LAB 2 Laboratory Activity

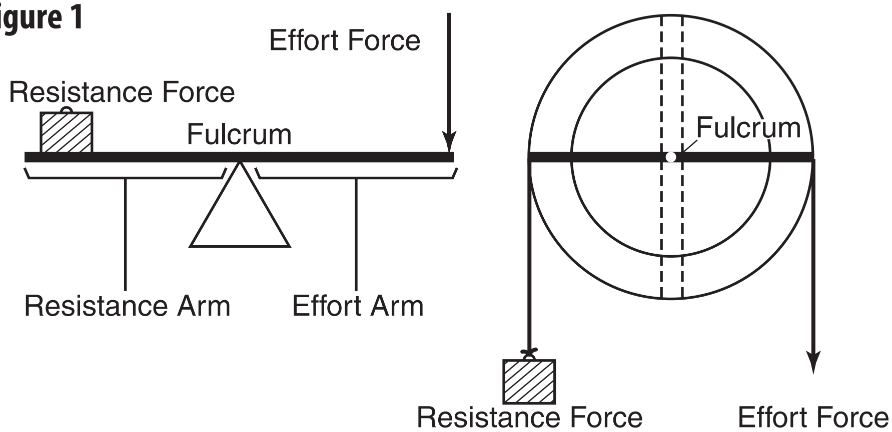
# Pulleys



If you have ever raised or lowered a flag or slatted blinds, you used a simple machine called a pulley. As you recall, simple machines can change direction of a force and multiply either the size of the effort force or the distance that the resistance force moves.

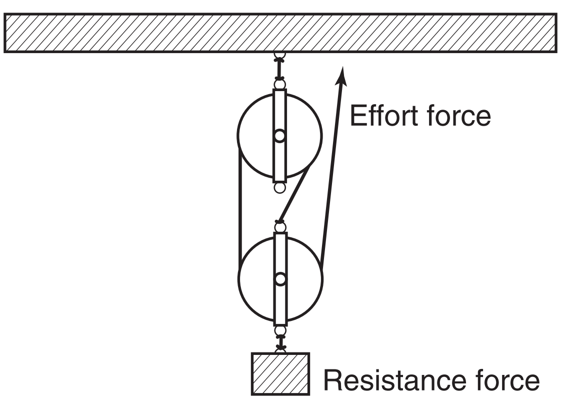
A single fixed pulley is a pulley that can't move up and down. As you can see in Figure 1, a fixed pulley is actually a lever in the form of a circle. Can you locate the effort arm and the resistance arm in a single fixed pulley?

**Figure 1**




A series of pulleys is called a block and tackle. You may have seen a block and tackle in an auto repair shop. It sometimes is used to lift car engines. Look at the block and tackle shown in Figure 2. Can you locate a single fixed pulley in the block and tackle?

**Figure 2**




## Strategy

You will perform work using a single fixed pulley.

You will construct a block and tackle and per form work with it.

You will compare the properties of a single fixed pulley and a block and tackle.

## Materials

utility clamp
ring stand
plastic-coated wire ties, 10 cm and 30 cm long
2 pulleys
meterstick
1-m length of cotton string
masking tape
metric spring scale
0.5-kg and 1-kg standard masses

Laboratory Activity 2 (continued)

## Procedure

### Part A—Single Fixed Pulley

1. Attach the utility clamp to the top of a ring stand. Use the short plastic-coated wire tie to attach one of the pulleys to the utility clamp. Attach a meterstick to the ring stand with tape. See Figure 3.
2. Tie a small loop at each end of the 1-m length of string. Thread the string over the pulley.
3. Tightly wrap the second plastic-coated wire tie around the 0.5 kg mass. Attach the mass to the hook of the spring scale with the wire tie. Measure the weight of the 0.5 kg mass. Record this value as the resistance force in Table 1.
4. Remove the mass from the spring scale. Use the wire tie to attach the mass to one loop of the pulley string. Attach the hook of the spring scale to the loop at the opposite end of the string.
5. Slowly pull straight down on the spring scale to raise the mass. Measure the force needed to raise the mass 15 cm. Record this value as the effort force in Table 1.
6. Lower the mass to the table top. As you again pull down on the spring scale, measure the distance the spring scale moves as you raise the mass a distance of 15 cm. Record this value as the effort distance in Table 1.
7. Remove the 0.5 kg mass and the spring scale from the string.
8. Repeat steps 4–7 for the 1 kg mass and the combined 0.5 kg and the 1 kg masses.

### Part B—Block and Tackle

1. Attach a second pulley to one of the loops of the pulley string. Thread the loop at the opposite end of the pulley string under the second pulley as shown in Figure 4.
2. Adjust the height of the utility clamp so the pulley can move upward at least 25 cm from the table top.

**Figure 3**

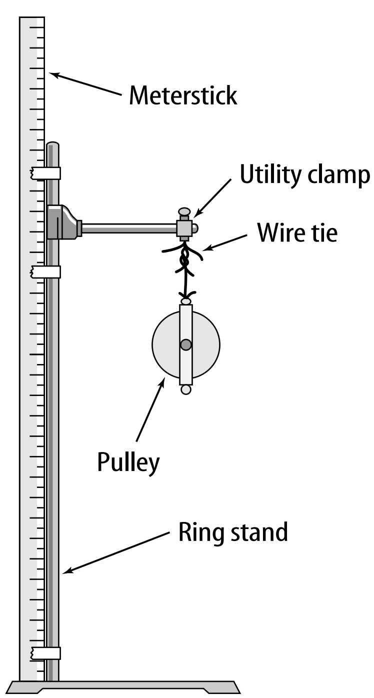
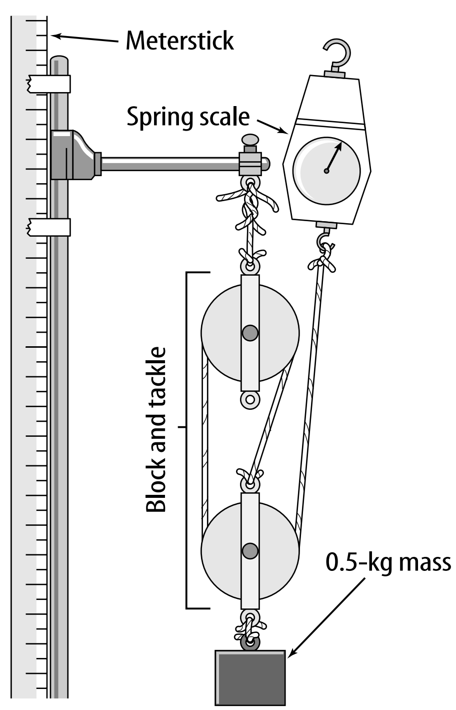



**Figure 4**



## Laboratory Activity 2 (continued)



3. Wrap the plastic wire tie securely around the 0.5 kg mass. Use the spring scale to measure its weight. Record this value as the resistance force in Table 2. Attach the mass to the second pulley.
4. Attach the spring scale to the loop on the free end of the string.
5. Slowly pull straight up on the spring scale to raise the mass as shown in Figure 4. Measure the force needed to raise the mass 15 cm. Record this value as the effort distance in Table 2.
6. Lower the mass to the table top. As you again pull up on the spring scale, measure the distance the spring scale moves as you raise the mass a distance of 15 cm. Record this value as the effort distance in Table 2.
7. Remove the 0.5 kg mass from the pulley and the spring scale from the string.
8. Repeat steps 4–7 for the 1 kg mass and the combined 0.5 kg and 1 kg masses.

## Data and Observations

1. Use Graph 1 to construct a bar graph comparing the effort force of the single fixed pulley, the effort force of the block and tackle, and the resistance force for each of the three masses. Plot the value of the masses on the *x* axis and the force on the *y* axis. Label the *x* axis *Mass (kg)* and the *y* axis *Force (N)*. Clearly label the bars that represent the values of the effort force of the single fixed pulley, the effort force of the block and tackle, and the resistance force.
2. Use Graph 2 to construct a bar graph comparing the effort distance of the single fixed pulley, the effort distance of the block and tackle, and the resistance distance for each of the three masses. Plot the value of the masses on the *x* axis and the distance on the *y* axis. Label the *x* axis *Mass (kg)* and the *y* axis *Distance (cm)*. Clearly label the bars that represent the values of the effort distance of the single fixed pulley, the effort distance of the block and tackle, and the resistance distance.
3. Work input is the work done by you. Work input can be calculated using the following equation.

   *Work input = Effort force × Effort distance*

   If the force is measured in newtons (N) and the distance is measured in meters (m), work will be expressed in joules (J). Calculate the work input for the pulley and the block and tackle for each mass. Record the values in Table 3.
4. Work output is the work done by the machine. Work output can be calculated using the following equation.

   *Work output = Resistance force × Resistance distance*

   If the force is measured in newtons (N) and the distance is measured in meters (m), work will be expressed in joules (J). Calculate the work output for the pulley and the block and tackle for each mass. Record the values in Table 3.
5. The efficiency of a machine is a measure of how the work output of a machine compares with the work input. The efficiency of a machine can be calculated using the following equation.

   *Efficiency = Work output/Work input × 100%*

   Use this equation to calculate the efficiency of the single fixed pulley and the efficiency of the block and tackle in raising each mass. Record these values in Table 4.

## Laboratory Activity 2 (continued)

**Table 1**

| Mass (kg) | Resistance force (N) | Effort force (N) | Resistance distance (cm) | Effort distance (cm) |
|---|---|---|---|---|
| 0.5 | | | 15.0 | |
| 1.0 | | | 15.0 | |
| 1.5 | | | 15.0 | |

**Table 2**

| Mass (kg) | Resistance force (N) | Effort force (N) | Resistance distance (cm) | Effort distance (cm) |
|---|---|---|---|---|
| 0.5 | | | 15.0 | |
| 1.0 | | | 15.0 | |
| 1.5 | | | 15.0 | |

**Table 3**

| Mass (kg) | Single fixed pulley | | Block and tackle | |
|---|---|---|---|---|
| | Work input (J) | Work output (J) | Work input (J) | Work output (J) |
| 0.5 | | | | |
| 1.0 | | | | |
| 1.5 | | | | |

**Table 4**

| Mass (kg) | Efficiency (%) | |
|---|---|---|
| | Single fixed pulley | Block and tackle |
| 0.5 | | |
| 1.0 | | |
| 1.5 | | |

## Laboratory Activity 2 (continued)

### Graph 1

### Graph 2

## Laboratory Activity 2 (continued)

### Questions and Conclusions

1. The effort distance is very much greater than the resistance distance in which machines(s)?

2. The effort force is very much less than the resistance force in which machine(s)?

3. In which machine(s) is the work output greater than the work input?

4. Explain how using a single fixed pulley to raise a flag makes the task easier.

5. Explain how using a block and tackle to lift a car engine makes the task easier.

6. Compare the efficiencies of the single fixed pulley and the block and tackle. Why would you expect the block and tackle to be less efficient than the single fixed pulley?

### Strategy Check

_______ Can you perform work with a single fixed pulley and with a block and tackle?

_______ Can you explain the differences between a single fixed pulley and a block and tackle?