

GYROSCOPE

OBJECTIVE:

You will understand and demonstrate how a gyroscope resists motion and maintains a stable position.

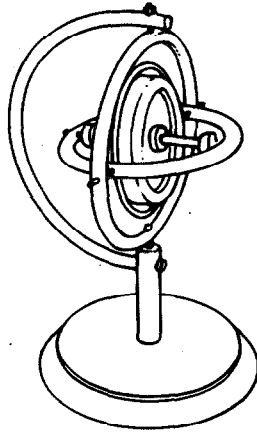
INTRODUCTION:

A gyroscope is a rotating instrument that maintains a stable direction or horizon. It consists of a small, accurately machined flywheel (see 7.11) mounted in encircling rings called gimbals which enable it to rotate on any axis (see figure 1). Because of its momentum, the spinning gyroscope can resist efforts to change its axis of spin. It is used in devices that need to maintain a stable direction while the structures around it are moving and changing position relative to gravity. For example, in navigation a gyroscope provides a stable axis enabling reliable readings to be taken in spite of turbulence from the sea or air.

Because the bearings used in gyroscopes require such accuracy, the development of gyroscopes was not possible until precision engineering had reached high enough standards. By 1816 early forms of the gyroscope were in use, but it was the French physicist Jean Foucault (1819–1868) in 1852 who made systematic studies of the gyroscope and gave it its name. Foucault was using the gyroscope to demonstrate how the earth rotates on its axis. Later, in the early twentieth century, gyroscopes—and devices based on them, such as the gyrocompass—were being used to guide torpedoes.

Today, gyroscopes are used in stabilizers on ships and aircraft and are a vital component in autopilot, navigation, and guidance systems on airplanes and ships.

Figure 1



TIME NEEDED:

45 minutes

MATERIALS:

Note: You will need a partner for this investigation.

bicycle wheel and tire, 12–20 in. in diameter
 2 plastic woodworking file handles (available from an art supply or hardware store).
 2 cardboard disks of the same diameter as the inner diameter of the wheel
 transparent tape

X-acto® knife
 cutting board
 paper
 pencil
 swivel chair

Original Materials:

Nineteenth-century gyroscopes were precision instruments made from brass. It is not possible to construct such a highly engineered device in this setting. Instead, you will investigate how a gyroscope works using everyday materials.

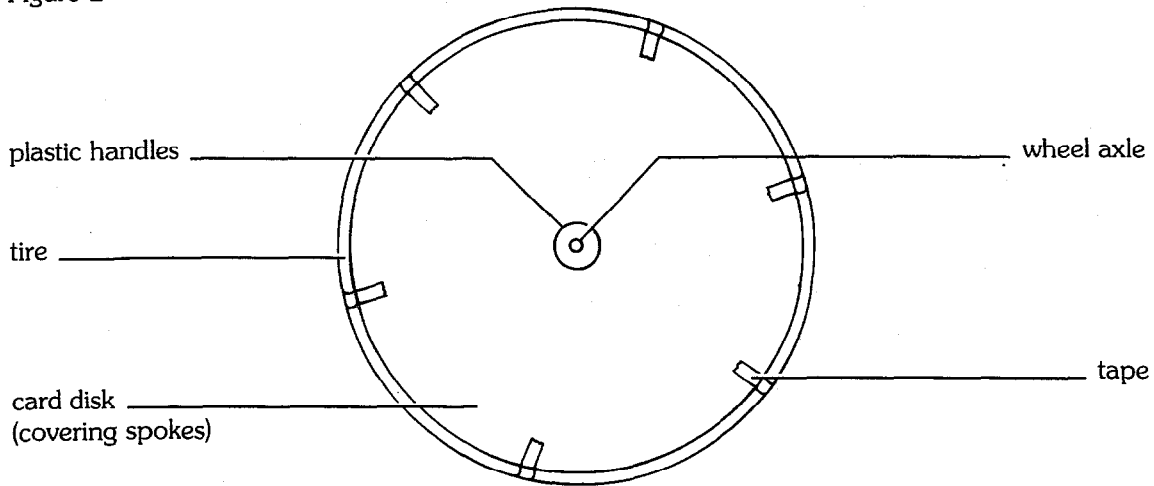
Safety Precautions

Adult supervision required. Please read and copy the safety precautions at the beginning of this book. Be careful not to let the spinning wheel touch any part of your body. Do not attempt to slow the wheel down by touching any of the revolving parts.

PROCEDURE:

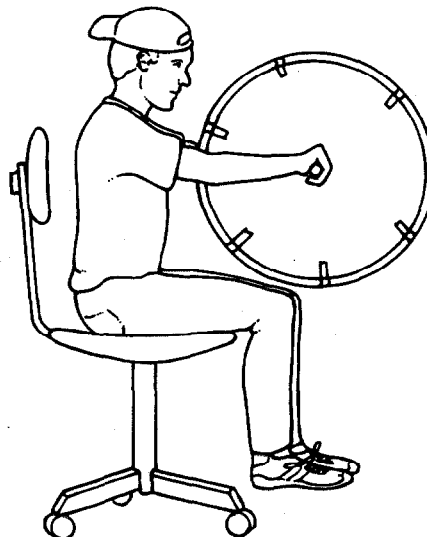
1. Place the plastic handles over both ends of the axle of the bicycle wheel and press them firmly in position.
2. Working on the cutting board, use the X-acto® knife to cut out a small circle (approximately the diameter of the handle-covered axles) in the center of each cardboard disk. Secure the disks to both sides of the wheel with tape so as to completely cover the spokes of the wheel (see figure 2). This is a safety feature to prevent your fingers from coming into contact with the spokes of the revolving wheel.

Figure 2



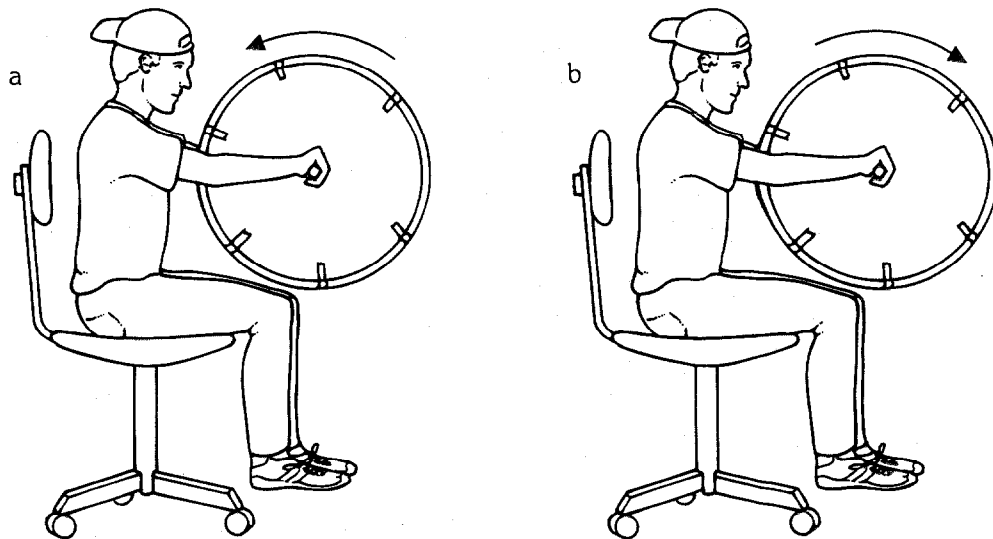
3. Sit in the swivel chair with your feet off the ground and with your arms stretched out in front of you, holding the wheel by the handles (see figure 3). Have your partner record the results of the following investigation by making simple sketches of what he or she observes and noting what you observe.

Figure 3



4. Tilt the wheel to your right about 45° from the vertical. Note how easy or difficult this is to do, and tell your partner. Also note any reaction by the chair.
5. Gradually bring the wheel back to the vertical and note any changes.
6. Now tilt the wheel to your left about 45° from the vertical. Again note how easy or difficult this is to do, and tell your partner. Also note any reaction by the chair.
7. Relax and rest for a moment. Now repeat steps 4–6, but first get your partner to spin the wheel gently at high speed toward you (see figure 4a). Be sure to keep hold of the wheel, and keep it well away from your body. When you have finished and your partner has recorded all observations, gradually allow the wheel to come to a halt.
8. Relax and rest. Repeat steps 4–6 again, but now have your partner spin the wheel gently in the opposite direction, away from you (see figure 4b). When completed, gradually allow the wheel to come to a halt.

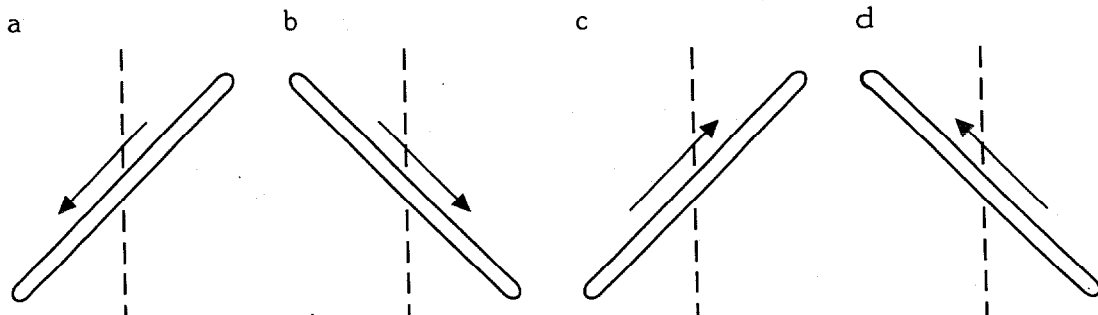
Figure 4



ANALYSIS:

1. In steps 4–6, with the wheel stationary, was there any effect on you or the chair when the wheel was tilted?
2. In the diagrams below, use arrows to show what forces, if any, are generated when the spinning wheel is tilted in step 7 (figures 5a and 5b) and in step 8 (figures 5c and 5d):

Figure 5



3. Do some research. What is precession? Are your results for steps 7 and 8 examples of precession?
4. Do some research. How are gyroscopes used in navigation and stabilization equipment on ships and aircraft?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO INVESTIGATORS

Each invention includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific investigation. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly when you are constructing or demonstrating a model invention. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are carrying out the project, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual projects. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each project you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not 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, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while carrying out these projects. Be sure to check the individual projects in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:

- Clear all surfaces before beginning projects
- Read the instructions before you start
- Know the hazards of the procedures and anticipate dangers

PROTECTING YOURSELF:

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

USING EQUIPMENT WITH CARE:

- Set up apparatus far from the edge of the desk or bench
- Use knives and other sharp or pointed instruments with caution
- Pull plugs, not cords, when removing electrical plugs
- Clean glassware before and after use
- Check glassware for scratches, cracks, and sharp edges
- Clean up broken glassware immediately
- Do not touch metal conductors
- Use only low voltage and current materials such as lantern batteries
- Be careful when using stepstools, chairs, and ladders
- Never look directly at the sun with your observation devices

USING CHEMICALS:

- Never taste or inhale chemicals
- Label all bottles and apparatus containing chemicals
- Read 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 SUBSTANCES:

- Use goggles, apron, and gloves when boiling water
- Keep your face away from test tubes and beakers
- Never leave 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 fire extinguisher on hand

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
- Clean up all residue and put in proper containers for disposal
- Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES