Work: a force acting through a distance

Work = Force X Distance

W = F d

The units of force are **Newtons** and the units of distance are **meters**

The answer is in **Newton-Meters**. These units are referred to as **Joules**

Work Problems

1. A force of 800 Newtons is needed to push a car across a lot. Two students push the car 40 meters. How much work is done?
2. How much work is done in lifting a 60Kg crate a vertical distance of 10 meters?
3. A 1000 N mountain climber scales a 100 m cliff. How much work is done?
4. You are using 50 N of force to push an empty cart down the school hall. Your friend, who weighs 800 N, jumps on the cart and wants to be taken for a ride. You push your friend down the hall for 20 meters before being caught by the Principal. How much work did you do pushing your friend on the cart?

Power: the rate at which work is done

Power = Work / Time
or
Power = Force X Distance / Time

P = F d / t

In this equation, the units of work are **Joules** and the units of time are **seconds**

The answer is in **Joules per second**. These units are referred to as **Watts**

Power Problems

1. A machine produces 4000 Joules of work in 5 seconds. How much power does the machine produce?
2. A box that weighs 1000 Newtons is lifted a distance of 20 meters in 10 seconds. How many kilowatts of power are produced?

Machines make work easier by changing the size or direction of a force.

2 forces are **always** involved when using a machine

1. **Resistance Force - F_R** -the force applied **by** a machine
2. **Effort Force - F_E** - the force applied **to** a machine

Work is done **to** a machine as well as **by** a machine

1. **Work Output - W_O** - the work done **by** a machine
2. **Work Input - W_I** - the work done **on** a machine

When using a machine, distances are not the same

1. **Effort Distance - d_E** - the distance through which the machine moves
2. **Resistance Distance - d_R** - the distance the object moves

Mechanical Advantage: the number of times a machine multiplies the effort force.

Mechanical Advantage = Resistance Force / Effort Force

$$\mathbf{MA = F_R / F_E}$$

MA is equal to 1 - the machine is used to change the direction of the effort force.

MA is less than 1 - the machine is used to increase the distance an object moves or the speed at which it moves.

MA is greater than 1 - the machine is used to increase the effort force.

Efficiency: a comparison of work output to work input

Efficiency is always expressed as a **percentage**
Work output is **never** greater than work input.

Efficiency = Work Output / Work Input X 100

Efficiency = W_O / W_I X 100

Mechanical Efficiency Problems

1. What does friction do to the efficiency of a machine?
2. You use a pair of pliers to crack a pecan. It takes 1200 N of resistance force to crack the pecan, but you only exert 400 N of effort force with your hand on the pliers. What is the mechanical advantage of the pliers?
3. Think of pliers as a pair of **first-class levers**. The fulcrum about which the levers turn is located at point B. The lever arm represented by the line AB is 6 cm long. The lever arm represented by line BC is 3 cm long. What is the mechanical advantage of this set of pliers?

- adapted from www.middleschoolscience.com