**WORK, POWER AND ENERGY**

**WORK**

*Work* is a measure of the amount of change (in a general sense) that a force produces when it acts on a body. The change may be in the velocity of the body, in its position, or in its size or shape.

By definition, the *work done by a force acting on a body is equal to the product of the force and the distance through which the force acts*, provided **that *F* and *s* are in the same direction**. Thus

***W* = *Fs***

**Work = force x distance**

Work is a scalar quantity; no direction is associated with it. If **F** and **s** are not parallel but **F** is at the angle θwith respect to **s**, then

***W* = *Fs* cosθ**

Since cos00= 1, this formula becomes *W* = *Fs* when **F** is parallel to **s**.

When **F** is perpendicular to **s**, θ = 90o and cos 90o = 0. No work is done in this case.

The unit of work is the product of a force unit and a length unit. In SI units, the unit of work is the *joule* (J).

1 joule (J) = 1 Newton-meter = 0.738 ft•lb

**Example:** A horizontal force of 420 N is used to push a 100-kg crate for 5 m across a level warehouse floor. How much work is done?

**POWER**

*Power is the rate at which work is done by a force.* Thus

**P =**

**Power =**

The more power something has, the more work it can perform in a given time.

Two special units of power are in wide use, the *watt* and the *horsepower*, where

1 watt (W) = 1 J/s = 1.34 x 10-3hp

1 horsepower (hp) = 550 ft.lb/s = 746 W

When a constant force **F** does work on a body that is moving at the constant velocity **v**, if **F** is parallel to **v**, the power involved is

**P = = = Fv**

because *s*/*t* = *v*; that is

**P=Fv**

**Power = force x velocity**

**Example:** A 40-kg woman runs up a staircase 4 m high in 5 s. Find her minimum power output.

**ENERGY**

*Energy* is that property something has that enables it to do work. It is given to an object when a force does work on the object. *The amount of energy transferred to the object equals the work done.* The more energy something has, the more work it can perform. Two general categories of energy are kinetic energy and potential energy.

**Note!**

The units of energy are the same as those of work, namely the joule and the foot-pound.

**Kinetic Energy (K)**

The energy a body has by virtue of its motion is called *kinetic energy*.

If the body’s mass is *m* and its velocity is *v*, its kinetic energy is

**Kinetic energy = K = ½mv2**

**Work = ΔK = KE– KE = ½mv22 - ½mv12**

**Example:** Find the kinetic energy of a 1000-kg car whose velocity is 20 m/s.

**Potential Energy (U)**

The energy a body has by virtue of its position is called *potential energy*.

The *gravitational potential energy* of a body of mass *m* at a height *h* above a given reference level is:

**Gravitational potential energy = U = *mgh***

**Work done by gravity = -ΔU**

**\*Work done by external force = ΔU**

where *g* is the acceleration due to gravity.

**Example:** A 1.5-kg book is held 60 cm above a desk whose top is 70 cm above the floor. Find the potential energy of the book (*a*) with respect to the desk, and (*b*) with respect to the floor.

**Mechanical Energy (E)**

The *mechanical energy (E)* of an object is the sum of its kinetic energy and potential energy.

**E = K + U**

**Conservation of Energy**

According to the law of *conservation of energy*, energy cannot be created or destroyed, although it can be transformed from one kind to another.

The total amount of energy in the universe is constant. A falling stone provides a simple example: More and more of its initial potential energy turns to kinetic energy as its velocity increases, until finally all its kinetic energy has become potential energy when it strikes the ground. The kinetic energy of the stone is then transferred to the ground as work by the impact.

In general,

Work done (by nonconservative forces) *on* an object = change in object’s KE + change in object’s PE

**WNC = ΔK+ΔU**

If there’s **NO NONCONSERVATIVE FORCE**, then:

**0=ΔK+ΔU (conservative forces only)**

**ΔK = -ΔU**

**(Kinetic Energy gained = Potential Energy lost)**

**-ΔK = ΔU**

**(Kinetic Energy lost = Potential Energy gained)**

**K2+U2=K1+U1**

Additional Problems:

1. In figure below, assume that the object is being pulled along the ground by a 75-N force directed 28o above the horizontal. How much work does the force do in pulling the object 8.0 m?
2. A 0.50 kg block slides across a tabletop with an initial velocity of 20 cm/s and comes to rest in a distance of 70 cm. Find the average friction force that retarded its motion.
3. A projectile is shot upward from the earth with a speed of 20 m/s. How high is it when its speed is 8.0 m/s? Ignore air friction.
4. Just before striking the ground, a 2.0 kg mass has 400 J of Kinetic Energy. If friction can be ignored, from what height was it dropped?
5. A 10N-block moves up a 30o incline under the action of certain forces, three of which are shown in the figure below. F1 is horizontal and of magnitude 40N. F2 is normal to the plane and of magnitude 20 N. F3 is parallel to the plane and of magnitude 30N. (a) Determine the work done by forces F1, F2, and F3 as the block moves 80 cm up the incline. (b) What is the work done by the normal force and gravitational force on the block? (c) What is net work done on the block?
6. How large a force is required to accelerate a 1300-kg car from rest to a speed of 20 m/s in a distance of 80 m?