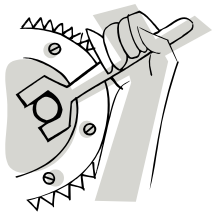
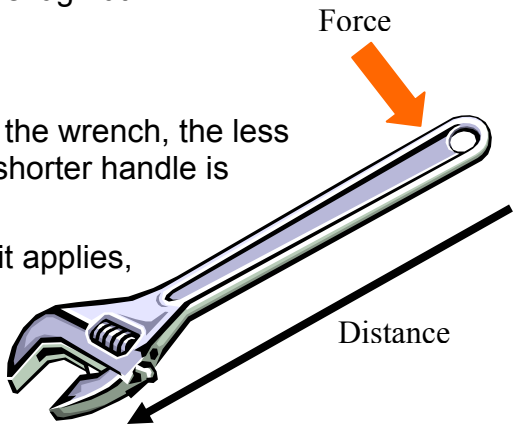


Torque

What is Torque?

Torque (pronounced "tork") **is a force that you use to rotate or turn things**. You generate torque any time you apply a force using a wrench. Tightening the lug nuts on the wheels of your car is a good example of torque. When you use a wrench, you apply a turning force to the handle. This torque turns the lug nut.



What two things help make this easier?

The wrench acts like a **lever**. The longer the handle on the wrench, the less pushing you have to do to turn the nut. . A wrench with a shorter handle is harder to turn.

Said another way, the **longer the handle**, the **more force** it applies, and the easier it is to turn the nut

So, in order to figure out how to make things turn easier **you need to know:**

1 - the **distance from the end to the center of the thing you are trying to turn**, and

2 –**how much force** you need to push on the handle in order to make it turn.

Why do you need to know this?

Cars are heavy. You need to make sure the motor and gear ratios produce enough torque (**rotational force**) to move them.
Robots can be heavy, too. You need to make sure the motor and the gear ratio produces enough torque to move them. And motors are rated in torque!

If you make a mistake figuring out the torque, it is easier to make changes on little robots that you snap together than big robots that you have to weld together.

What is the equation to use to find torque?

Torque = (distance) x (force)
Or
T = df

For small motors the **distance is measured** in inches and the **force is measured** in ounces.

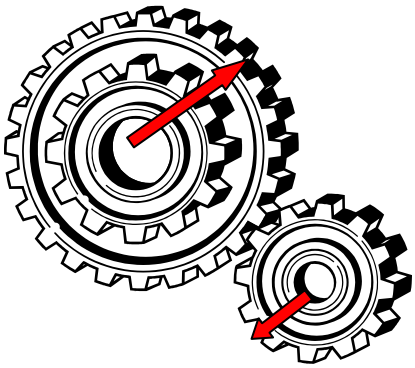
For large motors the **distance is measured** in feet and the **force is measured** in pounds.

So… the rotational force is measured in **inches per ounce** (in-oz) or **feet per pound** (ft-lbs).

Where is the torque on your robot?

The motor on your robot uses torque to turn the wheels.
The driver gear uses torque to turn the follower gear.

Student Activity:



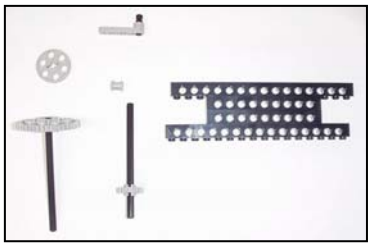
Gather Data:

If the **distance from the center to the end** of the thing being used to turn something is important,

then which one of these gears will produce the most torque (rotational force).

Build it:

Build a set of gears as shown below using a 16 tooth and 40 tooth gear.



1. Put each gear on an axle. Make sure the smaller gear is on the axle as shown. Put four support beams together

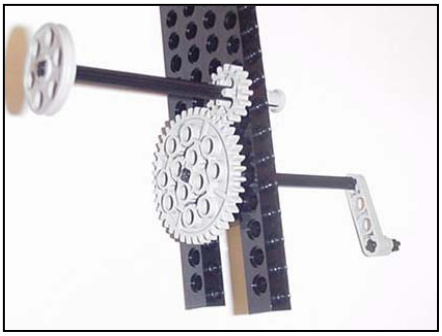
2.
3.

2. Attach the gears to the beams as shown.
3. Use the L-bracket and 2-bump axle to make a handle.

4. Use the holes in the pulley to help you count the rotations.

Investigate Basics:

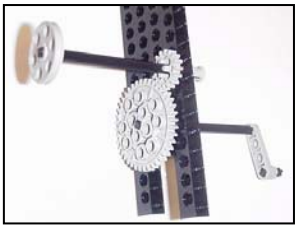
1. Be very careful. Use the handle to turn the axle with the large gear slowly. Then, move the handle and use it to turn the small gear slowly.



1. Which gear is easier to turn?
2. Which gear will require more force to turn?
3. Which gear should produce the most torque?
4. When you turn the large gear, is the final output of speed on the small gear faster or slower?
5. When you turn the small gear, is the final output of speed on the large gear faster or slower?

Power and Torque

Gear Size	16 tooth	40 tooth
Distance in cm from Center of Gear to End of Teeth		
Amount of Force Needed to Turn the Gears **(More or Less)**		
Amount of Torque Produced **(More or Less)**		
Final Output of Speed Produced **(More or Less)**		



Gear Speed:

1. What is the distance from the center of the driver gear to the teeth?
2. Does the follower gear turn faster or slower than the primary gear?
3. For every turn of the driver gear, how many rotations does the follower gear make?

Concept Questions:

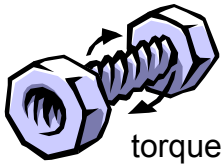
1. Which took more force to turn, the large gear or the small gear?
2. Try stopping it with your hand.
3. Which took more force (torque)?
4. Which ratio gives more power? More speed?

Extension:

1. Add more gears and repeat the investigation with three gears.
2. Try it with a different gear combination.
3. Make a chart of different gears and gear ratios. Indicate which gear ratios would be useful for heavy loads, going over rough terrain, or going fast.

Gear Ratios

# Teeth Driver Gear	# Teeth Follower Gear	Gear Ratio	Best Use



A car engine creates torque, and uses it to spin the crankshaft. This torque is created exactly the same way; a force is applied to a rod which spins the shaft.

Wind creates torque which makes things spin