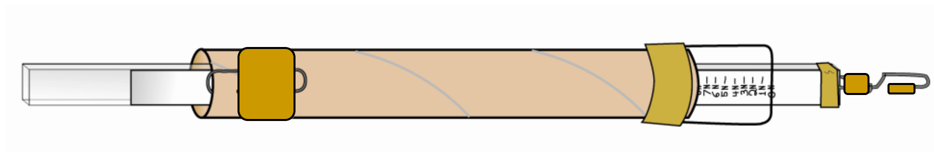
Force Meter

A force can measure a force of course



RAFT IDEAS

Topics: Forces, Gravitation, Vectors

Materials List

- ✓ 3 Paperclips, jumbo
- ✓ Rubber band, long and wide, #64, ¼" x 3½" or similar
- ✓ Cardboard tube about 2.5 x 15 cm (~1" x 6") long
- ✓ Dowel, stick, plastic tube, or similar length of stiff material, narrower than above tube, ~30 cm (~12") long
- ✓ Adhesive labels or paper
- ✓ Drill
- ✓ Cup hook or equal
- ✓ Re-sealable bag
- ✓ Sand
- ✓ Scale that weighs in grams
- ✓ Tape, masking or equal
- ✓ Pencil

This activity can be used to teach:

- Forces & Motion (Next Generation Science Standards: Middle School, Physical Science 2-2; High School, Physical Science 2-1)

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Develop a deeper understanding of forces, mass, weight, gravitation, vectors, and more with an easy to make force meter.

Assembly

1. Slip 2 jumbo paperclips onto a wide rubber band as shown.
2. Use masking tape to securely attach one of the paperclips from step 1 to the center of a dowel or plastic tube. Wrap the masking tape around the paperclip several times. Pull on the rubber band to check that the paperclip is securely fastened. See figure 1.
3. Attach a paper strip or adhesive labels along the entire length of the dowel. Doing the same on both sides will allow two scales to be created (e.g., newtons, grams, ounces). Leave the strip(s) or label(s) blank so calibration marks can be written in later.
4. Slip the dowel into the cardboard tube. Hook the free paperclip to the top edge of the tube and secure by wrapping masking tape around both. See figure 2.
5. Straighten and then bend a jumbo paperclip into a "U" shape with a flat on the bottom, see arrow in figure 2.
6. Position the "U" at the bottom end of the cardboard tube (see figure 2) such that the bottom of the "U" is about 2 cm (3/4") from the end of the tube. See the double headed arrow in figure 3. Tape the ends of the paperclip "U" to the sides of the tube as shown.
7. Attach a hook (e.g., cup hook, "s" hook, or bent paperclip) to the end of the dowel. Drill a hole if needed.
8. If an "S" hook is needed then bend a paperclip to create an "S" shape. Inserted end of the paperclip "S" into the hole made in step 7. Twist and/or tape the inserted end of the "S" hook to secure the hook in place.
9. Wrap tape around any sharp protruding points.

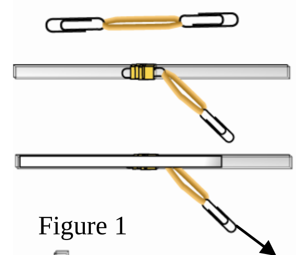


Figure 1

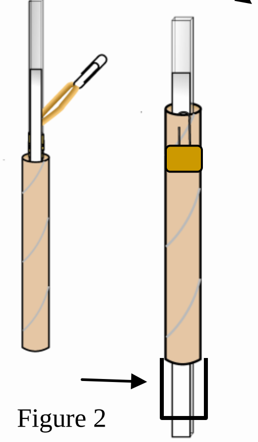


Figure 2

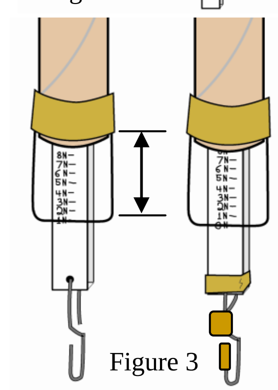


Figure 3

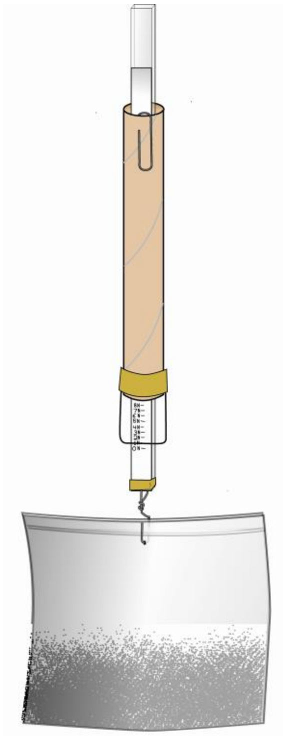
Calibrating the Force Meter

This force meter can be used to measure up to 10 newtons (N) of force, about ~1,000 grams (g) or ~2 pounds (lbs).

1. Hold the cardboard tube vertically. Check that the rubber band is relatively straight and not twisted inside the tube. Tug gently on the hook of the meter and then release to establish a zero setting. Make a horizontal calibration mark on the paper strip at the zero setting and label the setting "0 N" or "0 newton".

Developed by Jay Gluckman (RAFT)

2. Fill 10 re-sealable bags with sand in amounts that are multiples of 102 grams (g) (102g, 204g, 306g, etc) up to 1020 grams. Hang the 102 g bag on the force meter by pushing the hook through the plastic bag (see the illustration to the right). Make a line by the wire "U" and label the line 1N. Repeat for the 204g bag, labeling the line 2N. Repeat for the other bags until the scale measures up to 10 N of force (1020 grams). If the ability to measure other units of force (pounds, ounces) or mass (grams) is desired, create appropriate weight/mass calibration bags of sand and use to add additional calibration marks to the label on the other side of the dowel.
3. Note the calibration of the meter should be check every few weeks and after the meter has been used to measure large forces. Replace the rubber band if it is over stretched or breaks, then recalibrate the meter before using it to measure forces.



To Do and Notice

There are numerous uses for a force meter. Some possibilities include:

- Measuring the gravitational force on different small objects.
- Measuring the force necessary to drag a small object up an inclined plane.
- Using a catapult and a force meter to gather data on the distance traveled by a projectile vs. the force applied to the catapult's throwing arm (See the RAFT Idea Sheet ***Catapults***) (Use a safe projectile such as a cotton ball, foam dowel, or pom-pom.)
- Using a force meter to measure the force on a mousetrap spring. See the RAFT Idea Sheet ***Mousetraps in Motion***.

The Science Behind the Activity

Measurement is basic to the scientific process. When a **force** acts upon an object, the force might cause the object to be pushed, pulled, accelerated, rotated, or deformed. Many types of forces exist including: spring, chemical, magnetic, gravitational, tension, and friction forces. In physics, a force has both a size (**magnitude**) and a **direction**; the combination is expressed as a force **vector**. One common unit for measuring force is the **newton (N)**, named after Sir Isaac Newton. On the surface of the Earth, the force of Earth's gravity will pull on 101.972 grams (0.224809 lbs) with a force of 1 N. **Unbalanced forces** cause a change in motion. **Balanced forces** do not cause a change in motion. When a bag of sand is attached to a force meter and the bag stops moving, the forces involved are said to be balanced. In this activity the downward force of gravity upon the bag of sand is balanced by the upward elastic force of the rubber band.

In 1678, **Robert Hooke** showed that the distance a spring will stretch is proportional to the amount of force applied to the spring (Hooke's Law). For this reason, springs are frequently used in force meters. Rubber bands will approximately follow Hooke's Law for relatively small amounts of force. The rubber band does not follow Hook's Law exactly due to the rubber band's variable elasticity, which changes with use. A rubber band based force meter is still suitable for simple force explorations, but not where more accurate or consistent measurements are needed.

It is easy to confuse the terms force, mass, and weight. A bathroom scale and many other types of scales are force meters. The term **mass** refers to the amount of matter contained within an object, a number that would be the same anywhere in the universe. **Weight** is a measure of the force of gravity pulling on an object and will vary with location (Earth vs. moon, for example). The weight of an object is proportional to the mass of the object. The measurement of the gravitational force upon an object will provide an indirect measurement of an object's mass.

Web Resources (Visit www.raft.net/raft-idea?isid=534 for more resources!)

- Difference between mass and weight - http://www.physlink.com/Education/AskExperts/ae321.cfm