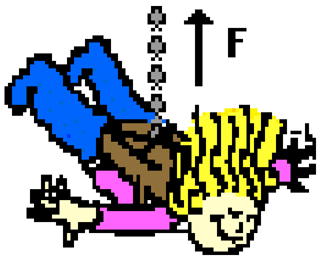
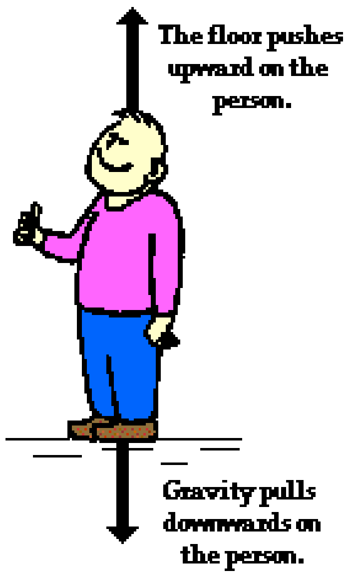
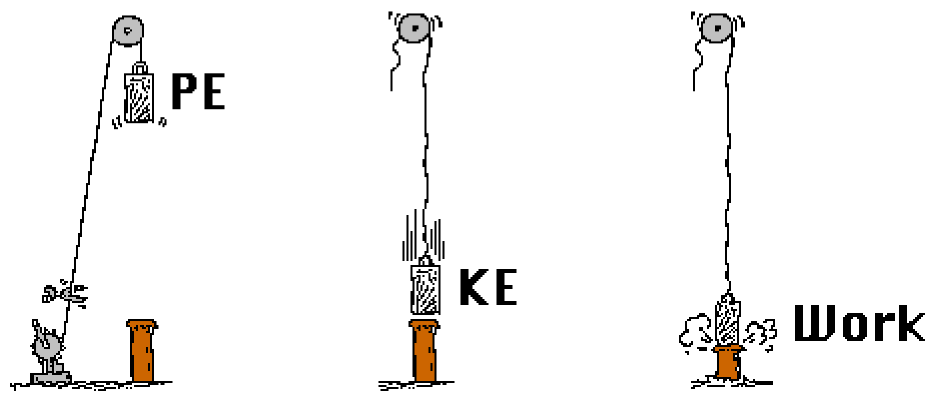
Force and Work

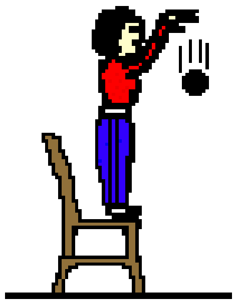
A. Force
B. Work

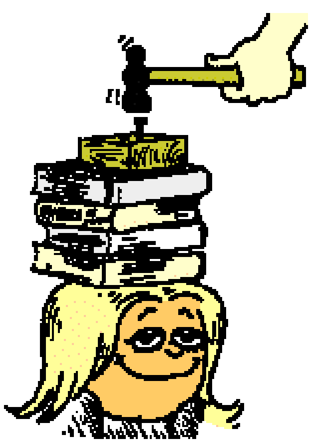


The forces on the person are balanced.



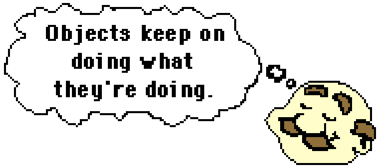






The ram of a pile-driver possesses mechanical energy – the ability to do work. When held at a height, it possesses mechanical energy in the form of potential energy. As it falls it possesses mechanical energy in the form of kinetic energy. As it strikes the spike, it applies a force to displace the spike – i.e., it does work on the spike.

A. Force



- Whenever an object accelerates there has to have been a force applied to the object that changed its velocity
- The only way in which an object speeds up or slows down is if there is a push or pull. The amount that the object accelerates depends upon two things; its mass and the force applied to the object.
- What would happen if the same object is pushed with two different forces?
- Example: Suppose that you push a stopped tennis ball with a little push and then with a big push. Which time will the ball have a greater acceleration?
- We can say that there is a direct relationship between force and acceleration, the greater the force, the greater the acceleration

- What would happen if the same force (amount of push) were applied to two objects having different masses?
- Example: Suppose that you push a bowling ball and a tennis ball with the same force. Which object would have a greater acceleration?
- We can see that there is an inverse relationship between the mass and acceleration. The greater the mass is for a certain force, the smaller will be its acceleration
- Formula $F_{net} = ma$

  where F_{net} => force (N, Newtons) $1 \text{ Newton} = 1 \text{ kg} * \frac{m}{s^2}$

  m => mass (kg)

  a => acceleration (m/s^2)
- The unit of force, Newton, was named after the physicist Sir Isaac Newton.

Weight

- A measure of the force of gravity acting on an object.

- The direction of the force (weight) acts in the same direction as the acceleration ($\vec{g}$), downwards towards the centre of the earth.

- Newton's second law is sometimes written as:

$$\vec{F}g = m\vec{g}$$

Where:

$\vec{F}_g$ = weight (N)

m = mass (kg)

$\vec{g} = -9.81\ m/s^2$

Example 1: A person pushes a 10 kg box and a 1.50 m/s^2 acceleration is noticed. What was the net force that was applied to the box?

Example 2: A 2000 kg car is decelerating at a rate of 2.3 m/s^2. What net force was required in order to slow the car down?

Example 3: What is the mass of a rock that hits the ground with a force of 150N?

(NOTE: the acceleration due to gravity- g – is equal to 9.81 m/s^2)

Example 4: A small airplane with a mass of 1600kg touches down on a runway with a speed of 25m/s. It slows to a stop in 18s. Calculate the force required to stop the airplane (hint- you have to use 2 different formulas)

B. Work and Energy

- Work is defined as a measure of the amount of energy transferred from one object to another
- In order to do work a force must be applied over a certain distance.
- In order for work to take place, the following conditions must be fulfilled:
  i. There must be movement
  ii. A force is applied to the object
  iii. The force and the distance the object travels must be in the same direction (If the F_{app} and displacement are perpendicular, then the work is equal to zero)
- Example: moving a suitcase – Is work being done?



The relationship between work and energy:

- Energy is defined as the ability to do work.
- If an object has energy, it can do work by transferring the energy to another object (as one object loses energy, the other gains the same amount of energy)
- Therefore the change in energy = work, and therefore the units for energy is also Joules (J)

Calculating work:

- The formula for calculating work is:

Work = Force X distance

$W = F \cdot d$

= Newton metres ($N \cdot m$)   Note: $N = kg \cdot m/s^2$

= Joules (J)

Therefore, $1\ J = 1\ kg \cdot m^2/s^2$

Examples:

1. Jonny pushes a box with a force of 200 N for a distance of 15.0 m. How much work did he do?

2. A log is pulled and 150 J of work is done as it moves 20.0 cm. What was the applied force?

3. A truck with a mass of 11 700 kg is traveling at 41 m/s. Suddenly, the driver slams on the brakes. The truck takes 5.00 s and 52 m to stop. Calculate the work done on the truck by the brakes (hint: you have to use 2 different formulas!)