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## Suspension System: Wheel Truing & Spoke Tension

### Part One - Planning

#### I. Objectives

- A. Student can identify the difference between a warped rim and a loose hub.
- B. Student can understand the basic concept of truing.
- C. Student can determine when a rim is bent (not fixable) versus having improper spoke tension (fixable).
- D. Student becomes more familiar with the math concepts of perpendicular and parallel.
- E. Student can name the parts of the wheel and the tools involved in the process of wheel truing.
- F. Student gets a background lesson that will assist in future learning about resolving force vectors into X and Y components.

#### II. Materials Needed

##### Demonstration Parts

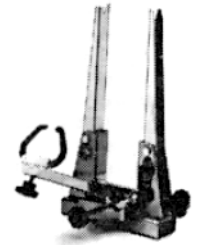
Variety of Wheels in various states of True/Out of True  
Spoke and Nipple, not installed

##### Tools

Truing Stand  
Metric Ruler  
Spoke Wrenches  
Freewheel Removing tools  
Dishing Tool  
Vice Grips  
Bench Vise

##### Other Materials

Grease  
Penetrating Oil  
Rags



Truing Stand

III. Setting Workshop, with tool benches, bike repair stand and bike storage.

#### IV. Evaluation

- A. **Teacher Observation During Work Session** Rotate amongst the students as you work. Observe for general mechanics skills (e.g. body mechanics, tool use), work habits (e.g. keeping part orderly, replacing tools), and ability to follow the steps of the process in the proper order. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help her come up with a solution?
- B. **Oral Review at end of work session.**
  - 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
  - 2) **Systems:** Can the student say what components are part of the system worked on? How do they function as a whole?
  - 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?
- C. **Written Evaluation** How well can student narrate what she did that day on her time sheet?



## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### **II. Process**

**A. Goal** — What are we trying to get done when we true a wheel? What are the necessary steps that must be accomplished with all wheels before we can begin the process of truing?

**B. Steps to Truing Wheels** — Go over the names of each step, as a list. Then describe each step to the students and have them each carry out that step on their bikes before you move the group onto the next step.

**1. Evaluate Condition** of as many parts as possible before disassembly:

- a) Check Adjustment of Your Hubs Before we can begin the process of truing our wheels we must make sure that our hub is properly adjusted. If the hub bearing assembly is loose, the whole wheel (and the rim!) will move back and forth in the truing stand whether or not the rim is true.
- b) Spokes It's no good to attempt to true a wheel with broken spokes. In many cases a broken spoke is the reason why a wheel will go suddenly out of true. Measure the length (in mm) of a spoke on the same side of the rim as the broken spoke. You do this by measuring from the center of the head of the spoke to about the center of the nipple.

It is also important to check the condition of the spokes and the nipples. If these are too rusty there is a good chance that the spokes will not be able to turn inside of the nipple. This will prevent you from truing your wheel. You will recognize this condition if you attempt to turn the nipple and the spoke turns with it. A possible way to remedy this situation is to drip oil in between the nipples and the spokes and let it soak. Come back later and see if things have loosened up any.

- c) Rim Condition Is the rim really rusty? What about bent? Remember, steel rims can be bent back into shape, aluminum rims cannot. Also look for serious divots in the rim. An aluminum rim with a serious divot is ruined. A steel one might be able to bend back into shape. Also, if the wheel wobbles more than 3 inches in either direction there's a good chance that it cannot be fixed.

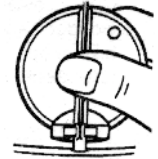
If the spokes look like they are in good condition and the rim doesn't seem to be bent you can begin the process of truing your wheels.

**2. Truing**

- a) Take the Wheel off the Bike
- b) Put the Wheel in the Truing Stand There are a lot of different types of truing stands out there. A lot of at home mechanics use the brake pads on the bike as a truing stand and just true the wheel on the bike. However, if a stand is available, use it! The industry standard is the Park Truing Stand, which we highly recommend. It's durable, very adjustable, and just about everyone uses it, so you can always get parts.



- c) Pick out your Spoke Wrench If you pick the right wrench you won't ruin your wheel. Without the proper spoke wrench size there is a very good chance that you will strip the nipple as you attempt to turn it. Once the nipple is stripped, no more truing. Make sure the spoke wrench fits very tightly around the nipple. If it looks like you might be stripping the nipple (the wrench is turning but the nipple is not), STOP!!!! Change your spoke wrench or see if the nipple is too rusty to move at all.



- d) Begin Truing OK. Now that you've done all the easy stuff, here comes the hard part. Truing wheels has got to be the closest thing to an art form in the arena of bike mechanics. Those that are great at it are revered as gods. Those that are not good at it live life frustrated and angry. (Just kidding.) Seriously though, truing is much more difficult than any other task on a bike. It takes a certain "touch" that only comes with a lot of experience. Beginners will succeed to the extent that they get down the repetitive steps and the concept of making the rim straighter little by little. Here is a starting point and remember: Practice makes Perfect.

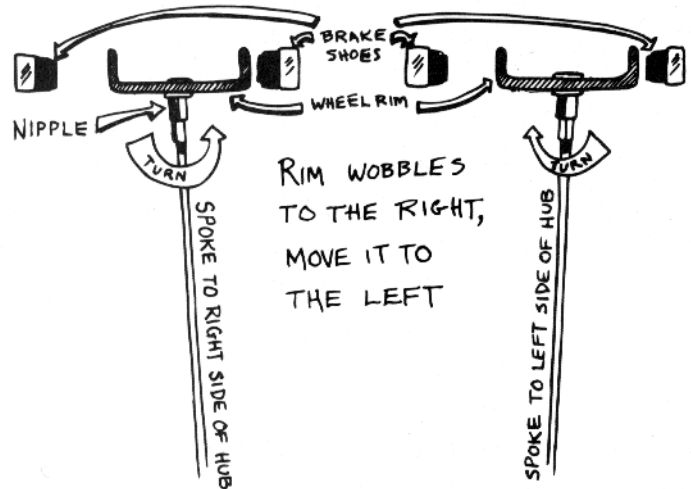
Step 1 Find the Worst Spot: Once your wheel is locked into the stand, spin the wheel lightly and begin to screw in the stand's caliper arms gradually until one of the caliper arms just barely brushes the side of the rim. You will hear a "Ping" whenever that part of the rim passes by the caliper. What you don't want to do is screw in the caliper arms so quickly that they contact the rim so quickly and so hard that you hear "SCREEEEEEEE" and the wheel stops moving. Nor do you want to screw it in so far that the caliper arm touches the wheel more than once per revolution. You are looking for the worst spot (the place the rim is farthest off to one side), not the several worst spots.

Step 2: Identify on Which Side the Rim is Out of Line. Now that you've found the "Ping" you know that this is the spot of the rim that is the farthest out of true. Identify the three or four spokes right next to the "Ping" and which side of the rim is rubbing on the caliper to create the "Ping."

Step 3: Decide Which Spokes to Tighten. You need to pull the rim at the "Ping" spot back in towards the center line of the wheel, in order to start to "flatten out" this bulge/warp in your rim. To move the rim you will tighten some of those 3 or 4 spokes you've picked out. Trace the spokes from the rim back up to where the spoke heads are attached to the hub flange. Notice which of your 3 or 4 spokes are attached to the opposite side of the flange from the side where the "Ping" is rubbing on the stand's caliper arm – these are the ones you want to tighten, since they will pull the rim which bulges a bit in that direction a bit back into line.

d) Begin Truing - continued

Step 4: Tighten the Spokes that coincide with the “Ping” and that are attached to the opposite side of the hub flange than the part of the rim that is warped. Always tighten only 1/4 turn of the spoke wrench at a time. Often you will only have to tighten spokes as you are truing. The only time you want to loosen a lot of spokes much is when the spoke tension is high around the entire wheel. However, if after you tighten the spokes that will pull the “Ping” back into line, twang the 1 or 2 spokes at the “Ping” that are pulling in the other direction. If they seem much tighter than the 1 or 2 spokes you just tightened, loosen these spokes by 1/4 turn also.



Step 5: Go back to Step 1 and find the “Ping” that identifies the spot that is now your worst spot (it may be the same spot, or, if your adjustment at the 1<sup>st</sup> “Ping” brought the rim enough back into alignment, you may now have a new worst spot). Repeat the above steps until you’ve gotten the wheel straight enough so that the rim doesn’t scrape the calipers at all when you have them set about as far from the rim as you would like to have your brake shoes set. Small gradual changes are the secret to getting a strong, straight wheel!

e) Pre-Stress the Wheel Once your rim seems true enough, you need to pre-stress it. As you ride a bike the rolling wheels are under constantly changing stresses. Sometimes as a spoke goes from being under tension to being released from tension as the wheel rotates when you first ride the bike after truing the wheel, spokes or nipples will rotate slightly and settle into a new position. Your wheel might end up out of true again. To avoid this, pre-stress your wheel while you are still in the shop.

Step 1: Take it out of the truing stand and put it on the ground, vertically.

Step 2: Lean all your weight down onto the top of the wheel.

Step 3: Rotate the wheel about 1/8<sup>th</sup> of a turn and lean on it again. Do this all the way around the rim. You will probably here some snapping and popping sounds which are the spokes settling in.

Step 4: Put the wheel back in the stand and check to see if it’s still true. If not, go back to the truing steps.



### 3. Checking and Correcting Dish

All rims must be centered over the center of the axle in your hub in order for the wheel to run centered in the bike frame. A wheel that is centered in this way has the right “dish” to it. A wheel can be true, i.e. no warps from left to right, and still not work because it is not properly dished and therefore won’t sit in the center of the forks or the rear stays. *At Bikes Not Bombs we don’t usually teach dishing unless a student has grasped truing with some ease. If the wheel is so out of dish that the braking or gears systems will be affected, we usually have an instructor fix it after class.*



**Dishing Tools**

- a) Take your dishing tool and place it so that the ends of the arms rest flat on the rim on opposite sides of the wheel. This can only be done with the tire off or fully deflated. Adjust the dial-in arm of the tool until it just barely touches the top of the lock nut on the axle.
- b) Now take the tool off and flip the wheel over. Put the tool back onto the rim. If the dial-in arm does not touch the lock nut on the opposite side of the wheel in exactly the same way, your wheel is not dished properly.

- c) Dishing the Wheel If your wheel is not dished properly you’ll need to tighten and loosen all the spokes in an alternating pattern until the wheel is dished properly.

Step 1: Determine which way you need to pull the rim in order to get the rim centered over the center of the axle. (Think about it for a moment – when the wheel is correctly dished, the dial-in gauge will touch the locknut on the 2<sup>nd</sup> side perfectly once you’ve adjusted it to touch the locknut on the 1<sup>st</sup> side.)

Step 2: Determine which spokes you have to tighten and which to loosen. The spokes to tighten are those that are attached to the hub flange on the side of the wheel towards which you need to move the rim. Going along the rim, you will find that every other spoke needs to be tightened.

Step 3: Adjust 1/2 of the spokes. Starting at the inner-tube valve hole in the rim, take the 1<sup>st</sup> pair of spokes and loosen the one to be loosed 1/4 turn. Then tighten the other one 1/4 turn. Now skip the next two spokes. Take what is now the 3<sup>rd</sup> pair of spokes (or the 5<sup>th</sup> and 6<sup>th</sup> spokes from the hole), and tighten and loosen them each their respective 1/4 turn. Proceed in this manner, skipping every other pair of spokes, until you get all the way back to the rim hole.

Step 4: Adjust the other 1/2 of the spokes: Now skip the first pair of spokes (the 1<sup>st</sup> and 2<sup>nd</sup> spokes, which you already adjusted on the last pass), and go ahead and adjust the second pair (the 3<sup>rd</sup> and 4<sup>th</sup> spokes from the hole). Proceed all the way around again, until you get back to the valve hole. Now, if you kept track(!), you should have tightened, by 1/4 turn, all the spokes that are attached to the hub flange on the side of the wheel towards which you need to move the rim, and loosened, by 1/4 turn, all the others.

Step 5: Check the dish again with the dishing tool. It should have gotten better! If it’s worse, you tightened the wrong side. If it’s still not right, do steps 1-4 again.

Note: Rear wheels with gears don’t have the rim centered over the middle of the hub. They are centered over the axle and have a “flat side of the wheel,” the side the gear cluster is mounted on, where the spokes are all pulled in tighter in order to make room for the gear cluster.

**III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to have the students touch each of these parts on their bikes & say the name.

**Main Part**

Rim  
Spokes  
Nipples  
Hub  
Axle  
Tire  
Tube

**Minor Parts**

Ferrules  
Spoke Head  
rim strip  
Flange  
Drop out

**Necessary Tools**

Truing Stand  
Metric Ruler  
Dishing Tool  
Spoke Wrenches  
Adjustable or Box End Wrenches  
(to remove wheel)

**Other Materials**

Grease  
Light oil  
Rags

**Math Words**

Circumference  
Radius  
Tension  
Torque  
Centrifugal Force  
Triangulate

**Note:** Mention here the other systems you end up dealing with in the course of this lesson (e.g. the brake system), and include the main words to remember.

**IV. System Understanding** Try different ways of phrasing this question.

What components are part of this wheel system? How do they interact/affect each other/work together? How do they function as a whole?

**V. Problem Solving/Diagnosis.**

1. What does it mean if your wheel is out of true?
2. How can you tell if the wheel can be trued or is unfixable?
3. How do you know which spokes to tighten or loosen when truing a wheel?
4. What other problem solving did we do?

**VI. Review****VII. Clean Up**

**VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.