Gain Ratios

A new way to think about bicycle gears

By Sheldon Brown

The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man.

- George Bernard Shaw

There are several systems for measuring bicycle gears, none of which is entirely satisfactory. That's why I'm proposing a new, more accurate and more universal system for measuring gears, which I think we all should adopt. But before I go any further, let's look at the existing measurement systems.

Crank arm length has been ignored in past calculations of gearing. No longer!

Front/Rear

Some cyclists, i.e. racers, make do by simply naming the chainwheel and rear sprocket they are using. This is a bit

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cumbersome, using two numbers where only one is really needed, and can also be confusing. For example, a 39/14 is the same as a 53/19, but you'd never know it using this sys-

tem of gear measurement. Since there are only four chain-wheel sizes in common use on road racing bikes (39, 42, 52 and 53) this is still usable for the cyclist who only deals with this type of machine.

More well-rounded cyclists, who are likely to deal with wider variations in chainwheel and tire size, need a more sophisticated system to realize that the 46/16 on their mountain bike, and the 52/12 on their Moulton and the 52/14 on their Bike Friday are all about the same as the 53/19 and 39/14 on their road racer.

Also, the front/rear system is useless when planetary or hybrid (planetary plus derailleur) gears are involved.

Gear Ratio

This is the ratio of the chainwheel size to the rear sprocket size. The gear ratio of a 39/14 or a 53/19 is 2.79. This is a slight improvement over the front/rear system, because it relies on a single number.

Unfortunately, however, like the front/rear system, the gear ratio system does not take the wheel size into account. This makes it useless for comparing the gears on bikes with different wheel sizes.

Gear Inches

The simplest and most comprehensive system for measuring gears in common use is the "gear inch" system. This system dates back to the days before the invention of the chain-drive bicycle. Originally, it was determined by the diameter of the drive wheel of a high-wheel bicycle. When chain-drive "safety" bikes came in, the same system was used, only modified by multiplying the drive wheel diameter by the sprocket ratio.

It is a very easy number to calculate: (the diameter of the drive wheel) x (the size of the front sprocket) / (the size of the rear sprocket). This formula gives a convenient two- or three-digit number. The lowest gear on most touring bikes is around 22-27 inches. The highest gear on road racing bikes is usually around 108-110 inches. Unfortunately, the handwriting is on the wall for all inch-based measurement systems.

Development in Meters

In "metric" countries, the usual system for measuring gears is "development" in meters. This is the distance that the bicycle moves with each revolution of the pedals. This system is a bit more cumbersome than the gear inch system, for two reasons. First, it is a little more difficult to calculate: (wheel diameter in meters) x (front sprocket) / (rear sprocket) x (pi).

Having to multiply by a constant (an irrational one, no less!) needlessly complicates things. Also, the resulting value is a less convenient number to work with — a single digit plus two decimals. For example a road bike's 52/13 would be expressed as 8.64. A mountain bike's 24/28 would be 1.78.

What About Crank Length?

All of these systems share a common inadequacy, which

is that none of them takes crank length into account. A mountain bike with a 46/16 has the same gear as a road bike with a 53/19 only if they have the same length cranks. If the mountain bike has 175s and the road bike 170s, the gear on the mountain bike is really about three percent lower than the gear on the road bike!

A New Standard: "Gain Ratio"

I would like to propose a new system, called "gain ratio," which does take crank length into account. This system is independent of units, being expressed as a pure ratio, so it doesn't matter whether you calculate it in inches, centimeters, furlongs or nano light-years.

Gain ratio is calculated by first dividing the wheel radius by the crank length. This calculation yields a single radius ratio applicable to all of the gears of a given bike. The individual gear ratios are then calculated the same way gear inches are calculated, only using the radius ratio instead of the wheel size.

To calculate gain ratio, you'll need to know the number of teeth on each of your bicycle's sprockets, front and rear. You'll also need to know the radius of your tire. The actual diameter or radius of the tire is required to calibrate a cycle computer, so you may already have this figured out for your own tires. If not, check my universal Cyclo computer Calibration Chart on the Web at *http://sheldonbrown.com/cyclecom puter_ calibration.html)*

So far, the numbers I've referred to, except for crank length, are needed for any gear numbering systems. The length of your cranks will usually be stamped (in millimeters) in the inside of each crank. The most common sizes are 165 mm (6 1/2"), 170 mm (6 3/4") and 175 mm (7"). So let's calculate some gain ratios!

Consider a road bike with 700 x 30 tires and 170 mm cranks. The diameter of the tires is approximately 680 mm, so the radius would be half that, or 340mm. To figure the radius ratio, divide 340mm by 170mm, yielding the answer of 2.0.

Now, to calculate the gain ratio of the 53/19 gear we multiply the radius ratio by the number of teeth on the chainring, and divide by the number of teeth on the freewheel cog: 2.0 X 53 / 19 = 5.58

This "gain ratio" (my thanks to Osman Isvan for suggesting this term) means that for every inch, or kilometer, or furlong the pedal travels in its orbit around the bottom bracket, the bicycle will travel 5.58 inches, or kilometers, or furlongs. The unit of measurement is irrelevant, because what is actually being measured is the mechanical advantage of the entire drive train.

Let's look at another example of determining the gain ratio, using inches, for a mountain bike with 26-inch wheels (13-inch radius) and 6 3/4" cranks. To figure the radius ratio, divide 13" by 6 3/4", yielding a ratio of 1.93.

Here's the formula for calculating the gain ratio of the 46/16: 1.93 X 46 / 16 = 5.55.

Remember, the radius ratio only has to be figured out once for a given bike, because it is the same in all gears. Then, any individual gear is calculated as: Radius ratio X front(teeth) / rear (teeth).

Any measurement units may be used, as long as the same units are used for both the wheel diameter and crank length.

If you're accustomed to one of the traditional systems, it takes a while to get used to a new one, but I urge you to give it a try. To get you started, my Web site has a page that automatically calculates gain ratios (or gear inches, or meters development) at *http://sheldonbrown.com/gears* ●