FLYWHEEL

OBJECTIVE:

You will demonstrate how a rotating wheel can be used to store and conserve energy.

INTRODUCTION:

A flywheel is a weighted wheel that acts as an energy-storage device. It stores energy as its speed of rotation increases and gives up energy as its speed decreases. These properties enable it to help regulate the speed of operating parts in machines. For example, when an engine is working under load, an attached flywheel gives up some of its energy to boost the power of the engine, and thus helps reduce any changes in engine speed.

The earliest flywheels were probably made of stone and were used thousands of years ago to make simple drills more efficient. By the early sixteenth century, flywheels were common in milling machines and crank-driven pumps. Today, most motors or engines have a flywheel incorporated in their design. In a modern automobile engine, for example, the flywheel is positioned at one end of the crankshaft. The intermittent power produced by different parts of the engine's stroke cycle is absorbed by the flywheel, which then smoothly passes on power to the transmission system, which drives the wheels.

TIME NEEDED:

1 hour

MATERIALS:

Note: You will need at least two partners for this investigation.

- woodworking vice
- cloth rag, about 12 in. x 12 in.
- small wheel (e.g., tricycle wheel available from a bicycle store)
- 5-ft.-long piece of string
- 4 pieces of modeling clay, each weighing about 100 g
- spring balance measuring up to about 5 kg
- stopwatch
- 6 in. x 1/2 in. piece of medium-weight cardboard
- strong tape (e.g., packing tape)
- 35mm film canister
- small, heavy weight (e.g., 250 g)
- ruler

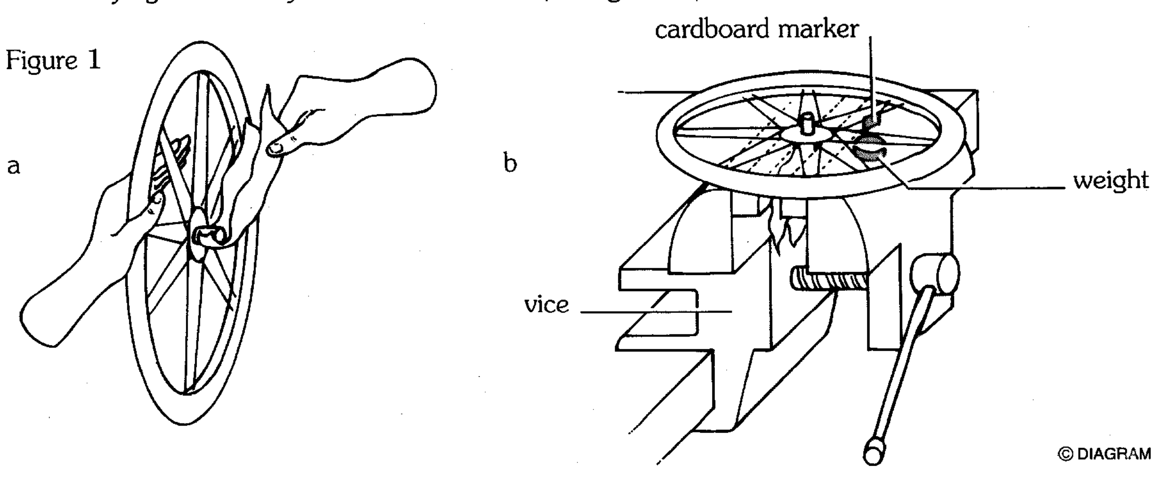
Safety Precautions

Please read and copy the safety precautions at the beginning of this book.

PROCEDURE:

1. Wrap the cloth rag around the axle of the wheel and clamp the axle in the vice, so that the wheel is lying horizontally and is free to rotate (see figure 1a).

Figure 1

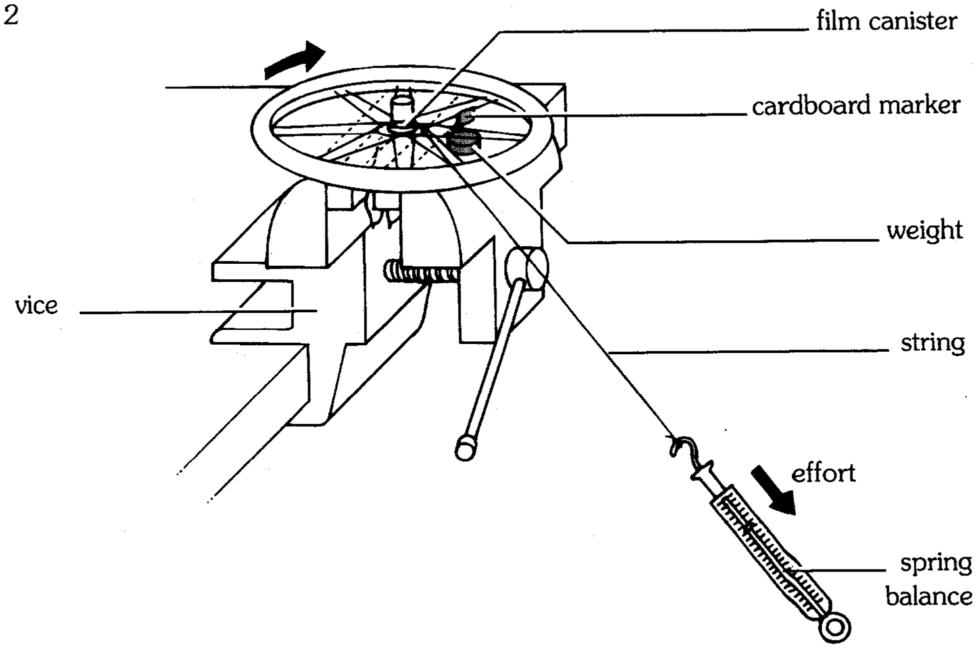


2. Place a small, heavy weight underneath the wheel, positioned away from the axle a distance of about one-third of the radius of the wheel. Use tape to attach the piece of cardboard to one spoke of the wheel, pointing downward, so that for each revolution of the wheel the cardboard clicks against the weight (see figure 1b). This device enables you to count the number of revolutions of the wheel.

3. Place the film canister centrally over the wheel hub, and tape it securely in position.

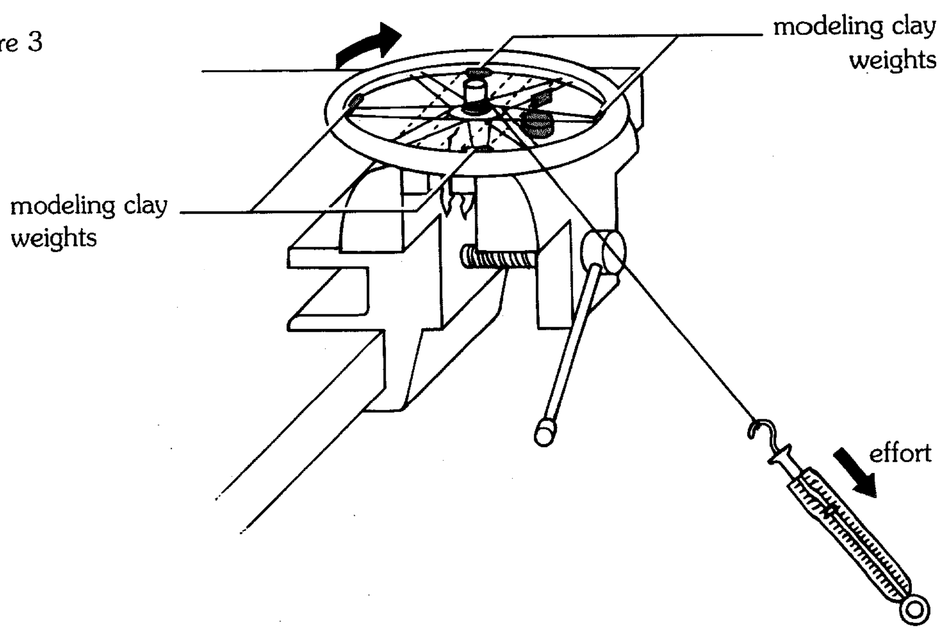
4. Wind 3 ft. of the string around the film canister. Tie the other end of the string to the spring balance (see figure 2).

Figure 2



5. Now, carefully and smoothly walk backward, pulling on the spring balance and turning the wheel as you go. As you do this, have one partner walk alongside you and note the peak reading on the balance. Have the other partner start the stopwatch at the time the string is released from the wheel. He or she then counts the number of rotations of the wheel in the first 15 seconds (determining the speed). This person also records how long it takes for the wheel to slow down and eventually come to a halt. Enter the results in the Data Table.

Figure 3



6. Repeat step 5 two more times, making sure in each case that the starting speed of the wheel is the same. Calculate the average for the three readings.

7. Place the four pieces of modeling clay at equal distances from one another on the edge of the wheel (see figure 3). It is important that the clay is positioned carefully, so that the wheel is balanced. The wheel will now operate essentially as a flywheel, weighted toward the outer edge.

8. Repeat steps 5 and 6, again trying to keep the starting speed the same in each case. Work out an average for the three readings.

DATA TABLE

Peak reading on balance (g or oz.)	Number of rotations in the first 15 seconds (speed)	Time taken for the wheel to come to a halt
Without clay		
1.		
2.		
3.		
Average		
With clay		
1.		
2.		
3.		
Average		

ANALYSIS:

1. What is the effect of adding clay on:
   a) the force needed to bring the wheel to starting speed?
   b) the time taken for the flywheel to slow down and stop?
2. What do your answers to question 1 tell you about:
   a) the energy needed to bring a weighted wheel up to operating speed as compared to using an unweighted wheel?
   b) the energy stored by a rotating weighted wheel as compared to an unweighted one?
3. Do some research. What is inertia? Do wheels of the same diameter and mass have the same inertia?
4. How can the energy-storing capacity of a flywheel be increased?
5. What are the major technical problems to be overcome when designing flywheels with a high energy-storing capacity?

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

Our Findings

VII. POWER

7.11 Flywheel

1. Adding clay to the wheel a) increases the force needed to bring the flywheel up to operating speed and b) increases the time taken for the wheel to slow down and stop.
2. a) The investigation shows that the weighted flywheel requires more energy to reach operating speed than does the unweighted flywheel. b) In addition, the weighted wheel is shown to store more energy—it takes longer to slow down and stop.
3. Inertia is the resistance of an object to any change in its speed. Inertia is related to mass: the greater an object's mass, the greater its inertia. In a rotating wheel, inertia also depends on how the mass is distributed. A wheel has more inertia if its mass is concentrated near the rim (the outer edge) than if it is concentrated around the center. This means that two wheels of the same mass can have different inertia. The one weighted toward the outer edge will have more inertia than the other. This principle is applied in the design of flywheels. As a rule, flywheels are manufactured with a wide diameter and weighted toward their outer edge.
4. The energy-storing capacity of a flywheel can be increased by increasing the speed of rotation and increasing the weight toward the outer edge of the flywheel.
5. Having a fast-rotating, heavy flywheel places enormous stresses on the flywheel itself and on the axle to which it is attached. The flywheel and axle must have high tensile strength, be well lubricated and have low-friction bearings, and be made with high precision to minimize the possibility of imbalances that would impose additional stresses.