Name: ____________________ Date: __________ Skill and Practice

7C Mechanical Advantage

Read:

Mechanical advantage (MA) is the ratio of output force to input force for a machine.

$$MA = \frac{F_o}{F_i}$$

or

$$\text{MA} = \frac{\text{output force (N)}}{\text{input force (N)}}$$

Did you notice that the force unit involved in the calculation, the newton (N) is present in both the numerator and the denominator of the fraction? These units cancel each other, leaving the value for mechanical advantage unitless.

$$\frac{\text{newtons}}{\text{newtons}} = \frac{\text{N}}{\text{N}} = 1$$

Mechanical advantage tells you how many times a machine multiplies the force put into it. Some machines provide us with more output force than we applied to the machine—this means MA is greater than one. Some machines produce an output force smaller than our effort force, and MA is less than one. We choose the type of machine that will give us the appropriate MA for the work that needs to be performed.

Example:

Example 1: A force of 200 newtons is applied to a machine in order to lift a 1,000-newton load. What is the mechanical advantage of the machine?

$$\text{MA} = \frac{\text{output force}}{\text{input force}} = \frac{1000\ \text{N}}{200\ \text{N}} = 5$$

Machines make work easier. Work is force times distance ($W = F \times d$). The unit for work is the newton-meter. Using the work equation, as shown in example 2 below, can help calculate the mechanical advantage.

Example 2: A force of 30 newtons is applied to a machine through a distance of 0.60 meters. The machine is designed to lift an object to a height of 2 meters. If the total work output for the machine is 18 newton-meters (N-m), what is the mechanical advantage of the machine?

input force = 30 N   output force = (work ÷ distance) = (18 N-m ÷ 2 m) = 9 N

$$\text{MA} = \frac{\text{output force}}{\text{input force}} = \frac{9\ \text{N}}{30\ \text{N}} = 0.3$$

Skill and Practice

Practice:

1. A machine uses an input force of 200 newtons to produce an output force of 800 newtons. What is the mechanical advantage of this machine?

2. Another machine uses an input force of 200 newtons to produce an output force of 80 newtons. What is the mechanical advantage of this machine?

3. A machine is required to produce an output force of 600 newtons. If the machine has a mechanical advantage of 6, what input force must be applied to the machine?

4. A machine with a mechanical advantage of 10 is used to produce an output force of 250 newtons. What input force is applied to this machine?

5. A machine with a mechanical advantage of 2.5 requires an input force of 120 newtons. What output force is produced by this machine?

6. An input force of 35 newtons is applied to a machine with a mechanical advantage of 0.75. What is the size of the load this machine could lift (how large is the output force)?

7. A machine is designed to lift an object with a weight of 12 newtons. If the input force for the machine is set at 4 newtons, what is the mechanical advantage of the machine?

8. An input force of 50 newtons is applied through a distance of 9 meters to a machine with a mechanical advantage of 3. If the work output for the machine is 450 newton · meters and this work is applied through a distance of 3 meters, what is the output force of the machine?

9. 200 newton·meters of work is put into a machine over a distance of 20 meters. The machine does 150 newton·meters of work as it lifts a load 10 meters high. What is the mechanical advantage of the machine?

10. A machine has a mechanical advantage of 5. If 300 newtons of input force is used to produce 3,000 newton·meters of work,

    a. What is the output force?

    b. What is the distance over which the work is applied?