Bicycle Gear Shift Patterns

Thomas R. Bross

Topic

Simple machines

Time

1 hour

Safety

Please click on the safety icon to view the safety precautions. Make sure the bicycle is well supported when upside down on the table. Be careful that clothes, hands, fingers, and long hair don't get caught between gears and chain. Bicycle gears are greasy; be sure to wash your hands and clean up the area after the experiment.

Materials

bicycle with 10 or more speeds
pencil or pointer
two bricks or wooden blocks
newspaper
magic marker

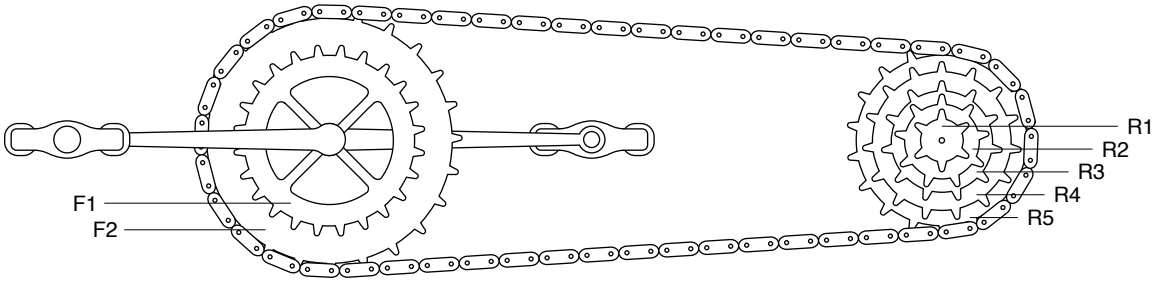
Procedure

Part A

1. Turn the bicycle upside down on the floor or a table. (A table is preferable, but if the experiment is done at home, make sure it's okay with your parents to put a bicycle on the table.) Place the bricks under the handle bars on each side of the stem. Make sure that the bike is secure.
2. Holding the bike so it doesn't fall, turn the pedals with your other hand and observe the rear sprocket. You will notice that both gears move in the same direction. This is because of the addition of the chain into the arrangement. Since you can apply more force pushing down and forward with your feet, the chain is necessary so that both gears run in the same direction. If you were directly connected, you would have to pedal backwards in order to go forwards.
3. Mark a spot on the largest front-gear wheel and one on the smallest rear gear. (Make sure the chain is on this gear combination.) You can also mark a spot directly in line on the wheel itself. Slowly rotate the pedals, and count how many times the rear sprocket rotates by the time the front sprocket has made one rotation. The force applied to cause one rotation in the front causes a larger number of rotations in the rear.
4. Carefully count the teeth on each gear wheel, and enter these values in data table 1 (see the illustration).

DATA TABLE 1							
Sprocket	F1	F2	R1	R2	R3	R4	R5
No. of teeth							

5. The number of teeth on a front gear or input sprocket is designated by "Ni," and the number of teeth on a rear gear or output sprocket is designated by "No." Enter these combinations on line 1 of data table 2. These are the gear ratios. For example, if your front sprocket (F1) has 52 teeth and the first rear sprocket (R1) has 14 teeth, the gear ratio is 14:52. Calculate the gear ratios in decimal notation for each sprocket combination by dividing the No value by the Ni value. Record these results on line 2 of data table 2.



6. Rank the gear ratios from 1 to 10 on line 3 of data table 2, with 1 being the largest value and 10 the smallest value.

DATA TABLE 2										
Combination	R1:F1	R2:F1	R3:F1	R4:F1	R5:F1	R1:F2	R2:F2	R3:F2	R4:F2	R5:F2
No:Ni										
Decimal value										
Shift sequence										

PART B

1. Now that you have ranked the gears (1 through 10), develop hypotheses for the following two questions:

   If the combination of R1:F2 is referred to as a high gear, and the combination R5:F1 is referred to as a low gear:

   A. Which sequence of gears—1 through 10 or 10 through 1—would be the most effective to shift through in order to go from a slow speed to a fast speed while riding on a flat surface?

   B. Which would be best for climbing a hill?

2. Find an area where you can take your bicycle and ride safely. First look for a flat area where you can test hypothesis A. Record your observations.

3. Find a relatively steep hill and try out hypothesis B. Make sure that there is enough of a flat run leading up to the hill so that you can get up some speed. Record your observations.
4. a. What was your hypothesis A?
   b. What data did you base it on?
   c. What were your results when you tested it?
   d. Why?
5. Answer the above questions for hypothesis B.

What's Going On

A correct hypothesis for A is 1 through 10. When you start the bicycle and are going slowly, you want to be in a lower gear because it's easier to pedal. As you speed up, however, you will get to a point where you can't pedal any faster, so you shift to a higher gear. The lower the gear the closer in size the two sprockets are, and the less frequently the rear sprocket rotates relative to the front. If you go back to step 3, Part A, and mark a spot on the largest rear sprocket, you will clearly see that it rotates less frequently than the smallest one did relative to the front sprocket. Fewer rotations mean you go slower.

The easiest way to understand this is as follows: Say you have two gear wheels the same size; when the front wheel rotates once, the back wheel rotates once. Now if you shift the chain to a rear sprocket half the size of the front one, as the front sprocket rotates once the rear sprocket rotates twice. This is how the gearing on a bicycle works. While you pedal at the same rate, the rear wheel moves twice as fast. A correct hypothesis for B is to shift from a high to a low gear. When you go up a hill, you also have to work against gravity. This means you have to apply more force to the pedals to move up the hill. By shifting into a lower gear you can apply less force, although you have to turn the front sprocket more times to cover the same distance.

Connections

Machines allow us to do work more easily by changing the direction or size of the force applied. A bicycle is a machine that uses different combinations of wheels, axles, and levers to make it easier to move an object—your body. When you pedal a bicycle, the force your legs supply to the pedals is transmitted to a gear *wheel* (or *sprocket*). This in turn moves a chain that is connected to a smaller gear wheel. In this experiment, you saw how this arrangement of gear wheels and chain, and the use of a range of gearing, make travel easier.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES