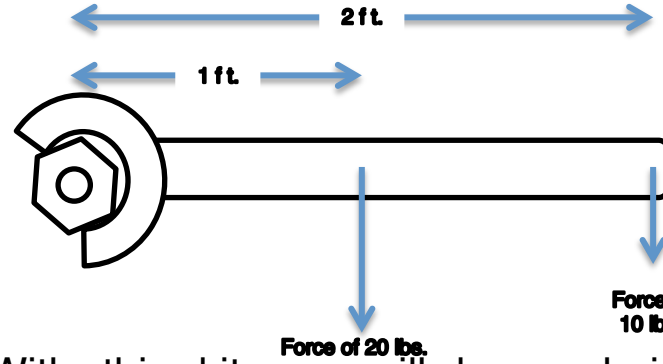
GARAGE PHYSICS

by eisco

Torque Feeler Kit

GP00002

Torque is a quantity that measures how well a force can cause rotation. A good example of how torque is applied would be using a wrench to loosen or tighten a bolt. The longer the wrench handle is, the less force is necessary for the same torque.



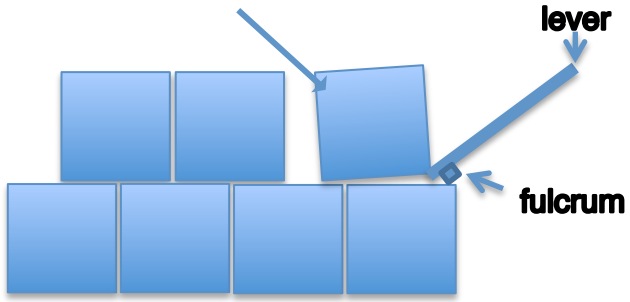
With this kit, we will be exploring torque by sliding a hanging mass across a dowel rod while trying to balance a marble on the end of the dowel rod.

Next Generation Science Standards (NGSS):

PS2 Motion and Stability: Forces and Interactions

The Lever:

Ancient Egyptians would use long poles to lift and position the giant stone blocks used to build the pyramids. These long poles used torque to create a mechanical advantage in which a relatively small force applied at a large distance from the fulcrum (or rotational point) could create a large lifting force close to the fulcrum.



The Greek Philosopher, Archimedes, was considered the first person to grasp this concept in describing simple machines like the lever. One of Archimedes most famous quotes is, “Give me a lever long enough and a fulcrum on which to place it, and I shall move the world.”

To try: Close an open door by pushing directly on it’s handle. Was it easy or hard? How can you make the door close faster? Now try to close the open door by pushing directly in the middle of the door. Was it easier than using the handle? Why or why not? Lastly try to close an open door by pushing directly on the door as close to the hinges as possible. Do you notice a difference in how much force you need to apply as you move away from the door handle and closer to the hinges? Can you use the relationship of torque to force and distance to explain these differences that you observe?

To try: Balance a yard stick on your pointer finger. Where is your finger located on the yard stick when you balance it? Place a roll of tape at the five inch mark on the yard stick and balance it again. What changes?

Construction:

To assemble the Torque Feeler, you will need a Phillips head screwdriver and a small adjustable wrench.

Insert the flat side of the long pole into the opening in the short pole. Align so you can insert the bolt through the opening. Thread one of the nuts onto the bolt and tighten fully with a screwdriver and wrench.

On the opposite end of the long pole (with the rounded end), slide on the washer, then insert the remaining bolt into the hole and secure with the second nut.

Torque:

Torque (τ) is determined by the magnitude of the force (F) multiplied by length at which the force acts on the lever arm (L).

$$\tau = F \times L$$

The **x** above signifies a special type of vector multiplication called the cross product. Here though, since the direction of the dowel is horizontal and the direction of gravity pulling on the mass is straight down, the cross product reduces to the straightforward multiplication, $\tau = F \ L$, where the force is the amount of mass hanging, m, multiplied by the acceleration due to gravity, g, thus $\tau = mgL$.

The torque created by the hanging mass must be counterbalanced by an opposite torque in your hands to keep the dowel level.

Feeling the Torque:

Move the washer close to the cross dowel rod that you grip with your hands. Hang a 1000 gram mass from the hole in the washer.

Set the bolt nut on the opposite end of the dowel rod to a position in which it is just barely screwed on to the bolt. While holding the dowel rod horizontal, place a marble in the hole of the bolt and try to hold it steady so that the marble does not fall out.

Have someone else slide the 1000 gram mass away from the cross dowel grip. As it becomes more difficult to hold the long dowel level, you are experiencing greater and greater torque. How far can you slide the mass before the marble falls? Can you hang the mass next to the marble and hold the dowel horizontal for 10 seconds without dropping the marble?

Torque in the Garage:

In a car, torque is what allows a car to accelerate quickly.

For cars, torque is measured in foot pounds, so if an engine is rated for 300 foot pounds of torque, that is equivalent to 300 pounds of force applied to the end of a one foot long wrench.

How can one make a car accelerate faster for the same amount of torque? The acceleration can be increased for a car by using tires with a smaller diameter, or by decreasing the weight of the car.