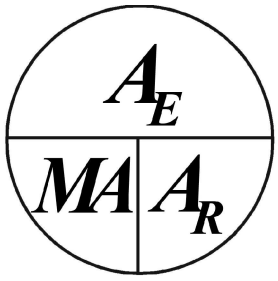
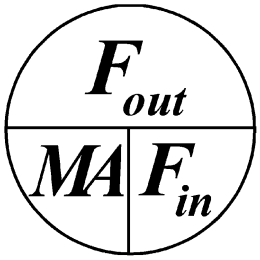
Levers

A lever is a rod that rotates about a point or fulcrum. There are three types of levers based on the relative placement of the fulcrum, the resistance force, and the effort force. A first class lever such as a crow bar or see saw has a fulcrum between the effort and the resistance. A second class lever such as a wheel barrow or bottle opener has the resistance between the effort and the fulcrum. A third class lever such as a fly swatter or baseball bat has the effort between the resistance and the fulcrum. The region between the fulcrum and the resistance is the **resistance arm** (A_R). The region between the fulcrum and the effort is the **effort arm** (A_E). The product of either the effort force or the resistance force is the **moment** ($M = F \times A$). For a balanced lever, the moments on both sides of the fulcrum are equal. The mechanical advantage of a lever is the ratio of the effort arm to the resistance arm.

$$IMA = \frac{A_E}{A_R}$$





Sample Problems

A meterstick is balanced at the center. If 1.0 N weight is hanging at the 10 cm mark, and a 3.0 N weight is hanging at the 20 cm mark, where does a 5.0 N weight need to be placed?

$$M_1 + M_2 = M_3$$
$$F_1A_1 + F_2A_2 = F_3A_3$$
$$(1.0N)(40cm) + (3.0N)(30cm) = (5.0N)A_3$$
$$40Ncm + 90Ncm = (5.0N)A_3$$
$$130Ncm = (5.0N)A_3$$
$$\frac{130Ncm}{5.0N} = A_3 = 26cm$$

A 3.0 m long wheel barrow has 500 N load 0.6 m from the wheel. Ignoring the weight of the wheel barrow, how much force is needed to lift the end so it can be rolled?

$$IMA = \frac{A_E}{A_R}$$
$$IMA = \frac{3.0m}{0.6m} = 5$$
$$F_{in} = \frac{F_{out}}{MA}$$
$$F_{in} = \frac{500N}{5} = 100N$$

Based on the examples above, solve the problems below. Show your work. Use the proper units in your answers.

1. An 800 N man sits 0.8 m from the center of a seesaw. Where does his 600 N son have to sit in order to balance?

CONTINUED ON THE NEXT PAGE ☞

2. A slugger swings an 86 cm long bat with a force of 500 N. If the batter's hand presses the bat 6.6 cm from one end of the bat, and the ball hits 20 cm from the other end of the bat, what force is imparted to the ball? (*HINT:* If the ball hits 20 cm from the end of an 86 cm bat, how far is it from the player's hands?)

3. In order to move a large rock, a man needs to press down with a force of 400 N on a 1.22 m long crow bar with a bend 2 cm (0.02 m) from the end. How heavy is the rock? (*HINT:* If the bend is 0.02 m from the end of a 1.22 m crow bar, how long is the other lever arm?)

4. A man rolls a large 500 N rock onto the center of a 1.5 m long plank. How much force would be needed to lift one end of the plank and dump the rock at the bottom?

5. A student places four identical weights at different locations on a meter stick as follows: one at 20 cm, one at 40 cm, one at 65 cm, and one at 75 cm. Will the meterstick balance at its center?