube. If cups become extremely crooked, remove cup and re-press. Ensure cups are fully pressed into head tube.
g. Inspect for full seating where cups meet frame. A gap between the frame and cup indicates incomplete pressing (figure 14.27).
h. Remove headset press tool from bike. If pressing one cup at a time, repeat process for second cup.

FIGURE 14.26

Arrangement of cups and pressing guides for the HHP-2 Headset Press

FIGURE 14.27

This cup is not fully seated into headtube

FORK CROWN RACE INSTALLATION

The fork crown race is pressed to a crown race seat at the base of the steering column. Because the bearing race is smaller than the crown race seat of the fork, the bearing race expands as it is pressed. The crown race seat should be larger than the race by only 0.05 mm to 0.15 mm. If the difference between the race and seat is too large, it may crack the bearing race. When the crown race seat is too large for the fork crown race, the crown race seat may be cut smaller. A professional mechanic will use a crown race seat cutter such as the Park Tool CRC-1. If the crown race seat is nearly equal to or only slightly larger than the race (0.04 or smaller difference) use a strong retaining compound.

The fork crown race must be pressed to the fork crown. Determine acceptability of press fit as described above. The Park Tool CRS-1 Crown Race Setter will drive on the race. Use the CRS-15 for 1½ inch or 1¼ inch steering columns. Place race on fork crown and select most compatible Park Tool CRS aluminum ring. Place ring on tool and insert over fork. Use a steel hammer and strike top of tool until race fully seats (figure 14.28). The sound of the hammering will change as it seats. Inspect sides of race for full seating against fork.

There are some models of headsets using cartridge bearings that use a lower race made with a split ring. The split ring races are pressed on by hand. The split race does not directly ride on the rotating bearings, it simply inserts into the cartridge-bearing race.

FIGURE 14.28

Installing the fork crown race with a Crown Race Setter

FORK STEERING COLUMN SIZING

The steering columns on new forks are typically longer than required, and the column is cut to fit the bike and rider. Threadless columns must be long enough to fit the stem and any required spacers. Threaded columns must be long enough to engage the threaded race, spacers, and locknut. Steering columns that are too long may be susceptible to failure.

THREADLESS STEERING COLUMNS

Threadless steering column length limits height options for the stem and handlebars. When installing a new fork, consider where you would like the handlebars to be. It is possible to cut a threadless column relatively long and to use spacers under the stem to raise the bars. However, there are limits to how far the stem can safely be raised above the headset. For steel and aluminum steering columns, do not exceed 40 mm between the stem and headset bearings. If more stem and bar height is required, purchase a new stem with more height and/or rise, or, alternatively, get a larger bike.

Carbon fiber steering columns also have limits on the height of spacers between stem and headset. Generally, manufacturers recommend no more than 30 mm additional stack height between stem and upper race. Contact the fork manufacturer for limits in regards to your fork.

The column can also be purposely cut too long so that extra spacers are stacked above the stem to allow for future changes to height. However, too much exposed column above the stem can cause safety issues, potentially striking the rider during a crash. It is not necessary to have more column height above the stem than would allow the stem to be safely raised. In general, avoid cutting the column so long that it requires more than 30 mm combined in spacers above and below the stem.

The safest and most practical method to determine column length is to install the fork first without cutting. Install all desired spacers and stem. Mark the fork at the top for a reference point for cutting. Remove fork from the bike. Use a saw guide to produce a consistent square cut. For steel hacksaw blades use the Park Tool SG-6 or SG-7.2 Saw Guide. For the wider blades called “ceramic” or “carbon blades” use the SG-8 Saw Guide.

Carbon fiber steering columns are best cut with a fine 32 TPI steel blade or a “ceramic” or “carbon blade.” Cut using moderate pressure only, do not force the blade. Carbon dust is a potential health risk due to the small size of the dust particulates. Take normal precautions of wearing a dust mask and working in a well ventilated area. Additionally, to minimize dust from the carbon, keep the cutting area wet. Use a fine emery cloth to finish the end, again wetting the paper.

Procedure for cutting of threadless steering columns:

a. Assemble steering column into the head tube with bearings and parts in place. Install stem and all desired spacers, including any spacers desired above the stem.
b. Press downward on stem to simulate an adjusted headset and snug stem bolts. Remove what play you can. The adjustment need not be perfect.
c. Mark the steering column at top of stem or topmost spacer (figure 14.29).
d. Remove fork from bike. For aluminum or steel columns, measure an additional 3 mm from your mark toward fork crown, and re-mark the cut line at this point. This allows the top of the column to sit slightly below the top of the stem. For carbon fiber fork columns, add at least a small amount (3 mm) to this mark. Spacers will be required above the stem for carbon fiber columns.
e. Place fork inside saw guide. Loosely secure handle. Move saw guide opening over cut-mark on column and secure handle. Place saw guide in vise. If no vise is available, hold column in repair stand jaws.
f. Cut through column using proper hacksaw techniques and a good blade (figure 14.30).
g. Loosen saw guide handle and push column further into saw guide.
h. Steel and aluminum forks: Use a flat file to finish and bevel end of column. Hold file at approximately a 45-degree angle to bevel the end of the column. Use a round file or deburring tool to remove the sharp inside

FIGURE 14.29

Make a reference mark on the column for cutting

FIGURE 14.30

Cut with pressure in the forward cut and do not force the blade into the column

FIGURE 14.31

Deburr and finish the end of the steering column edge of the column (figure 14.31). Carbon fiber forks: Column cuts can be finished with fine sand paper.

i. Remove fork from saw guide, wipe clean, and install on bike.

Star Nut and Compression Plug Installation

Threadless headsets are adjusted with pressure on the bearing races from the adjustment of the bolt in the top cap. The bolt is threaded into either a compression plug or a "star nut" that engages the steering column (figure 14.32), pulling the steering column upward.

FIGURE 14.32

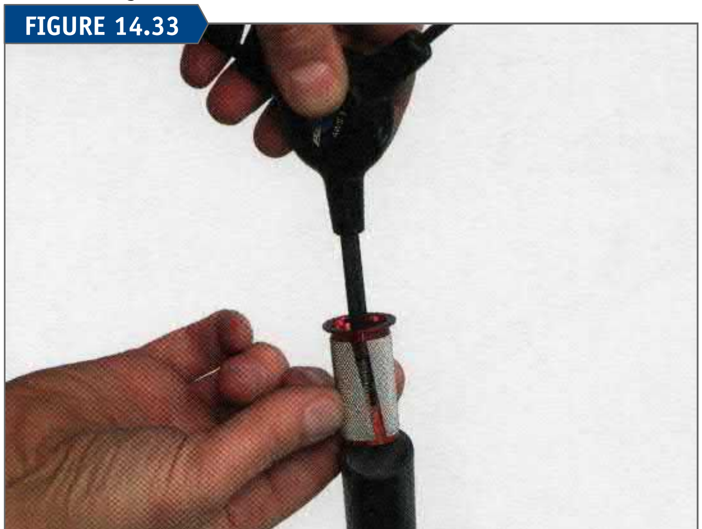
Compression plug on the left. Star nut with bolt and top cap on the right.

Compression plugs are a threaded system installed into the steering column to hold the top cap bolt. A socket fitting is tightened to expand a friction plug inside the column. An internal thread inside the plug accepts the M6 bolt from the top cap. The plug diameter must be compatible with the inside diameter of the steering column. The compression plug recommended for carbon fiber steering columns is removable and reusable.

To install a compression plug, begin by dismantling the unit and lubricating the internal threads. Note orientation of cones and wedges, and use care not to get grease or lubrication on the outside surfaces of the plug. Insert plug into column and tighten fully (figure 14.33).

The star nut features a series of concave metal flanges surrounding a threaded nut. The outer diameter of the flanges are slightly larger than the inside diameter of the fork column. The star nut is forced into the column and the flanges press and bite inside the column to hold the nut tight.

FIGURE 14.33



Install compression plug and secure into fork column

The star nut system is designed to not to move upward after installation and cannot effectively be removed once installed. If a new star nut is needed in the column, use a large punch and drive the first star nut down deeper into the column. This allows a new star nut to be installed on top of the old one. This system is not generally recommend for carbon fiber steering columns. Use a star nut on aluminum, steel, or titanium columns only.

To install a star nut, use a tool such as the Park Tool TNS-1 or TNS-4 Threadless Nut Setter. The TNS-15 Threadless Nut Setter will work for large 1½ inch diameter fork columns. The tool will drive the star nut about 15 mm (9⁄16 inch) below the top of the steering column. This allows the adjusting bolt to thread fully into the nut for bearing adjustment pre-load. Mount the nut with concave side toward tool thread. Hold TNS tool over steering column. Use care to keep TNS tool aligned with the column. Tap squarely on top of tool with a steel hammer. Continue until TNS-1 is fully seated (figure 14.34).

The TNS-4 uses a sleeved guiding system to drive the star nut into the column. Thread the star nut into the tool and slide the tool over the column (figure 14.35). Use a hammer to drive down the mandrel until the star nut is fully seated.

FIGURE 14.34

Using a stem to guide the TNS-1 and star nut straight with the column

FIGURE 14.35

Drive the star nut down while guiding with the TNS-4

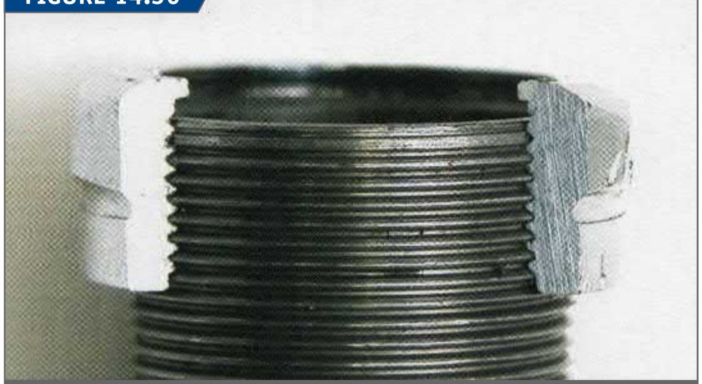
THREADED STEERING COLUMNS

Threaded steering columns require enough thread on the column to allow the adjusting race to reach and press on the bearings. However, threading on the steering column should never extend past the insertion depth of the quill stem. Cutting threads removes material and actually weakens the column. However, the quill of the stem supports the steering column when installed, giving it extra strength in the threaded section, especially where the column flexes when riding.

Procedure for cutting of threaded steering columns:

a. Assemble the threaded fork in the bike with all spacers.
b. Measure how much steering column extends past the top spacer and write this number down.
c. Turn the locknut upside down and measure the amount of depth of locknut to "lip" at the end of the nut. This is the amount of available threading in the nut. The steering column should not contact this inner lip when the locknut is secured (figure 14.36). Deduct an additional millimeter from this number to allow a small gap between nut and column.
d. Deduct the available threaded height in the locknut from the amount of steering column extending past the spacers. For example, a steering column extends 27 mm above the spacers. The threaded locknut measures 7 mm down to the lip. Deduct one millimeter from the nut, making only 6 mm of threading available. Shorten the column by 21 mm.

FIGURE 14.36



Cutaway of locknut on threaded column. Locknut lip should not contact top of column.

e. Use a saw guide such as the Park Tool SG-1 Saw Guide (1 inch column), or SG-2 (1⅛ inch column) to ensure that the cut is square to the fork. Thread fork into saw guide until it reaches desired cut length at the gap for the blade. Clamp the guide in a vise. If no vise is available, hold column in repair stand jaws. Use a hacksaw and cut fork.
f. The threads at the end of the fork will require extra finishing after the cut. Thread the fork farther into the guide to expose freshly cut threads. Hold a flat file at approximately a 45-degree angle to bevel the threads at the end of the fork (figure 14.37). Rotate the fork into the file as the file is pushed forward. Use a round file to finish the inside of the fork, removing any sharp edges or burrs.

If no Park Tool Saw Guide is available, it is possible to use a steel threaded race as a saw guide. Thread race on column and measure exposed threads. Hold column in bike repair clamp. Press race to clamp so it cannot move. Cut the column using a hacksaw, holding the blade against the face of the race. Finish the cut with a file to bevel the end of the column.

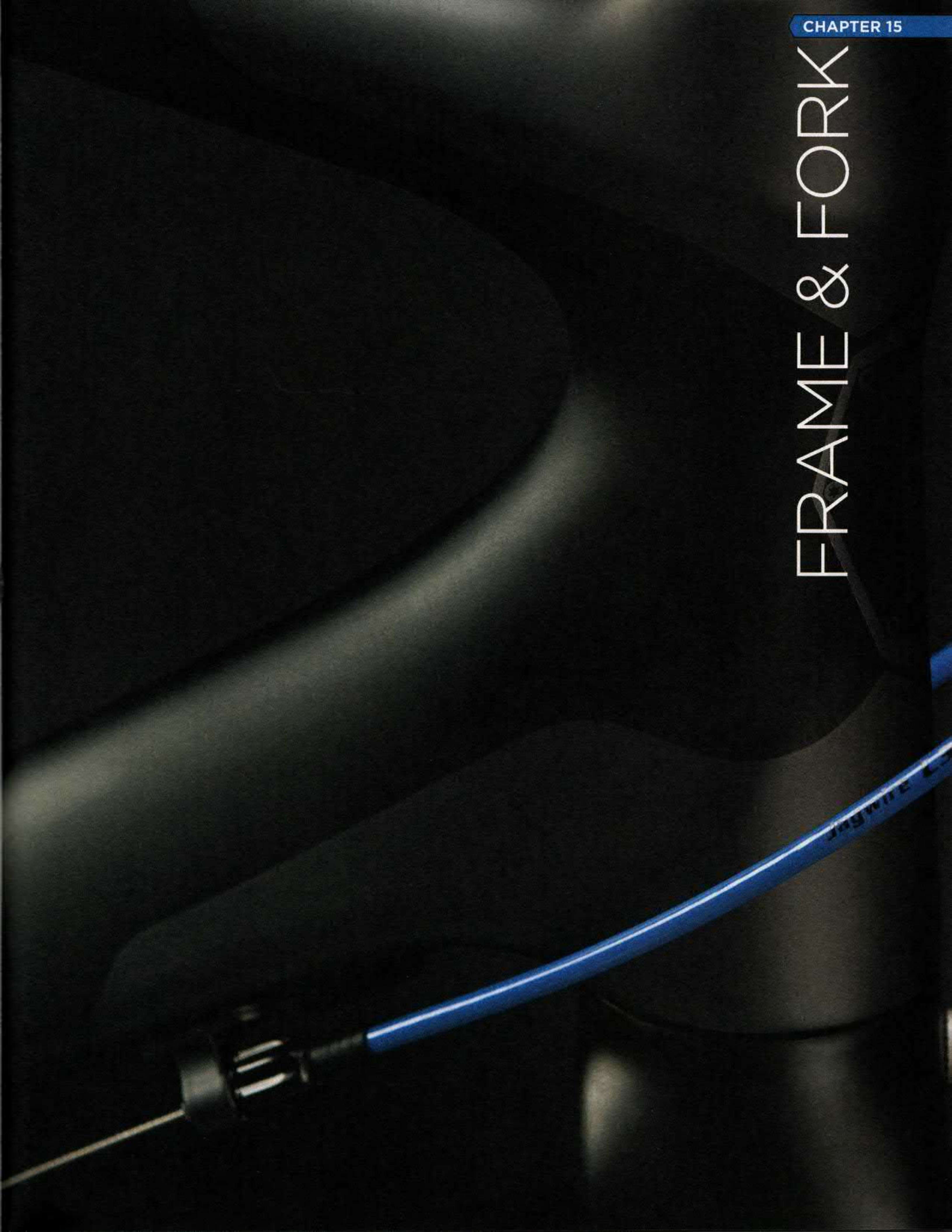
Threaded columns often are made with a machined groove running vertically along the threads. Threaded headsets may include spacers with a tab or "tooth" on the inside diameter. The groove is for this tooth. Shortening a fork may remove the groove. Do not attempt to extend or create a new groove for the toothed washer. Simply file the tooth away or get a new spacer without the tooth.

FIGURE 14.37

Bevel end of fork thread

CHAPTER 15

FRAME & FORK

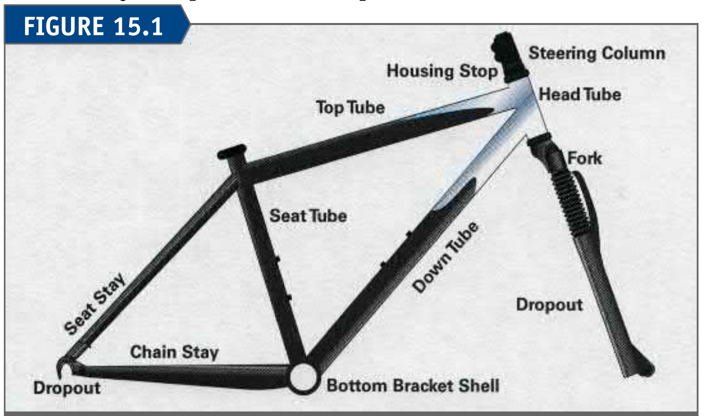


The frame and front fork form the skeleton of the bike to connect the two wheels. The frame also supports the rider and the various components of the bike. The front fork allows the wheel to pivot, which permits steering. The front wheel is designed to be in line with the rear wheel. As we ride, it is the rider's balance that keeps the bike upright. Like motorcycles, bicycles have a "self-steering" feature that helps the cyclist stay upright and maintain a straight line. The bicycle is steered by leaning in combination with turning the handlebars.

FRAME COMPONENTS

The frame has different parts or sections (figure 15.1). Bicycle designers will manipulate the length and angle of each section, tube, or tube junction to obtain certain ride and handling characteristics. As an example, headtube angles differing by just one degree may cause two different bicycles to handle differently. Bicycle design is a complex topic because there are many interacting variables, including the rider's body and performance expectations.

FIGURE 15.1



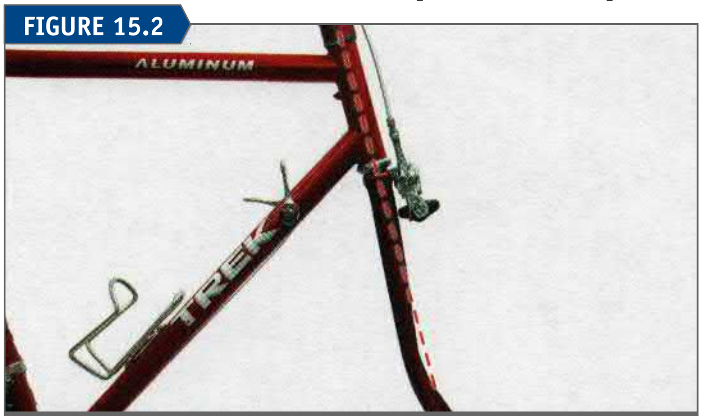
The parts of the frame

FORK

The fork is the connection between the front wheel and main triangle of the frame. Fork dropouts hold the wheel at the end of the fork blades.

Fork blades meet at the fork crown, which attaches to the steering column. The steering column passes through the head tube and is supported by the headset bearing system. Forks vary in length to fit specific sizes of wheels. The fork will also have a "rake" or offset that puts the contact patch of the tire beyond the head tube. This gives bicycles their self-steering ability.

FIGURE 15.2



Bent front fork blades

The stress of riding tends to flex fork legs, which transmits stress to the fork crown. This area of the bike experiences a lot of stress, even from casual riding. Fork failure is especially dangerous because the results are often a loss of control and a wheel coming off the bike (figure 15.2).

A suspension fork will have moving parts that allow the wheel to move relative to the bike when riding over uneven terrain. For more discussion of suspension forks, see Chapter 16, Suspension.

HEAD TUBE

This is the frame tube that houses the fork's steering column. Headset bearings are seated here to allow rotation and steering. Head tube length will affect handlebar height. The inside diameter and design will determine the type of headset used.

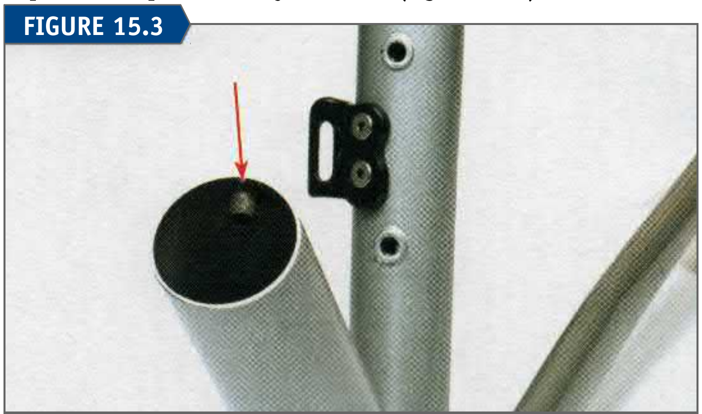
TOP TUBE

The top tube is the connection between the head tube and the seat tube. The top tube is vitally important to bike fit because the length will affect bar placement and rider comfort. This tube sees relatively low stress and is typically made lighter and thinner than other parts of the frame.

DOWN TUBE

This tube is the connection between the headtube and bottom bracket. It also experiences stress from pedaling and handling of the bike. It may also be fitted with water bottle cage nuts or threads. The common fitting on modern bicycles is the "pemnut," which is fitted into the tubing and then expanded to permanently install it (figure 15.3).

FIGURE 15.3



Cross section of down tube showing "pemnut" in place

SEAT TUBE

The seat tube connects the bottom bracket to the saddle or seat post. Frames are generally sized according to the seat tube length. The seat tube may also be fitted with water bottle mounts and a fitting or brackets for the front derailleur.

CHAIN STAY

These connect the rear dropouts to the bottom bracket and see a relatively high amount of stress from riding. The length of the stay is designed for the type and size of wheel used as well as for bicycle performance.

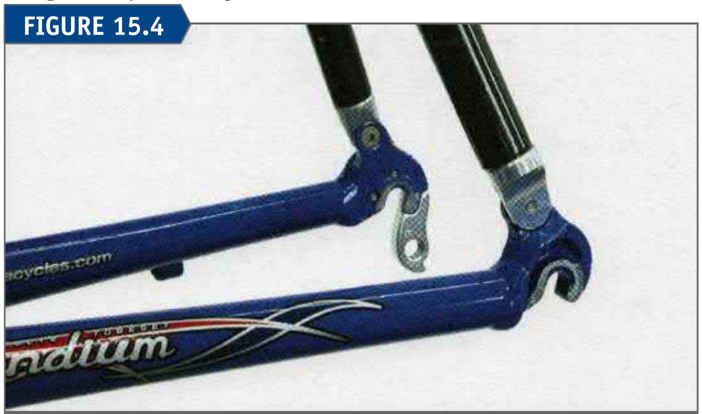
SEAT STAY

This is the connection from the rear dropouts to the seat tube. These two tubes see less stress than the chain stays but still support the bike over the rear wheel. The rear brake caliper, either rim or disc, is commonly mounted to the seat stays.

DROPOUTS

Dropouts are the fittings at the end of the front fork and the rear stays that accept the hubs and wheels. Traditionally, the front dropouts accept a 9 mm axle, while the rear dropouts accept a 10 mm axle (figure 15.4). Through-axle dropouts on downhill and freeride bikes may use a 12 mm axle in the rear and a 20 mm axle or a 15 mm axle in the front. There are also proprietary dropout designs made to fit unique hub/frame systems.

FIGURE 15.4



Rear vertical dropouts

BOTTOM BRACKET SHELL

This is a short tube between the cranks that holds the bottom bracket bearings. It is connected to the down tube, the seat tube, and the chainstays. Traditionally, this has an internal threading for attaching and adjusting the bearing cups (figure 15.5). The shell width may be 68, 70, 73, 85, or 100 mm depending upon the design. There are also unthreaded designs that use pressed bearings.

SWING ARM

A swing arm is the rear part of the frame of some full suspension bicycle designs. These function as moveable stays that react to impact on the rear wheel. The swing arm is attached to the main frame with bearings. A spring system keeps the swing arm extended and allows it to pivot. Bearing design in the swing arm is generally proprietary and bearing service varies with each model.

FIGURE 15.5

Threaded bottom bracket shell

FRAME CONSTRUCTION & SERVICE

Frame material may be steel, aluminum, titanium, carbon fiber, magnesium, special plastics, or a combination of any of the above. Each type of material has different properties, which will affect the ride of the bike. All these materials flex to varying degrees under load or stress. Additionally, each material will require different manufacturing processes and will have limits for repairability.

Like any mechanical part subjected to stress, the frame may fail. If the frame was poorly designed, improperly constructed, or simply subjected to excessive loads and abuse, cracks and bends can occur.

Regardless of the material, when a frame fails it tends to fall apart at the tubing joints. These are the areas where stress is concentrated. In some cases, a joint may be poorly made, or the design may simply be too weak for the use. Failure may also be the result of a crash. Tubing joints may suddenly yield, or weaken, and begin cracking or failing. The repeated stress of riding creates a stress cycle: loading and unloading of the part. This may, in time, cause cracks and eventually, failure. A severe impact or crash may bend metal frame tubes. Repair by simply re-bending the deformed tubing is typically impractical and will create a stress riser or weak spot in the area of the repair without further heat treatment.

Bicycle frames are best inspected during cleaning. Most types of paint tend to be somewhat brittle and will crack if the material has moved under it (figure 15.6). This is often a sign of failure or future failure. Cracked paint may simply be paint coming off the surface or poor paint bonding. Inspect to confirm a failure or crack and consult a professional mechanic if in doubt.

FIGURE 15.6

Bent metal on down tube from impact

STEEL

Different types of welding typically join steel tubing. Tubes may be fitted into a lug, and then brazed or welded with alloys of silver or with brass. Tubes can also be mitered and welded by sophisticated electrical welding known as “tig” or “mig” welding (figure 15.7). Steel frames are susceptible to rust or oxidation. Water inside the frame and lack of paint

FIGURE 15.7

Welding of a steel frame (Photo credit Independent Fabrication®)

can worsen issues of rust, even to the point of frame failure. It is also recommended to use grease or an anti-seize on any threaded or press fit frame fitting, such as bottom bracket threads or headtubes. A good frame builder is able to repair some failures in a steel frame. In welded steel frames, tubing can sometimes be replaced.

ALUMINIUM

Aluminum is a very common material for many uses and is easily worked and welded. Aluminum frames may also be bonded together with lugs and adhesive. Aluminum is a relatively lightweight metal but can require more material to match the strength of steel. Aluminum does not rust exactly like steel but can corrode. This results in pitting and corrosion products on the surfaces. The consequence is that components such as seat posts or bearing cups may seize in an aluminum frame. As with steel, it is useful to use grease or anti-seize when installing components. Local repair to aluminum frames is difficult because of the special skills needed and the need for heat treatment of the frame after welding.

TITANIUM

Titanium is a very strong material, but it can be difficult and expensive to work and shape. It is hard to form it to the desired shape. Titanium is commonly welded for bicycle frames. There is very little issue with corrosion, but greasing the fittings is still recommended. Local repair of titanium is difficult due to the special skills and equipment involved.

CARBON FIBER

Carbon fiber is a fabric material held in place by epoxies, called the "matrix." The carbon cloth or fabric is laid into a mold and the matrix applied. This can create tubes or entire sections of the frame. When carbon fiber tubing is joined, it is often with a thermal-set epoxy. Often the carbon fabric will be laid up with fittings or metal tubing to add strength or to allow installation of components. For example, carbon fiber is a poor material for threading, so metal inserts are installed for threaded parts such as the bottom bracket or water bottle fittings.

FIGURE 15.8

A suspicious paint crack in a carbon fiber frame

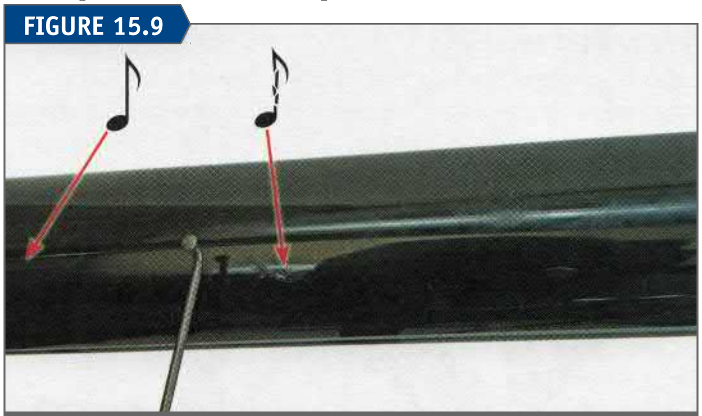
Carbon fiber is susceptible to sudden failure from the stresses of riding and impacts of crashing. Because each manufacturer uses different wraps and different materials it is difficult to draw broad guidelines as to when to replace a carbon frame. When in doubt, contact the manufacturer.

Carbon fiber may develop a stress crack from use, especially if the material was under-designed. Like other materials, this is typically where tube shapes come together. Look for long cracks in the paint or in the epoxy matrix (figure 15.8).

Another type of carbon fiber failure is from impact or from puncture. Carbon fiber material is aptly named because it is a "fiber," and punctures and cracks cause a "tear" in the carbonized cloth. Damaged tubing will resonate differently at the failure or tear. Use a coin or spoke to tap the tubing along a section of good tubing, noticing the type of sound it makes. The pitch will rise and fall along the length of the tube depending upon the size of the tubing. By comparison, in a damaged carbon fiber frame, the sound will suddenly change and become deadened at the point of failure because the fibers are compromised at that point (figure 15.9).

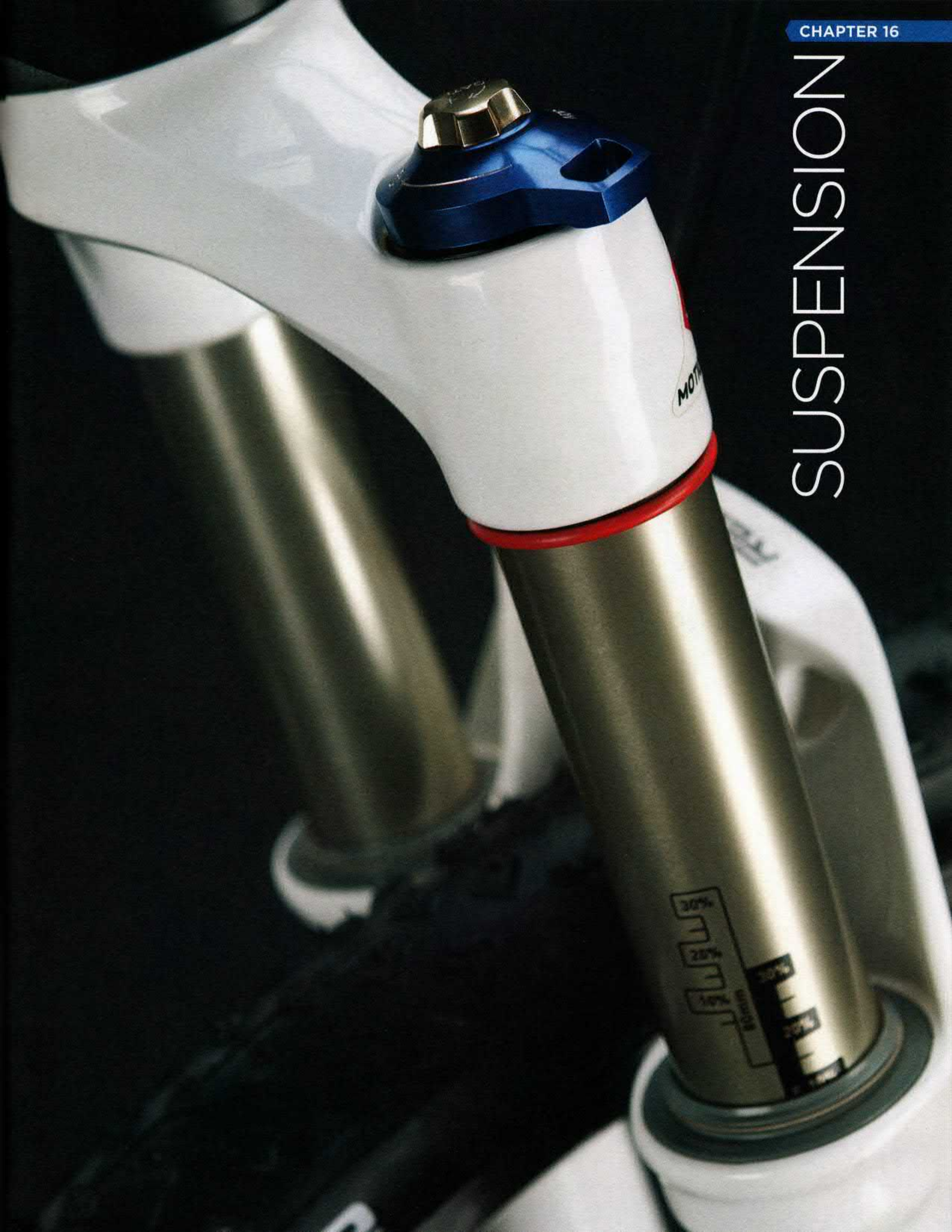
Repair of damaged carbon fiber is difficult but not impossible. New carbon fiber laminate can, in some cases, be laid up over the failure with epoxy resins. Heat is applied to cure the matrix and the result is refinished for a good look. This repair should be left to professionals.

FIGURE 15.9



Tap tubing and listen for deadened sound indicating cracks in fiber

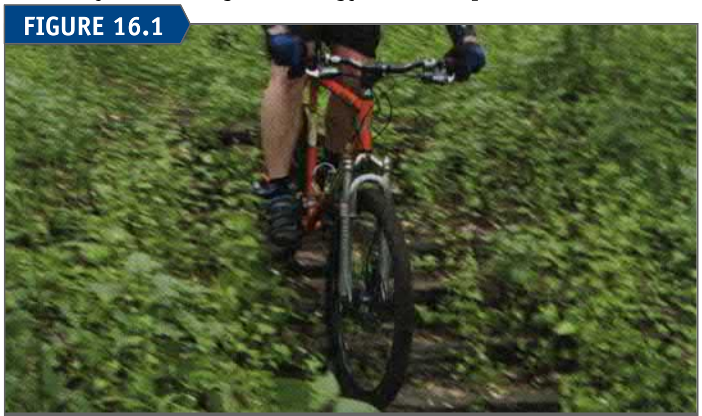
SUSPENSION



Bicycle suspension refers to a system of pivots, levers, sliders, and even tires, all parts of the bicycle that allow the rider to maintain a steady line or path on unsteady terrain. "Rigid" (non-suspension) bicycles have no pivots or linkage. If a rider uses any kind of suspension system, the wheels can track the terrain independently of the cyclist. Suspension on any vehicle allows the wheels to move up and down to accommodate bumps and dips in the trail or road. Suspension can improve both rider comfort and performance. Suspension systems provide more "forgiveness" for the rider's errors as they choose the best line off-road.

For many years, spring systems have been used for suspending forks and even saddle rails. A stress or load flexes the spring, and the spring returns all the energy used to flex it as it moves back. Damped suspension systems are now common in off-road forks (figure 16.1). These are telescoping forks that use a spring system to keep the entire fork extended with the lower legs sliding on the upper legs. A damping system in the legs reduces the speed of the fork leg return by consuming the energy of the impact.

FIGURE 16.1



Suspension fork compressing from the impact

The movements of a suspension system can be split up into two basic actions: compression and extension (also called rebound). Compression of the suspension results from the upward motion of the wheel(s) from the road or trail. The compression phase occurs due to a load or impact. The spring system compresses, which momentarily stores energy.

The extension phase dictates the downward returning motion of the wheels. Extension is the downward motion of the wheel(s) toward the terrain. When the force stored in the spring by compression is greater than the load put on it, the spring extends and returns all the energy it has stored. In other words, a tightened spring wants to relax. This relaxation is the extension phase.

Suspension systems are built with "sag." The weight of the cyclist partially compresses the suspension system to create sag, often just by sitting on the bike. This is desirable because it allows for extension of the wheel into dips and depressions as well as compression by bumps. The ride height of the bike also changes with the amount of sag.

SPRING SYSTEMS

Spring systems in shocks have a "spring rate" (deflection rate). This is the amount of force that is required to compress a spring a given amount. For example, if it takes 400 pounds of force to compress a spring one inch, the spring rate is 400 pounds per inch.

Many systems allow the rider to set the spring rate. Whatever type of spring is used, it is generally better to use the lowest spring rate possible. Softer springs reduce the impact to the bike and suspension system. Softer springs also allow more of the suspension travel to be used.

The following are several spring systems in use on bicycles.

HELICAL COMPRESSION SPRINGS

Commonly called "coil" springs, these are typically made of steel and are common on car suspension systems. Coil springs are common on rear suspension systems (figure 16.2). Metal springs generally are not affected by changes in temperature. Coil springs have consistent compression rates.

FIGURE 16.2

Helical compression spring from a shock fork

ELASTOMER AND RUBBER SPRINGS

Elastomer and rubber springs are similar to steel helical springs because they have fairly consistent or linear spring rate. The spring rate can vary with different types of polymer and other synthetic compounds. Unlike steel springs, elastomer spring rates tend to change with temperature. Colder temperatures stiffen polymers, and this will raise spring rates and make them stiffer. Elastomer springs can be found inside shock forks and on some suspension seat post systems (figure 16.3).

AIR (GAS) SPRINGS

Air can also be used as a spring in suspension systems (figure 16.4). Gas, usually ambient air, is contained in a sealed cylinder

FIGURE 16.3

Elastomer spring system on a suspension seat post

FIGURE 16.4

Air shock being charged with pump

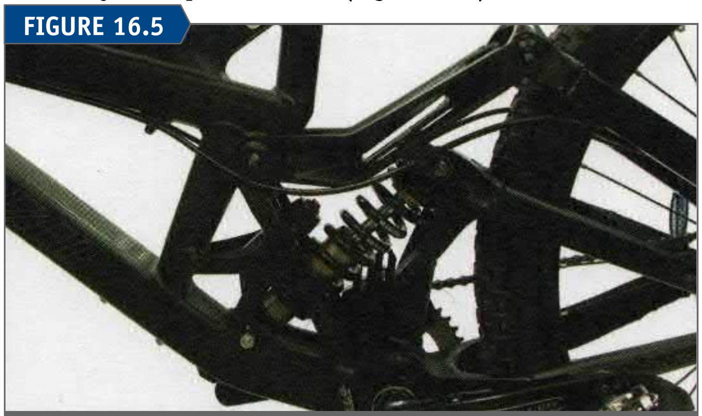
with a piston to compress the gas. The gas pressure can be raised or lowered for changes in spring rate. Assuming the temperature remains constant, the spring rate of gas tends to be progressive. As the suspension system is compressed, the air is pushed into a smaller space, and the spring rate increases.

Both outside air temperature and the working temperature of the unit will affect the spring rate of gas springs. Colder temperatures reduce the pressure of the gas, and lower the spring rate. Warmer temperatures will cause the gas to expand and raise the spring rate.

SHOCKS (DAMPERS)

A more precise term for "shock" is damper. An example of this suspension type is a car with coil or leaf springs and a separate damper unit. Generally, the cycling industry uses the word "shock" to mean both spring and damper. This integrated system of steel spring and damper is also seen on some bicycle suspension units (Figure 16.5).

FIGURE 16.5



Rear shock on full suspension bike

Damping systems are designed to help control motion (figure 16.6). A common place to see damping is on automatic, self-closing doors. As you push the door open, a spring is worked (either expanding or contracting). When you let go, the spring forces the door back closed, but it closes slowly because there is a damper to slow its return.

Damping in suspension shocks can occur both on the compression cycle and on the extension cycle. With simple dampers, the amount of damping is the same for both compression and extension. Sophisticated shock systems will be adjustable for the different amounts of compression and extension damping.

FIGURE 16.6

Internal damping system of a shock fork

Stiffer compression damping means the suspension linkage moves less, and there will be less compression of the springs. More energy is transmitted to the rider and makes a harsher ride. A lighter damping setting will allow the linkage to move relatively easily, but too light of a setting can cause the system to bottom out on large or even moderate impacts, jolting the rider and the bike.

The rear shock is removed for service. The procedure may vary somewhat between designs. When in doubt take notes and pictures on the original situation. For air shocks, use a shock pump and take a measurement of the current air pressure for reference. For spring shock, measure the amount of compression on the spring. Use a tape measure to measure spring length or count the number of turns from the compression ring, as it is unthreaded. Unthread the forward or upper pivot bolt, taking careful note of the orientation of any washers, spacers, and bushings. Unthread next and remove the lower or rear pivot bolt, again noting orientation of any parts.

SUSPENSION LINKAGES

The design of suspension linkage systems should permit the wheels to move only up and down in the vertical plane. If the wheel is allowed to move side to side while the suspension is working, the ride will be unpredictable and good handling will be sacrificed.

On rear suspension bikes, the rear wheel is connected to the rest of the bike with a moveable "swing arm" (figure 16.7). The swing arm is the back end of the bike. Typically the chain stays and seat stays act as a unit, which is bolted to the main triangle by pivots. The placement and design of the pivots

FIGURE 16.7

Swing arm system of a full suspension bike will affect performance. The rear wheel is allowed to swing independently of the main frame. As the rear wheel moves upward, some of the force that would throw the bike upward is stored in the swing arm spring. The forces involved are the same with a rigid bike, but the effect on a suspension bike and rider is spread out over time. The impact to the rider is reduced, and the wheels stay closer to the trail surface.

SERVICE & TUNING

Play or lateral movement can develop in both front and rear systems. In telescopic front fork systems, bushings are used to allow the outer legs to travel over the upper tubing. With use and time, play may develop in the bushings, which degrades handling.

Some rear suspension linkage systems move on pivots. Some pivots use an adjustable bushing system. Play can be adjusted out by tightening a bolt or nut. Other systems use replaceable washers, but a few systems have no provision for removing wear or play.

The rear shock can be removed from the rear linkage. This permits service of the shock and for the testing of the linkage pivots. Begin by removing rear wheel. If the shock has a coil spring, measure the amount the spring is compressed. Unthread the coil spring nut. For air sprung shocks, measure air pressure and then deflate. This permits the bike to be returned to the previous settings. Inspect the shock at the upper and lower eyelets. Remove the upper eyelet bolt. Push bushing from eyelet.

With the shock removed from the frame, test the pivots of the linkage for smoothness and for play. Move the rear end up and down, feeling for problems such as sticking. Pull the rear end of bike side to side to test pivot play.

Rear suspension bushings or sleeves may also be pressed into a fitting in the frame and suspension system (figure 16.8). These are usually brand specific diameters and widths, and this typically requires the use of brand specific tool and parts for servicing. A professional mechanic should be consulted for bushing replacement.

Tuning the suspension system is making modifications to change handling for the rider. Designers attempt to make the bike and its suspension system useable by a wide range of riders. The system may need adjustment, however, to suit a rider's particular expectations.

FIGURE 16.8

Bearings inside linkage pivot

When tuning a system, attempt to change one variable at a time. Tuning is considered a skill acquired with experience and time. This type of work can be slow and tedious at first, but with experience you will learn which procedures work in each scenario and which don't. For example, a stiff rear swing arm tends to tip the bike forward and compress the front fork. In a series of bumps, it might appear to the rider that the fork is too stiff, but this may be an illusion caused by too much preload on the fork from the transfer of force from the stiff rear end.

There are many aspects that affect the handling of a bike. Some of these will be very adjustable, others will be more or less fixed. Changes to handling may be affected by the following:

SPRING PRELOAD

Preload is typically the easiest thing to change in a system. Most companies design ways to change spring preload, such as by increasing air pressure or by compressing or relaxing the steel/elastomer spring.

FLUID VISCOSITY

Some damper designs allow for changing the suspension fluid to different viscosities. This will affect damping. A fluid with a higher viscosity rating (thicker) will move more slowly through porting in the shock system. This has a tendency to slow rebound. Fluid with a lower viscosity rating is more fluid and moves more quickly through the holes in the ports. Consult a professional mechanic for fluid changes.

VALVING

If there is access to a hydraulic system's valving, there may be changes that can be made to affect the flow of oil. Polishing ports, drilling new ports, or changing internal spring tensions are all done by professional mechanics.

LINKAGE

Some designs of full suspension systems have different positions for strut mounts and shock mounts. This changes the leverage of the wheel over the shock. By doing this, vehicles can be changed to better suit the racing situation.

CYCLIST POSTURE

The cyclist's posture and position on the bike greatly influence weight distribution and hence the bike's handling. Moving the saddle rails forward or back; raising or lowering the saddle; changing the stem's length, height, or angle; or any combination of these alters weight distribution and the vehicle's center of gravity and response to steering forces.

TIRE CONTACT

An often-overlooked source of suspension and handling is the tires. Tire width, casing, rubber tread design, and air pressure have a large influence on handling of any bike. A harder tire firms the suspension. A softer tire gives the bike more give on rough terrain. Many racers say the best suspension on any bike is between the wheels and the ground.

CHAPTER 17

ON-RIDE REPAIR

Mechanical problems can and do occur while riding on the trail or road. The best way to prevent these problems is to regularly clean, lubricate, and inspect the bike. Keeping your bike well maintained will prevent many of the mechanical problems described below, even when riding off-road.

TOOL CHOICES

Should problems arise, be prepared by carrying a few tools. When selecting tools for the ride, consider the type of bike components being used by you and others in your group. Consider the weight of the tools and the amount of space available for carrying. Your budget and level of mechanical skill will also affect your choice of tools.

There are numerous possibilities for tool options and pre-packaged tools kits. One versatile tool choice is the "multi-tool." These contain several tools, including hex wrenches, screwdrivers, spoke wrenches, tire levers, and others in one unit. This type of tool is compact and cost-effective. You may assemble your own take-along kit of tools. The list below outlines recommended tools for a typical MTB or road ride.

TABLE 17.1 *Take-Along Tools*

ITEM DESCRIPTION	PARK TOOL
Multi-Tools	MTB-3.2, MTB-7, IB-3
Chain Tool	CT-5, CT-6.2, IB-3
Tire Levers	TL-1, TL-4, TL-6
Patch Kit	VP-1, GP-2
Spoke Wrench	SW-7, or purchased to fit
Screwdriver	MTB-3.2, MTB-7, IB-1, IB-2, IB-11, IB-12
Portable Tire Pump	PMP-3, PMP-4, PMP-5
Tire Boot	TB-2

REPAIR PROCEDURES

Repairs made during the ride have some limitations. The right tools or parts are not always available. Some bikes can simply be flipped upside down to work on them, but be careful to not damage shift and brake levers or housing. Additionally, some hydraulic brake systems should not be turned upside down. If it is necessary to turn a hydraulic brake system upside down, allow it to sit upright several minutes after the repair, then test the brake to insure no air has entered the brake lines.

The following text outlines problems that may occur on the ride and gives suggestions for addressing them. If a repair seems questionable, walk the bike home or call for a lift. Do not ride an unsafe bike.

FLAT TIRE

Always carry a spare tube. On long rides or big group rides, carry two tubes if possible. A patch kit is also essential (see page 17, Inner Tube Repair). To clean the tube before patching, carry a foil sealed alcohol wipe. These are available in drug stores.

CUT OR RIPPED TIRE

Use a tire boot such as the Park Tool TB-2 (see page 19, Temporary Repair of Tire with Tire Boot). Plan ahead for this contigency. A paper dollar bill, for example, provides little holding strength for a cut tire. Always replace the tire as soon as possible.

BROKEN SPOKE

The only permanent repair for a broken spoke is to replace the spoke and re-true the wheel (see page 61, Broken & Damaged Spoke Replacement). If a single spoke is broken, the lateral true can be improved by loosening the two spokes immediately adjacent to the broken one. This will somewhat bring the wheel back into lateral true. It may be possible to continue the ride. If the wheel has 28 or fewer spokes, having one spoke missing or broken may make the wheel unsafe to use. Bent spokes, even severely bent ones, are less of a problem. If the wheel is still adequately true, continue the ride. True the wheel as necessary, and then replace the spokes after the ride. See page 56, Truing Procedures.

DENTED RIM

Rims can become dented from striking objects on the ground. First determine the extent of the dent. If the braking is not badly affected, it may be best to leave it alone and finish the ride. Have the rim repaired or replaced after the ride. With rim caliper brakes, severe dents will be felt during braking and may lock up the wheel unexpectedly. A badly dented rim can also affect the seating of the tire head. In either of these cases, it is best to not ride the bike.

BROKEN CHAINS

A broken chain can usually be shortened as an emergency repair. If you have extra links, these may be added, but the chain will be compromised and should be replaced with a new chain as soon as possible. Note that outer plates must be joined to inner plates and remove links accordingly. If the chain was shortened, use care not to shift into the largest rear sprocket and largest front chainring combination. The most common cause for a broken link is improper installation. When installing a chain, inspect all pins and links to prevent on-the-ride chain problems. Additionally, if a chain has broken on a ride, inspect all rivets and links after repairing. If there was one bad link, there are likely to be more. For chain link cutting, see page 98, Chain Removal.

CHAIN SUCK

Chain suck occurs when a chainring will not release the chain at the six o'clock position. The chain gets stuck on a tooth and continues upward with the chainring and eventually jams into the frame. If it is not too jammed, grasp the chain at the bottom, and pull down while turning the crank backwards. Scarring of the paint and frame is likely. If pulling the chain will not dislodge it, it may be possible to disconnect a link of chain, unthread the chain from the frame, and reinstall correctly. The last option is to remove the right crank, which requires a crank puller. Inspect the chain after pulling it free. The chain may have become twisted or damaged. Inspect the chainring teeth as well, which may be the cause of the problem. If a tooth is bent, avoid using that chainring if possible.

TWISTED CHAIN

Chains can twist from being shifted into the spokes or from jamming against the frame during chain suck. It may be possible to twist the chain back using a pair of pliers, but it is difficult to do so by hand. Isolate the twisted section and use the rear cog to hold one end of the chain. Twist the chain back using pliers at the end of the twist. Replace the chain as soon as possible after the ride.

SQUEAKY AND NOISY CHAIN

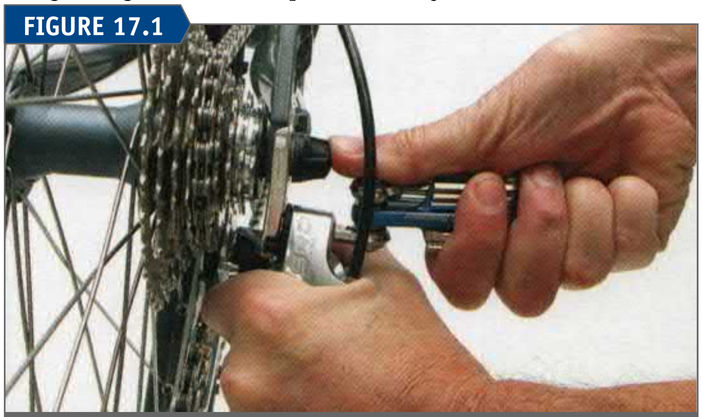
A squeaky chain is caused by the lack of lubrication in the links. It is usually not necessary to carry chain lubricant on shorter rides if the chain has been lubricated as part of regular maintenance. If the ride is especially wet, the lubricant may wash away. In this case, almost anything that will penetrate the link will provide some temporary lubrication. Sunscreen oils or creams, bug repellent creams, and cooking oils can provide some short-term relief from a noisy chain. Clean and lubricate the chain properly after the ride.

REAR DERAILLEUR SHIFTING INTO THE SPOKES OR FRAME

This problem is typically the result of improper limit screw settings. The limits of the rear derailleur act as a stop to the derailleur body. If the derailleur or derailleur hanger is bent, the previous limit screw settings will no longer be appropriate. View the derailleur from the back and sight that the pulley wheels are parallel to the cogs. If the derailleur hanger or pulley cage appears to be pushed inward toward the spokes, something has been bent. It may be possible to pull the derailleur back. Insert a hex wrench in the mounting bolt and pull upward until the derailleur appears parallel with sprockets (figure 17.1).

Check shifting and reset H-limit screw and L-limit screw as necessary. Take the bike to a professional shop for proper hanger alignment after the ride, or see page 130, Derailleur Hanger Alignment and Repair to do it yourself.

FIGURE 17.1



Bend hanger back until visually straight

DERAILLEUR NOT INDEXING PROPERLY

The most common cause for derailleurs not indexing properly is poor derailleur cable tension adjustment. Apply the same skills and procedures as with routine derailleur adjustment (see page 124, Rear Derailleur). Have someone hold the bike by the saddle while you pedal by hand, and make adjustments to the barrel adjuster.

BROKEN DERAILLEUR BODY, CAGE, OR HANGER

If the rear derailleur body, pulley wheel cage, or derailleur hanger has broken, shifting is no longer possible. The bike may be converted to a single-speed to get back home (figure 17.2).

FIGURE 17.2

Bypass derailleur to create a makeshift single-speed

Procedure for single-speed conversion:

a. Remove the chain. For removal procedures see page 98, Chain Removal.
b. Remove the derailleur or other affected parts.
c. Choose a gear. For triple chainring bikes, use the middle ring and one of the middle rear sprockets. For two chainring bikes, use the smallest ring.
d. Run the chain from the chosen rear sprocket to the front chainring and determine the correct pin to remove in order to shorten the chain. It may be necessary to change rear sprocket choices to get better chain tension.
e. Cut the chain and connect the links. The chain should be tight enough so it does not come off the front sprocket.
f. Rotate the pedals backwards by hand slowly, and bounce the chain up and down, keeping your fingers on the outside of the chain loop, to check tension.

MISSING DERAILLEUR PULLEYS

Look for missing parts on the trail or road behind you if possible. If the parts are not available, convert to a single-speed as described above in Broken Derailleur Body, Cage, or Hanger.

FRONT DERAILLEUR CAGE BENT OR TWISTED

The front derailleur cage can get twisted if a chain jams during a shift or if it is struck. Realign the cage if it has twisted (see page 116, Front Derailleur). Outer cage should be approximately parallel with the chainrings. The derailleur may not properly shift after the realignment, so select the preferred chainring and use cable tension or limit screws to keep the derailleur on that chainring.

CRANK FALLING OFF

If the crank has completely fallen off, the bolt may be missing. In this case, walk the bike back. It is dangerous to attempt riding it with the arm simply shoved back in place. If you have the bolt, reinstall the arm. The torque for crank bolts is relatively high, around 300 inch-pounds. Basically, tighten as much as you feel the tool will be able to withstand.

PEDALS FALLING OFF

A loose pedal may be secured with a correct fitting wrench. If there is a hex fitting behind the pedal threads, tighten it use the correct hex wrench, either a 6 mm or 8 mm. If no wrench is available, it is best to walk the bike. Riding with a loose pedal in the crank may cause the thread to pull out of the arm, resulting in a catastrophic crash for the rider.

BENT CRANK

If a bike has crashed with much force, the crank may bend. The pedal surface and your foot will then oscillate as the bike is ridden. If the crank clears the frame, it is best to finish the ride by riding lower gears and going slowly. Replace the arm. If the crank does not clear the fame, walk the bike or get a ride. Attempting to re-bend a bent arm may lead to eventual failure of the part and another crash.

BOTTOM BRACKET LOOSE OR FALLING APART

Depending on the specific bottom bracket, there may be very little repair that is possible. It is impractical to carry bottom bracket tools on the ride. If the bottom bracket is so loose that the cranks strike the frame, do not ride the bike.

BROKEN DERAILLEUR CABLE

If a derailleur cable has become frayed between the lever and cable pinch bolt, it is more likely to fail. Avoid using the derailleur if possible. Broken gear cables usually mean a non-functioning derailleur.

If a front derailleur cable has broken and a spare is not available, consider the remainder of the ride, then choose the most comfortable chainring for completing the ride. Typically the middle chainring is best for a triple crankset. For a double-chainring bike, select the smaller ring. Pull the cage up to the middle ring by hand and tighten the L-limit screw. For rear derailleurs, again consider the remainder of the ride. Choose one of the middle cogs and tighten the H-limit screw to hold the derailleur in that position.

Broken cables will tend to get caught in moving parts. Remove the old cable and store until it can be disposed of properly.

BROKEN BRAKE CABLE

Do not attempt to patch together broken brake cables. If the cable were to fail again when needed, the consequences could be disastrous. Ride the remainder of the ride with caution, and replace the cable as soon as possible. Walk the bike rather than ride if in doubt as to safety. Remove and store the broken brake cable until it can be disposed of properly. For brake cable installation, see page 171, Cable System.

TWISTED OR BENT HANDLEBARS OR STEM

Handlebars may become misaligned from crashing. To realign, stand in front of the bike and grab wheel firmly between knees. Loosen stem binder bolt(s) and pull stem back into alignment until bars appear parallel with front hub and stem is aligned with wheel. Re-secure binder bolt(s). It will likely be necessary to readjust the headset if the binders of a threadless stem are loosened. For headset adjustment, see page 198, Threadless Headset Adjustment. It is possible to ride with a slight misalignment in the bars. If the crash has actually bent the bars or twisted the stem, it is best not to continue riding. A bent bar or stem may fail without warning. Replace it as soon as possible.

BENT FRAME OR FORK

Very severe crashes may bend either the frame or fork. Inspect the frame, especially behind the head tube. Look for paint cracks and wrinkles in the metal, indicating bent frame tubing (figure 17.3). If the frame is bent, it should be considered unsafe. Do not ride this bike.

Fork blades and fork crowns can also bend. View the bike from the side to see if the alignment looks odd. Again, a bent fork makes the bike unsafe to ride.

FIGURE 17.3

Bent frame at head tube

BENT SADDLE OR SEAT POST

If the saddle has come loose on the post, it may simply be realigned and tightened. For saddle security, see page 188, Saddle and Seat Post Adjustment. If the clamp is broken, it will be difficult to repair away from home. In this case, remove both entire seat post and the saddle. Simply removing the seat and leaving the post installed is inviting an accident to happen.

REFERENCE MATERIALS

The tool list below will stock a very complete "home mechanic shop." The list does not duplicate a professional shop. For example, there are no bottom bracket taps, head tube reaming tools, and other tools a full service center at a retail bicycle shop would use. There are often several choices for a particular piece of equipment. It will be necessary to research these choices to make the best decision for your specific circumstances.

TABLE A.1 *Tool List*

✓	TOOL	PRODUCTS	INFORMATION
		General Tools	
	Bicycle Repair Stand	PCS-9, PCS-10, PRS-20, PRS-21, PRS-25	The stand forms the base of any good shop
	Socket and Bit Set	SBS-1	⅜ inch drive socket bit set with metric and Torx® bits
	Torque Wrench	TW-1, TW-2, TW-5, TW-6	For use on small threads, use TW-1 or TW-5 For larger threads and torques, use TW-2 or TW-6
	Hex Wrench Set	AWS-10, HXS-2.2, PH-1	
	Torx® Wrenches	TWS-2, PH-T1	Star-shaped wrenches for bolts using Torx® heads
	Shop Apron	SA-1, SA-3	
	Screwdriver Set	SD-SET	³⁄₁₆ and ¼ inch Straight Blade #0 and #2 Phillips
	Hammer	HMR-4	Double-ended, steel and plastic
	Needle Nose Pliers	NP-6	
	Diagonal Side Cutting Pliers	SP-7	
	Combination Wrenches	MW-SET.2	Box end with open end on other side (6-17 mm)
		Bottom Bracket Tools	
	Lockring Wrench	HCW-5	Fits most lockring types for adjustable square BBs
	Adjustable Cup Tool	SPA-1	Adjustable type bottom brackets
	Fixed Cup Tool, 36 mm	HCW-4	Adjustable type bottom brackets
	Cartridge Bottom Bracket Tool	BBT-22	Fits 20-tooth internal spline cups such as on Shimano® cartridge BBs, FSA®, and Race Face® ISIS Drive bottom brackets
	External Bottom Bracket Wrench	BBT-9, BBT-19	Shimano® Hollowtech® II
	Hollowtech® II Crank Cap Tool	BBT-10	Adjusts bearing load for Shimano® Hollowtech® II cranks
	Bottom Bracket Lockring Tool	BBT-7	Shimano® XTR® and Dura-Ace® lockrings (adjustable type bottom brackets)
	Bottom Bracket Tool	BBT-18	Fits 8-notched bottom bracket cups, ISIS Drive of Truvativ® and Bontrager®
	Bottom Bracket Tool	BBT-30.3	BB30 and PF30 service
	Bottom Bracket Tool	BBT-90.3	BB86 and BB90 service
	Bottom Bracket and Crankset Tool	CBP-3, CBP-5	Campagnolo® Ultra-Torque® and Power Torque™ service
		Headset Tools	
	Headset Locknut Wrench	HW-2, PAW-12	32 mm and 36 mm open end wrench in eight-point for threaded headsets; wrench wraps to fit all points
	Headset Lower Race Wrench	HCW-15	32 mm and 36 mm for threaded steering columns
	Headset Press	HHP-2, HHP-3	
	Fork Crown Race Setter	CRC-1	
	Star Nut Setter	TNS-4, TNS-1	
	Saw Guide for Steering Columns	SG-6, SG-8	
		Hub Tools	
	Axle Vise	AV-1, AV-5	Holds axles without damaging threads
	Cone Wrenches	SCW-SET.2	For some hub models, two wrenches of 13, 14, 15 or 16 mm required
		Wheel and Tire Tools	
	Truing Stand	TS-2.2, TS-8	Speeds the truing of wheels
	Truing Stand Base for TS-2.2	TSB-2	Tilting base for truing stand TS-2.2

✓	TOOL	PRODUCTS	INFORMATION
	General Tools		
	Spoke Tension Meter	TM-1	Checks tension on spokes
	Wheel Centering Tool	WAG-4	Also see optional WAG-5
	Spoke Wrenches	SW-0, SW-1, SW-2, SW-3, SW-5, SW-12, SW-13, SW-14, SW-15	Many possible sizes and options; select the correct size for your wheel
	Tire Levers	TL-1, TL-4, TL-5, TL-6	Levers vary in design and fit
	Patch Kit	GP-2, VP-1	VP-1 has glue in tube; GP-2 has pre-glued patches
	Floor Pump	PFP-7, PFP-8	Pump head fits both presta and schrader
	Spoke Ruler	SBC-1	Measures spoke length and ball bearing sizes
	Drivetrain Tools		
	Pedal Wrench	PW-3, PW-4	PW-3 had 15 mm and 9⁄16 inch; PW-4 has 15 mm only
	Pedal Wrench	HT-6, HT-8	For pedals with 6-point socket in axle
	Crank Arm Pullers	CCP-22, CCP-44, CWP-7	CCP-22 is for square type spindle only CCP-44 is for round, splined ISIS Drive or Shimano® Octalink® only CWP-7 works with either square or round spindles
	Cassette/Freewheel Removers	FR-1, FR-2, FR-3, FR-4, FR-5, FR-5G, FR-6, FR-7, FR-8, BBT-5/FR-11	Purchase model as needed
	Chain Whip	SR-1.2	Used to hold cassette while lockring is removed **Note:** Older freehubs required two sprocket tools
	Chain Rivet Tool	CT-3.2, CT-4.3, CT-5, CT-6.3	
	Master Link Pliers	MLP-1.2	
	Chain Wear Checker	CC-2, CC-3.2	Check chain for wear
	Drivetrain Cleaning Kit	CG-2.2	Includes Cyclone Chain Cleaner CM-5.2, gear brush GSC-1, and ChainBrite fluid CB-2
	Derailleur Hanger Alignment Gauge	DAG-2	Aligns rear derailleur hanger
	Brake Tools		
	Fourth Hand Tool	BT-2	Tightens cable slack by pulling cable
	Cable Cutters	CN-10	Cuts both cable and housing
	Hydraulic Piston Press	PP-1.2	
	Miscellaneous Parts and Supplies		
	Bearing Grease	PPL-1	Safe for suspension elastomers, ceramic bearings, and carbon fiber
	Bicycle Cleaning Brush Kit	BCB-4.2	
	Chain Lubrication	CL-1	
	Threadlocking adhesives		Medium duty, service removabe
	Degreaser	CB-2	For chain and parts
	Hand Cleaner		
	Alcohol		For cleaning brake surfaces and press fits
	Polisher	Glass cleaner, etc.	For cleaning frames
	Zip Ties		Various sizes and colors
	Rags		Lots and lots of cotton rags
	Spare Inner Tubes		Purchase to fit
	Spare Gear Cables		Use only high quality cables

Adjustable cup: The left side bearing cup of an adjustable bottom bracket.

Adjusting race: A movable bearing surface typically mounted to a thread that is used to adjust bearing play and movement.

Allen® wrench: See hex wrench.

Articulated housing: Brake and derailleur index housing made of small hollow metal segments strung together over a liner.

ATB: All Terrain Bike, or mountain bike.

Axle nut: A threaded nut that secures wheel to bike. Used with solid axle hubs.

Bead seat diameter: Rim diameter measured where the tire bead is seated.

Bolt circle diameter: Diameter of a circle defined by the chainring mounting bolts.

Bottom bracket: The bearings, cups, and spindle connecting both cranks.

Bottom bracket shell: The bottom of the frame that holds the bottom bracket.

Bottom bracket spindle: The axle in the bottom bracket. It connects both cranks.

Braided housing: A cable housing made of woven wire around an inner liner.

Brake bridge: Frame tubing connection between seatstays. Located above rear tire and used for mounting side pull and dual pivot brake calipers on some bikes.

Brake cable: Wound, multiple strand wire that connects brake lever with brake caliper.

Brake cable carrier: Transverse connection between brake caliper arms. Found on cantilever brakes. (See straddle cable)

Brake caliper: The lever arms that move brake pads to rim or rotor to apply friction needed to slow and stop the bicycle.

Brake centering screw: The screw that changes spring tension between caliper arms, allowing pads to center over wheel rim.

Brake fluid: Either a mineral oil based fluid or a D.O.T. brake fluid for hydraulic brake systems.

Brake lever: The mechanism pulled by hand to activate brake caliper and pads.

Brake pad: Synthetic rubber block fastened to caliper arm. Pad is forced against moving rim or disc causing friction, to slow rim rotation.

Brake pad fixing bolt/nut: Fastener system that holds brake pad to rim caliper arm.

Brake pad toe: An adjustment to the brake pad used to reduce brake squeal. Pad surface is adjusted to strike braking surface at a slight angle, usually with leading edge striking first or “toe in.”

Brake quick release: Mechanism found on rim brake caliper to open brake arms allowing wide tires to pass brake pads. The mechanism is sometimes found on the brake lever, or at a cable housing stop.

Braking surface: Part of the rim or rotor disc that is rubbed by brake pads.

British Standard Cycle (BSC): A thread standard system used by the British and adopted by much of the world.

B-screw: Body-screw on rear derailleur that changes the distance between the derailleur body, or the upper pulley (G-pulley or guide pulley) assembly, and the rear sprockets.

Cable: Wound, multiple strand wire used for brake calipers and derailleurs.

Cable adjusting barrel: Hollow bolt that acts as housing stop. Component adjusts in or out to effectively change housing length and cable tension on brake and derailleur systems.

Cable pinch bolt: Bolt and washer system that flattens and holds secure the cut end of a cable. Found on derailleurs and brakes.

Cantilever brake: Brake system found on mountain bikes, cyclocross bikes, and touring road bikes. Consists of two separate brake arms pivoting off studs fixed to the frame or fork.

Cassette: Sprocket and spacer assembly mounted to a freehub mechanism on the rear wheel.

Centerline: Mid plane of the bike in line with wheels.

Chain: A connected series of flexible links used to transfer motion of front chainrings to rear sprockets.

Chain rivet: Small pin that connects two outer chain plates, usually considered a permanent part of chain.

Chainring: Sprocket attached to the crank.

Chainring bolt: Special bolts that secure a chainring to crank.

Chainring nut: Thin-walled nut used with a chainring bolt.

Chainring nut wrench: Special wrench with two pegs used to hold chainring nut.

Chainstay: Frame tubes connecting the rear dropouts and the bottom bracket shell.

Cleats: fitting mounted to a cycling shoe that attaches the shoe to the pedal.

Cogs: Sprockets attached to rear hub.

Compressionless housing: Plastic and metal sheath that covers derailleur inner cable, allowing it to pass around corners and between moving parts of the frame. Differs from other housing in that outer support wires run longitudinally with inner cable. Also called SIS™ housing by Shimano®.

Cone: A cone-shaped and curved bearing race that rides against ball bearings.

Cone wrench: Thin wrench made to fit the narrow wrench flats of a hub cone.

Crank (crank arm): The lever arm between the pedal and the bottom bracket.

Crank bolt: Bolt that secures crank to bottom bracket spindle.

Crank puller: Tool used to remove cranks by pulling them from bottom bracket spindle.

Crankset: Rotating mechanism, turned by feet, or in some cases by hand, which includes the chainrings, crank arms, and chainring bolts/nuts.

Crown (fork crown): Horizontal portion of fork, located at top of fork blades.

Derailleur: Mechanism used to push chain from one cog or chainring to another.

Derailleur cable: The inner cable of the derailleur cable system. Sometimes called the gear cable.

Derailleur capacity: The rated ability of a rear derailleur to take up chain slack from the gear combinations on the bike. Given as the sum of the difference between the largest and smallest number of teeth on the rear sprockets, plus the difference between the largest and smallest front chainring tooth numbers.

Derailleur hanger: The fitting on a bicycle frame that holds the rear derailleur. On some bikes this piece is replaceable.

Derailleur limit screw: Screw that stops derailleur travel when shifting to either extreme position. One screw stops inward travel, a second screw stops outward travel.

Disc brake: Caliper brake system using a disc-shaped rotor bolted to hub as the braking surface. Brake caliper attaches to either fork end or frame adjacent to hub.

Dishing Tool: A gauge used to measure the centering of the wheel rim over the hub.

DOT brake fluid: Hydraulic brake fluid approved by the U.S. Department of Transportation. Does *not* interchange with mineral oil brake fluid.

Down tube: Frame tube connecting lower portion of the head tube to the bottom bracket shell.

Drop bars: Curved handlebars made with two bends, with the outermost section being lower than the top and offset 90 degrees. Most frequently used on road bikes.

Dropout: Part of frame and fork slotted to accept a wheel axle.

Dual pivot brake: Road type brake with two arms pivoting off separate studs mounted to a center bracket. One arm swings on an arc moving up and the other arm swings on an arc moving down.

E-plate derailleur: A front derailleur design that permanently mounts the derailleur to a plate held by the bottom bracket.

ETRTO: European Tire and Rim Technical Organization; an organization developing industry standards for tires and tubes.

Fixed cup: The right side cup of an adjustable bottom bracket.

Flat bars: A handlebar style where the handlebars bend very slightly from the center. Also called upright bars.

Foot-pound: A measurement of torque used mainly in the U.S.

Fork: Mechanism used to hold the front wheel.

Fork blades: Tubes connecting fork dropouts to fork crown.

Frame: Supporting structure for the components, the wheels of a bike, the rider, and the cargo.

Frame housing stops: fittings on the frame that hold either brake or derailleur cable housing ends.

Freehub: Ratcheting body bolted internally to hub of rear wheel. Holds cassette cogs. Mechanism does not detach when cogs are removed.

Freewheel: Ratcheting mechanism on the rear wheel fitted with one or more cogs. Cogs and ratcheting body unthread from hub as a unit.

Front derailleur: Mechanism located above front chainrings that pushes the chain from one chainring to another.

Gear cable: See derailleur cable.

Guide pulley (G-pulley): Uppermost pulley on rear derailleur. Guides chain onto rear cogs.

Gripshift®: Twist shifter manufactured by SRAM® Corporation.

Handlebars: Connector between stem and cyclist's hands.

Head tube: Tube connecting down tube and top tube; contains headset and steering column of fork.

Headset: Bearing assembly connecting the head tube and fork. Allows fork to rotate.

Hex wrench: Metal wrench made from a six sided rod (hex-shaped) made to fit inside bolts or other mechanical fittings. Also known as Allen® Wrench.

High normal derailleur: See top normal derailleur.

Housing: The outer plastic and metal sheath that covers brake or derailleur cable, allowing cable to pass around corners and between moving parts of the frame.

Housing end cap (ferrule): Small metal or plastic cap that fits over end of housing.

Hub: The center of the wheel, contains bearings and an axle.

Hub brake: Braking system located at the center of the wheel inside the hub.

Hydraulic brake: A brake system that uses fluid to transmit force from the rider's hand to the brake caliper.

Hydraulic-mechanical brake: A brake system that combines hydraulic and mechanical systems.

Inch-pound: A measurement of torque used mostly in the United States.

Indexing: Shifting system that uses "clicks" or dwell to indicate each sprocket location.

Inner tube: Rubber bladder inside tire that holds air.

Innermost: Closest point relative to the centerline of the bike.

Interference fit: A method of assembly where one part is slightly larger than its intended fitting. Parts are held together by the force of assembly, and the elasticity of the component materials.

Internal headset: A headset type that uses a pressed head tube cup that allows bearings to sit inside head tube. Also called Zero-stack or low-profile headset.

International Standards Organization: A group dedicated to setting standards for all industries involved in international trade, such as the bicycling industry.

ISIS Drive®: International Splined Interface System. A crank and bottom bracket spindle interface standard using 10 splines.

ISO: See International Standards Organization

Integrated headset: A headset design In which the frame acts as a holder for the bearings. Bearings are held inside head tube. Service or installation does not involve pressing cups, but uses a slip fit for the bearings.

Kilogram force: A force equal to a kilogram weight or a one-kilogram mass times the acceleration of gravity. Approximately equal to 2.2 pounds force.

Limit screws: Screws on front and rear derailleurs which stop the derailleurs from causing the chain to move too close to the bicycle center line or too far to the right of the center line, either into the spokes, or causing the chain to fall off.

Linear pull brakes: A caliper brake with two long arms holding pads. System uses housing stop in one arm, no straddle cable.

Locknut: Nut used to lock a cone, threaded race, or other threaded item to keep it from moving or unthreading.

Low normal derailleur: A rear derailleur design which, with no cable tension, the derailleur returns to the innermost (largest) sprocket position. Sometimes referred to as "low normal." Also called Rapid Rise®.

Low profile headset: A headset that uses a pressed head tube cup that allows bearings to sit inside headtube. Also called Zero-stack or internal headset.

Master link: Linkage system used to join the ends of a chain.

Maximum extension line: A line on a seat post or quill stem indicating the maximum amount the item should be raised above the frame or fork steering column. Also called the "minimum insertion line."

Maximum tooth size: The largest rear spocket size a rear derailleur will be able to shift onto.

Mechanical disc brake: A disc brake that uses a cable system and has no hydraulic fittings.

Mineral fluid: A type of fluid, based on mineral oil, used in some models of hydraulic brakes. Does not interchange with DOT brake fluid.

Minimum insertion line: See maximum extension line.

Mountain bike: Bicycle design intended for rugged, off-road use. Also called "ATB", or all terrain bike.

MTB: See mountain bike.

Nipple: See spoke nipple.

Octalink®: Registered trademark of Shimano® Inc. for a crank and spindle interface standard using 8 splines. Octalink® includes the non-interchangeable V1 and V2 systems.

One-key release: Crank system that allows removal of the crank without a crank puller.

One-piece crank: Crank that uses a single piece of metal for the arms and spindle. Also called "Ashtabula" crank.

Outermost: Farthest position laterally from centerline of bike.

Pawl: Articulating tooth in a ratcheting system. Used commonly in freehubs and freewheels.

Pipe Billet spindle: A splined bottom bracket spindle from Shimano® Inc. These cranks and spindles do not interchange with square spindles or square holed cranks.

Presta valve: Narrow valve system used for some inner tubes.

Pulley wheel: Small wheel on the rear derailleur that wraps the chain to prevent slack over a range of front and rear cog size combinations.

Quick release skewer: Metal shaft and lever with cam, fitted into hollow axle. Allows easy and quick removal of wheel.

Quill Stem: A type of stem that inserts and secures inside a threaded steering column, allowing a range of handlebar height adjustment.

Rapid Rise®: See low normal derailleur.

Rear derailleur: Shifting mechanism attached to the frame that moves chain from one rear sprocket to another.

Rear sprockets: The toothed cogs or gears on the rear wheel.

Repair stand: fixture designed to hold bike while doing repairs.

Retaining compound: Liquid adhesive designed to expand and harden in press fit situations.

Rim: Metal or composite hoop suspended around hub by spokes.

Rim caliper brake: A brake system that applies force, producing friction, directly to the rim for slowing and stopping the bike.

Rim strip: Protective strip covering holes between rim and inner tube.

Rotor: Round disc plate mounted to hub for disc brake caliper.

Saddle: Support for posterior of bicyclist.

Schrader valve: Inner tube valve commonly seen on many bicycle and car tires.

Seat post: Connection between saddle and frame.

Seat tube: Frame tube connecting top tube and bottom bracket. Seat post inserts into top of seat tube.

Seatstay: Frame tube connecting rear dropout and upper portion of seat tube.

Setscrew: Small screw used primarily for adjustments. Found commonly on brake levers and caliper brakes.

Self-vulcanizing fluid: Special fluid used on an inner tube to adhere patch.

Shift lever: Control mechanism designed to pull cable and control derailleur.

Sidepull brake: Caliper brake using one pivot for both arms and mounted to brake bridge above center of wheel.

Slip fit: Method of assembly where one part slides without force into its fitting.

Spanner: Wrench.

Spindle: Axle for the bottom bracket.

Spider: Arms that hold the chainrings to the crank.

Splined spindle: A tubular shaped bottom bracket axle with ends having machined notches and recesses. The splines mate to splines in the crank.

Spoke: Long thin bolt, connecting hub to rim. Threaded on one end with a hook or fitting on other end.

Spoke nipple: Nut located at threaded end of spoke.

Sprocket: Toothed gear or wheel used to connect with the chain.

Square spindle: A spindle design where the spindle ends are a square shaped stud. Fits into a square hole in the crank.

Star nut (Star fangled nut): A nut designed to press into the inside of the fork steering column. Nut provides method for headset bearing adjustment.

Steering column: Tubing that connects fork crown to stem.

Stem: Connector between fork and handlebars.

Tensiometer: Tool used to determine the amount of tension in the wire spokes of a wheel.

Tension: Tensile force, pulling along the axis line of an object.

Tension meter: See tensiometer.

Thread locker: A special adhesive designed to expand and harden in the threads of a fastener.

Thread pitch: Distance from one thread crest to the next thread crest.

Threadless stem: Stem that clamps to the outside of an unthreaded steering column.

Tire: Rubber and fabric casing which encloses the inner tube and contacts ground.

Tire bead: Wire or fabric cable molded into the tire edge. Holds tire on the rim when tire is under pressure.

Tire lever: Lever with smooth, rounded edge used to remove tire bead from rim.

Tire Sealant: A liquid placed in the tire or inner tube. The purpose is to block minor leaks.

Top normal derailleur: A rear derailleur design where with no cable tension the derailleur returns to the outermost (smallest) sprocket position. Also called high normal.

Top tube: Frame tube connecting head tube to seat tube.

Torque: Force applied around an axis.

True: Refers to wheel rim spinning laterally straight and radially round.

Tubeless tire: Tire and rim system that maintains air pressure without an inner tube. Similar to automotive and motorcycle tubeless tire systems.

Twist grip: Shift lever fitted as part of handgrip that actuates shifting by rotation.

Valve core: Mechanism in inner tube for inflating, maintaining inflation, and deflating tube.

V-brakes®: Registered trademark of Shimano® Inc. for a type of linear pull brake. Pads move on parallelgram attached to caliper arms.

Wheel: A composite component made of the rim, hub and spokes. May also include tire and tube.

Zero stack headset: A headset type that uses a pressed headtube cup that allows bearings to sit inside headtube. Also called low profile or internal headset.

Zip tie: Thin plastic straps used to secure most anything.

Specifications in the table below are in Newton meters (Nm). Inch-pounds (in-lbs) are given in parentheses. Some component manufacturers do not specify torque for certain components or parts. Contact the manufacturer for the most up-to-date specifications.

TABLE C.1 *Torque Recommendations*

COMPONENT	TYPE	TORQUE RECOMMENDATION
Handlebar, Stem, Fork, and Headset Area		
Stem binder bolt: quill type	Control Tech®	16.3–19 Nm (144–168 in-lbs)
	Shimano®	19.6–29.4 Nm (174–260 in-lbs)
Threadless stem steering column binder bolts	Control Tech®	13.6–16.2 Nm (120–144 in-lbs)
	Deda®	8 Nm (71 in-lbs)
	FSA® carbon	8.8 Nm (78 in-lbs)
	Syncros® cotter bolt type	10.1 Nm (90 in-lbs)
	Thomson®	5.4 Nm (48 in-lbs)
	Time® Monolink	5 Nm (48 in-lbs)
	Race Face®	6.2 Nm (55 in-lbs)
Handlebar binder: one- or two-bolt models	Shimano®	19.6–29.4 Nm (174–260 in-lbs)
	Control Tech®	13.6–16.3 Nm (120–144 in-lbs)
Handlebar binder: four-bolt faceplate models	Control Tech®	13.6–16.3 Nm (120–144 in-lbs)
	Deda® magnesium	8 Nm (71 in-lbs)
	Thomson®	5.4 Nm (48 in-lbs)
	FSA® OS-115 carbon	8.8 Nm (78 in-lbs)
	Time® Monolink	6 Nm (53 in-lbs)
	Race Face®	6.2 Nm (55 in-lbs)
MTB handlebar end extensions	Cane Creek®	7.9 Nm (70 in-lbs)
	Control Tech®	16.3 Nm (144 in-lbs)
Threaded headset locknut	Chris King® gripnut type	14.6–17 Nm (130–150 in-lbs)
	Tange-Seiki®	24.5 Nm (217 in-lbs)
Seat rail binder	Control Tech® two-bolt type	16.3 Nm (144 in-lbs)
	Control Tech® one-bolt type	33.9 Nm (300 in-lbs)
	Shimano®	20–30 Nm (174–260 in-lbs)
	Syncros®	5 Nm (44.2 in-lbs) each bolt
	Time® Monolink	5 Nm (44.2 in-lbs)
	Truvativ®	M8 bolt: 22–24 Nm (195–212 in-lbs); M6 bolt: 6–7.1 Nm (53–63 in-lbs)
	Campagnolo®	22 Nm (194 in-lbs)
Seat post binder	Campagnolo®	4–6.8 Nm (36–60 in-lbs); **Note:** Seat posts require only minimal tightening to not slip downward. Avoid overtightening.
Pedal, Crankset, and Bottom Bracket Area		
Pedal into crank	Campagnolo®	40 Nm (354 in-lbs)
	Ritchey®	34.7 Nm (307 in-lbs)
	Shimano®	35 Nm (309.7 in-lbs) minimum
	Truvativ®	31.2–33.9 Nm (276–300 in-lbs)
Compression slotted crank pinch bolts	Shimano® Hollowtech® II	9.9–14.9 Nm (88–132 in-lbs)
	FSA® MegaExo™	9.8–11.3 Nm (87–100 in-lbs)
Crank adjusting cap	Shimano® Hollowtech® II	0.5–0.7 Nm (4–6 in-lbs)
	FSA® MegaExo™	0.5–0.7 Nm (4–6 in-lbs)

COMPONENT	TYPE	TORQUE RECOMMENDATION
Crank bolt (including splined and square-spindle cranks)	Shimano®	34–44 Nm (305–391 in-lbs)
	Shimano® Octalink® XTR® (M15 thread)	40.3–49 Nm (357–435 in-lbs)
	Campagnolo®	32–38 Nm (282–336 in-lbs)
	Campagnolo® Ultra-Torque®	42 Nm (371 in-lbs)
	FSA® M8 bolt	34–39 Nm (304–347 in-lbs)
	FSA® M14 steel	49–59 Nm (434–521 in-lbs)
	Race Face®	54 Nm (480 in-lbs)
	Syncros®	27 Nm (240 in-lbs)
	Truvativ® ISIS Drive	43–47 Nm (384–420 in-lbs)
	Truvativ® square spindle	38–42 Nm (336–372 in-lbs)
	White Industries™	27–34 Nm (240–300 in-lbs)
Crank bolt one-key release cap	Shimano®	5–6.8 Nm (44–60 in-lbs)
	Truvativ®	12–14 Nm (107–124 in-lbs)
Chainring cassette to crankarm (lockring)	Shimano®	50–70 Nm (443–620 in-lbs)
Chainring bolt: steel	Shimano®	7.9–10.7 Nm (70–95 in-lbs)
	Campagnolo®	8 Nm (71 in-lbs)
	Race Face®	11.3 Nm (100 in-lbs)
	Truvativ®	12.1–14 Nm (107–124 in-lbs)
Chainring bolt: aluminum	Shimano®	5–10 Nm (44–88.5 in-lbs)
	Campagnolo®	8 Nm (70.8 in-lbs)
	Truvativ®	8–9 Nm (70.8–79.6 in-lbs)
Bottom bracket: cartridge	Shimano®	49.1–68.7 Nm (435–608 in-lbs)
	Campagnolo® (three-piece type)	70 Nm (612 in-lbs)
	Campagnolo® Ultra-Torque® cups	35 Nm (310 in-lbs)
	FSA®	39.2–49 Nm (347–434 in-lbs)
	Race Face®	47.5 Nm (420 in-lbs)
	Shimano® Hollowtech® II	34.5–49.1 Nm (305–435 in-lbs)
	Truvativ®	33.9–40.7 Nm (300–360 in-lbs)
	White Industries™	27 Nm (240 in-lbs)
Derailleur and Shift Lever Area		
Drop bar dual control brake/ shift lever clamp bolt	Shimano® STI™	6–8 Nm (53–69 in-lbs)
	Campagnolo®	10 Nm (89 in-lbs)
	SRAM®	6–8 Nm (53–70 in-lbs)
Shift lever: upright/flat bar type	Shimano®	5–7.4 Nm (44–69 in-lbs)
Shift lever: twist grip	Shimano® Revoshift®	6–8 Nm (53–70 in-lbs)
	SRAM®	17 Nm (150 in-lbs)
Front derailleur clamp bolt	Campagnolo®	5 Nm (44 in-lbs)
	Campagnolo®	7 Nm (62 in-lbs)
	Shimano®	5–7 Nm (44.2–62 in-lbs)
	SRAM®	4.5 Nm (39.8 in-lbs)
	SRAM®	5–7 Nm (44–62 in-lbs)
Rear derailleur mounting bolt	Campagnolo®	15 Nm (133 in-lbs)
	Shimano®	8–10 Nm (70–86 in-lbs)
	SRAM®	8–10 Nm (70–86 in-lbs)

COMPONENT	TYPE	TORQUE RECOMMENDATION
Rear derailleur cable pinch bolt	Shimano®	5–7 Nm (44–60 in-lbs)
	Campagnolo®	6 Nm (53 in-lbs)
	SRAM®	4–5 Nm (35.4–44.2 in-lbs)
Rear derailleur pulley wheel (idler wheel) bolt	Shimano®	2.9–3.9 Nm (27–34 in-lbs)
	SRAM®	
	Campagnolo®	
Wheel, Hub, and Rear Cog Area		
Spoke tension torque	—	Typically not used in wheels. Spoke tension is measured by deflection. Contact rim manufacturer for specific tension recommendations.
Wheel quick realease	—	Measured torque not typically used. Common industry practice is resistance at lever half way through swing from open to fully closed.
Wheel axle nuts to frame	Shimano®	29–44 Nm (260–390 in-lbs)
	SRAM®	30–39.5 Nm (266–350 in-lbs)
Cassette sprocket lockring	Shimano®	29.4–49 Nm (260–434 in-lbs)
	Campagnolo®	50 Nm (442 in-lbs)
	SRAM®	40 Nm (354 in-lbs)
Hub cone lockring nut	Bontrager®	17 Nm (150 in-lbs)
	Chris King®	12.2 Nm (100 in-lbs)
	Shimano®	9.8–24.5 Nm (87–217 in-lbs)
Freehub body	Bontrager®	45 Nm (400 in-lbs)
	Shimano®	35–50 Nm (305–434 in-lbs)
	Shimano® XTR® using 14 mm hex	45–50 Nm (392–434 in-lbs)
Disc Brake Systems		
Disc rotor to hub: lockring models	Shimano®	40 Nm (350 in-lbs)
	Avid®	40 Nm (350 in-lbs)
Disc rotor to hub (M5 bolts, six per rotor)	Shimano®	2–4 Nm (18–35 in-lbs)
	Hayes®	5.6 Nm (50 in-lbs)
	Avid®	6.2 Nm (55 in-lbs)
	Magura®	3.8 Nm (34 in-lbs)
Caliper body mount	Avid®	9–10.2 Nm (80–90 in-lbs)
	Magura®	5.7 Nm (51 in-lbs)
	Shimano®	6–8 Nm (53–69 in-lbs)
	Hayes®	12.4 Nm (110 in-lbs); with Manitou forks, 9 Nm (80 in-lbs)
	Tektro®	6–8 Nm (53–69 in-lbs)
Hydraulic hose fittings	Hayes®	6.2 Nm (55 in-lbs)
Brake Caliper and Lever Area		
Upright bar brake levers	Shimano®	6–8 Nm (53–69 in-lbs)
	Avid®	5–7 Nm (44–62 in-lbs)
	Campagnolo®	10 Nm (89 in-lbs)
Brake caliper mount to frame: side-pull, dual-pivot, center-pull	Cane Creek®	7.7–8.1 Nm (68–72 in-lbs)
	Shimano®	7.8–9.8 Nm (70–86 in-lbs)
	Tektro®	8–10 Nm (69–89 in-lbs)
	Campagnolo®	10 Nm (89 in-lbs)

COMPONENT	TYPE	TORQUE RECOMMENDATION
Linear-pull or cantilever caliper mount to frame	Avid®	4.9–6.9 Nm (43–61 in-lbs)
	Control Tech®	11.3–13.6 Nm (100–120 in-lbs)
	Shimano®	8–10 Nm (69–89 in-lbs)
	SRAM®	5–6.8 Nm (45–60 in-lbs)
	Tektro®	6–8 Nm (53–69 in-lbs)
Brake pad: threaded stud	Avid®	5.9–7.8 Nm (53–69 in-lbs)
	Campagnolo®	8 Nm (71 in-lbs)
	Cane Creek®	6.3–6.7 Nm (56–60 in-lbs)
	Tektro®	5–7 Nm (43–61 in-lbs)
	Shimano®	5–7 Nm (43–61 in-lbs)
	SRAM®	5.7–7.9 Nm (50–70 in-lbs)
Brake pad: smooth stud	Shimano®	7.9–8.8 Nm (70–78 in-lbs)
Brake cable pinch bolt: linear-pull and cantilever	Control Tech®	4.5–6.8 Nm (40–60 in-lbs)
	Shimano®	6–7.8 Nm (53–69 in-lbs)
	SRAM®	5.6–7.9 Nm (50–70 in-lbs)
	Tektro®	6–8 Nm (53–69 in-lbs)
Brake cable pinch bolt: side-pull and dual-pivot	Campagnolo®	5 Nm (44 in-lbs)
	Cane Creek®	7.7–8.1 Nm (68–72 in-lbs)
	Mavic®	7–9 Nm (62–80 in-lbs)
	Shimano®	6–8 Nm (53–69 in-lbs)
	Tektro®	6–8 Nm (53–69 in-lbs)
Side-pull and dual-pivot brake pad bolts	Cane Creek®	6.3–6.7 Nm (56–60 in-lbs)
	Shimano®	6–8 Nm (53–69 in-lbs)
	Campagnolo®	8 Nm (72 in-lbs)
	Tektro®	5–7 Nm (43–61 in-lbs)
Cantilever straddle wire carrier pinch bolt (M5 thread)	Control Tech®	4.5–6.7 Nm (40–60 in-lbs)
	Shimano®	3.9–4.9 Nm (35–43 in-lbs)
	Avid®	3–5 Nm (26–44 in-lbs) Avid Shorty Ultimate
	Tektro®	6–8 Nm (53–69 in-lbs)

The chart below is a quick conversion between inch-pounds, foot-pounds, and Newton-meters. For exact figures, use the formulas at right.

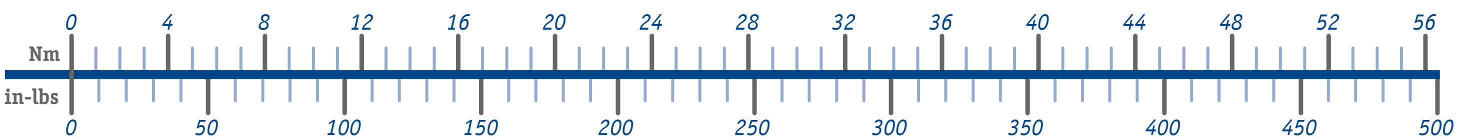
in-lb = ft-lbs x 12
in-lb = Nm x 8.851
in-lb = kgf-cm x 0.87

TABLE C.2 *Torque Conversion Table*

IN-LBS	FT-LBS*	Nm*
10	0.8	1.1
20	1.7	2.3
30	2.5	3.4
40	3.0	4.5
50	4.2	5.6
60	5.0	6.8
70	5.8	7.9
80	6.7	9.0
90	7.5	10.2
100	8.3	11.3
110	9.2	12.4
120	10.0	13.6
130	10.8	14.7
140	11.7	15.8
150	12.5	16.9
160	13.3	18.1
170	14.2	19.2
180	15.0	20.3
190	15.8	21.5
200	16.7	22.6
210	17.5	23.7
220	18.3	24.9
230	19.2	26.0
240	20.0	27.1
250	20.8	28.2
260	21.7	29.4
270	22.5	30.5
280	23.3	31.6
290	24.2	32.8
300	25.0	33.9
310	25.8	35.0
320	26.7	36.2
330	27.5	37.3
340	28.3	38.4
350	29.2	39.5
360	30.0	40.7
370	30.8	41.8
380	31.7	42.9
390	32.5	44.0
400	33.3	45.2
410	34.2	46.3
420	35.0	47.5
430	35.8	48.6
440	36.7	49.7
450	37.5	50.8
460	38.3	52.0
470	39.2	53.1
480	40.0	54.2
490	40.8	55.4
500	41.7	56.6

* Approximate values

TORQUE CONVERSION SCALE



The three tables below refer to the different headset standards now seen on bicycles. The common legacy names are listed as well as the new SHIS system (Standard Headset Information System). Table D.1 refers to the bicycle headtube and gives the cup or bearing outside diameter (OD) as well as the frame bore or inside diameter (ID). Table D.2 gives the fork column top standards for both threaded and threadless forks. Table D.3 gives the fork race seat standards.

Use a caliper to measure the old parts and or frame when replacing the headset. Look for the SHIS listing on new replacement headsets.

TABLE D.1 *Head Tube Standards*

TYPE	LEGACY NAME	SHIS NAME	CUP/BEARING OD (mm)	BORE ID (mm)
External cup Beyond headtube	1-inch JIS pressed cup	EC29	30.0	29.80–29.90
	1-inch Pro pressed cup	EC30	30.2	30.00–30.15
	1-inch BMX standard (old)	EC33	32.8	32.60–32.70
	1⅛-inch pressed cup	EC34	34.0	33.80–33.95
	1¼-inch pressed cup	EC37	37.0	36.80–36.95
	External cup (rare)	EC38	38.0	37.90–37.95
	External cup in the 44 standard	EC44	44.0	43.90–43.95
	1.5-inch pressed cup	EC49	49.7	49.55–49.60
	1.5-inch pressed cup	EC56	56.0	55.90–55.95
Semi-integrated, internal, ZS Bearing level or below headtube	1-inch semi-integrated	ZS41	41.5	41.35–41.40
	1⅛-inch semi-integrated	ZS44	44.0	43.90–43.95
	1½-inch semi-integrated	ZS49	49.7	49.55–49.65
	1½-inch semi-integrated (rare)	ZS55	55.0	54.90–54.95
	1½-inch semi-integrated	ZS56	56.0	55.90–55.95
Integrated Bearing stop built into frame	1-inch IS (Cane Creek®)	IS38	38.0	38.15–38.25
	1⅛-inch IS (Cane Creek®)	IS41	41.0	41.10–41.20
	1⅛-inch Italian (hiddenset)	IS42	41.8	41.95–42.05
	1¼-inch integrated (lower only)	IS47	47.0	47.05–47.10
	1⅜-inch IS (lower only)	IS49	49.0	49.10–49.20
	1½-inch IS (lower only)	IS52	52.0	52.10–52.15

TABLE D.2 *Steering Column Top Standards*

LEGACY NAME	SHIS NAME	OD (W/ TPI)
1-inch French threaded	25.0 mm x 1.0	25.0 mm x 1.0
1-inch threaded	25.4 mm x 24 tpi	25.4 mm x 24 tpi
1-inch threadless	25.4 mm	25.4 mm
1⅛-inch threaded	28.6 m x 26 tpi	28.6 m x 26 tpi
1⅛-inch threadless	28.6 mm	28.6 mm
1¼-inch threaded	31.8 mm x 26 tpi	31.8 mm x 26 tpi
1¼-inch threadless	31.8 mm	31.8 mm
1½-inch threadless	38.1 mm	38.1 mm

TABLE D.3 *Fork Race Standards*

LEGACY NAME	SHIS NAME	FORK SEAT OD (mm)	CROWN RACE ID (mm)
1-inch JIS	27	27.1	27.0
1-inch Pro or “euro”	26	26.5	26.4
1⅛-inch threaded/threadless	30	30.1	30.0
1¼-inch threaded/threadless	33	33.1	33.0
1⅜-inch integrated race	—	—	—
1½-inch with pressed races	40	40.0	39.9


SADDLE
SEATPOST
REAR DERAILLEUR
REAR SPROCKET
FRONT DERAILLEUR
CHAINRING
CHAIN
SPOKE
TIRE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