

Building a Force Meter

On SCIENTIFIC AMERICAN FRONTIERS, high school students measure the G-forces they experience while riding a roller

coaster. The device they use is a simple force meter they built themselves. In this activity, you will build your own force meter to measure the G-forces you feel during a ride on a roller coaster, swing or even a trip in an elevator.

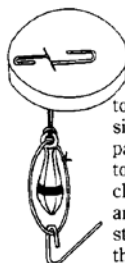
PROCEDURE



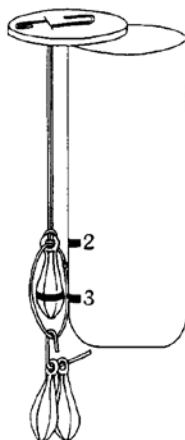
Step 1. Make a thick line across the widest part of one sinker. Push a rubber band through the eye of the sinker and loop one end of the rubber band through the other and pull tight.



Step 2. Unbend a paper clip to create a U. Hold the free end of the rubber band behind the U. Loop the other end with the sinker around the paper clip and through the top loop and pull it tight.



Step 3. Poke the ends of the U through the can lid so that the weight will hang close to but not touching one side of the can. Push the paper clip flush against the top; bend the ends of the clip back across the top and tape down. Slide the string through the eye of the sinker and tie the ends together. Connect the small paper clip to the string loop.



Step 4. Hang 2 more sinkers on the small clip. Hold the lid against the edge of the can with the weights hanging outside. Mark a heavy line where the permanent sinker hangs against the can as "3 G." Remove one extra sinker and mark the "2 G" level. Remove everything but the permanent sinker.

Step 5. Insert the suspended sinker into the can and tape the lid on securely. Mark the level of the sinker as "1 G" or normal. (Note: the marks are not evenly spaced because rubber bands are not linear. Double the force does not give double the stretch.)



Materials:

- clear tennis ball container
- (2) #1 (small) paper clips
- (3) 2-oz. fishing sinkers with eye holes
- several #18 rubber bands
- indelible marker
- 8" piece of string

Step 6. Estimate the 0 G or "weightless" position. Turn the can on its side; jiggle the rubber band so it is in a resting, unextended position and mark "0 G" on the can. Tape a 3-rubber band chain onto the meter as a wrist strap. (It will hold the meter on an exciting ride but will break in an emergency.) Hold the meter inside the roller coaster car. Remember, always follow the rules on amusement park rides.

Calculations

Calculate the force you experience on a roller coaster ride by multiplying your body weight by the number of Gs noted on the force meter. At what point in the ride do you feel the heaviest? The lightest? When and why do you feel weightless?

Measuring G Forces on a Swing

You can also use your force meter to measure G-forces on a swing. When you are sitting still on a swing, it pushes up against your body with a force equal to your weight, and the rubber band pulls up with a force equal to the weight of the sinker. As the swing moves along its curved path, centripetal force pulls you in toward the center of the curve. Once the swing is moving, you and the sinker need additional centripetal force to pull you in toward the center of the curve. The faster the swing goes through its bottom curve, the more extra force is needed and the heavier you feel.

1. Hold the force meter along the chain of the swing and describe what happens to the meter as the swing goes all the way forward and back again. Where are the forces largest? You may need a

partner to push you to keep the amplitude (size) of the swing's motion constant.

2. Repeat your readings with the swing going much higher. What happens to your speed? What happens to the forces registered?

3. Concentrate on your seat while you are watching the meter. Do you actually feel heavier and lighter when the meter indicates you should?

4. Compare your readings with your classmates, using the same swing going to the same height. Be sure the meter is at the same spot on the swing chain. Does body weight make a difference?