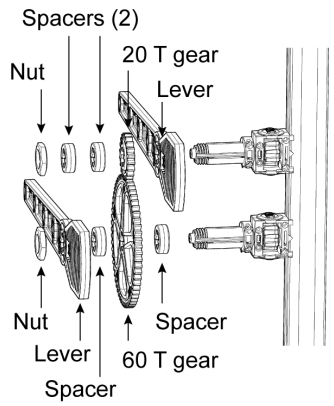
Investigation 12G: Mechanical Advantage of Gears

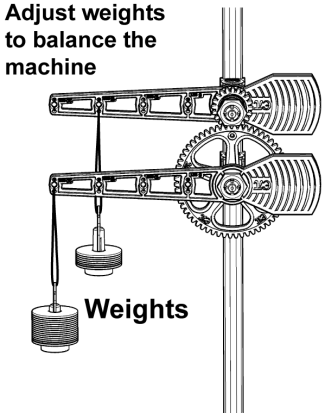
Essential question: What is a transmission?
How does a transmission work?

A transmission is a rotating machine that changes speed and torque. Transmissions are found in many machines including cars, clocks, bicycles, washing machines, and even fishing rods! The input of a transmission is where force is applied through motors or muscles. The output of the transmission does the useful work of the machine. In a car or bicycle transmission the output is connected to wheels which apply the output torque to the ground.

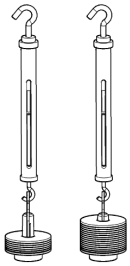
Build your machine



Balance your machine



Measure forces and distances



Measure and record both weights and distances.

1. Use two gears to construct a transmission with a gear ratio of 1:3. Use levers and weights to demonstrate that the mechanical advantage is 3:1.
2. Calculate the input and output torque in N-m.

Use the gear pulleys and weights to demonstrate that your transmission meets the design requirement by having 3 weights lift a load of 18 weights.

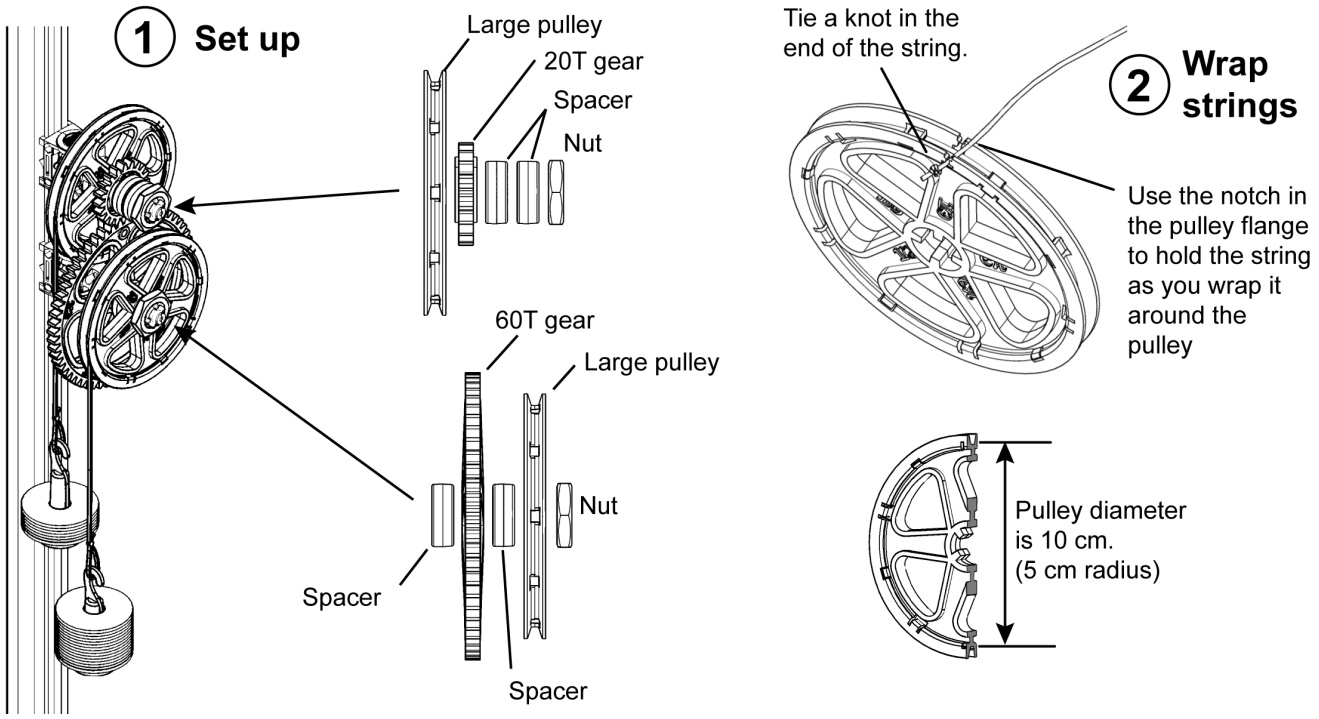
	Force (N)	Distance (m)	Torque (N-m)	Gear ratio
Input				
Output				

Questions for part 1:

1. What is the ideal mechanical advantage of your transmission?
2. What is the measured real mechanical advantage?

Part 2: Building a winch

The levers are fine for demonstrating the mechanical advantage but levers cannot move a load very far. A **winch** is a gear-driven device that combines pulleys and gears to create mechanical advantage. Winches are often operated with a hand crank. For our experiment we will use one falling weight as the input force to lift a second falling weight. This will allow us to measure the input and output work more easily.



1. Use two gears and two of the larger pulleys to construct a winch with a gear ratio of 1:3.
2. Wrap string around both pulleys and adjust the length of the string so that dropping the lighter weight to the table a distance, d_1, lifts the heavier weight a distance, d_2.
3. Weigh the input and output masses and calculate the input and output work done in joules. (one joule is 1 N × 1 m).
4. Use your *force* data to calculate the real mechanical advantage. Use your *work* data to calculate the efficiency of the machine. Efficiency is defined as the ratio of work output divided by work input. <u>Adjust your weights to get the highest efficiency you can.</u>

	Force (N)	**Distance (m)**	**Work (J)**
d_1			
d_2			
Real mechanical advantage $MA = \frac{F_2}{F_1}$			
Efficiency $\text{efficiency} = \frac{\text{work output}}{\text{work input}}$