# 5

# WORK, ENERGY, AND POWER

## WORK

(*College Physics* 9th ed. pages 124–129/10th ed. pages 127–132)

The term *work* is restricted in physics to cases in which there is a force and a displacement along the line of the force. When a force $F$ moves a body through a displacement $s$ and the directions of these two vectors are not the same, the work $W$ is defined as

$$W = Fs\cos\theta$$

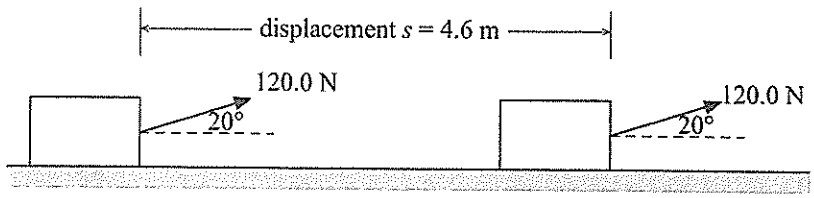
where $\theta$ is the angle between the direction of the force and that of the displacement. In the special case where the force has the same direction as the displacement, $\cos 0° = 1$, the work done is simply $W = Fs$. Even though work is the product of two vector quantities, it itself is a scalar quantity. When two vector quantities are multiplied to produce a scalar quantity the operation is called *scalar multiplication* of two vectors. The magnitude of a scalar multiplication always involves a cosine function. The unit of work in the SI is the newton-meter that is called the *joule*, J.

$$1\ \mathrm{J} = 1\ \mathrm{N \cdot m} = 1\ \frac{\mathrm{kg \cdot m^2}}{\mathrm{s^2}}$$

This unit is named for the British physicist James Prescott Joule (1818–1889) whose experimental investigations greatly contributed to the acceptance of the relationship between heat and work.

### Sample Problem 1

A wooden box is pulled at constant speed across a horizontal floor by a rope that makes an angle of 20° with the floor. The tension in the rope is 120.0 N. Ignoring friction, what work is done displacing the box 4.6 m horizontally?




### Solution to Problem 1

The force vector makes an angle of 20° with respect to the displacement; therefore the work done is

$$W = Fs\cos\theta = (120.0\text{ N})(4.6\text{ m})(\cos 20°) = \mathbf{518.7\ J}.$$

**AP Tip**

The work done on a body is always done by some agent.

### Sample Problem 2

A 600.0 N force is developed in the braking system of a car to bring it to rest over a horizontal distance of 80.0 m. What work is done by the braking system?

### Solution to Problem 2

The force developed by the brakes acts in the exact opposite direction to the displacement making $\theta = 180°$ and the $\cos 180° = -1$. Notice that the brake system is the *agent* doing the work on the car. The work done will be negative.

$$\begin{aligned} W &= Fs\cos\theta \\ &= (600.0\text{ N})(80.0\text{ m})(\cos 180°) \\ &= (600.0\text{ N})(80.0\text{ m})(-1) \\ &= \mathbf{-48.0\ kJ} \end{aligned}$$

## The Electron Volt

(*College Physics* 9th ed. page 559/10th ed. pages 569–570)

There is another unit of work we need to introduce. It is a unit used in addressing certain work and energy relationships in atomic, molecular, and nuclear physics. This unit is called the *electron volt*, eV, and we define it as

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

The electron volt is a tiny unit but quite important in dealing with the work involved in moving electron and protons through electrical and magnetic fields.

### Sample Problem 3

A minimum of 13.6 eV of work is required to remove an electron from a hydrogen atom. What is this amount of work expressed in joules?

### Solution to Problem 3

We will use the value $1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$ as a conversion factor.

$13.6 \text{ eV} \times \frac{1.602 \times 10^{-19} \text{ J}}{1 \text{ eV}} = \mathbf{2.18 \times 10^{-18} \text{ J}}$ is required to separate an electron from a hydrogen atom. Note that in the division, eV divides out leaving J as the unit of work.

### Sample Problem 4

In a battery that is in operation, the chemical agents of the battery do an average of $2.4 \times 10^{-19} \text{ J}$ of work transporting an electron to the negative terminal. In eV, how much work is this?

### Solution to Problem 4

As in the previous sample problem treat $1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$ as a conversion factor. $2.4 \times 10^{-19} \text{ J} \times \frac{1 \text{ eV}}{1.602 \times 10^{-19} \text{ J}} = \mathbf{1.5 \text{ eV}}$. As we will see later in the course, volts in a roundabout way are related to work in batteries and electrical fields.

## Kinetic Energy

(*College Physics* 9th ed. pages 129–132/10th ed. pages 132–135)

In physics we say that anything that has *energy* has the capacity to do work. Energy, $E$, exists in many forms and can be transformed from one form to another. At present we are making a study of a branch of physics we call *mechanics*, and for now, our primary interest is *mechanical energy*. When we consider energy in our study of mechanics we primarily make reference to three forms:

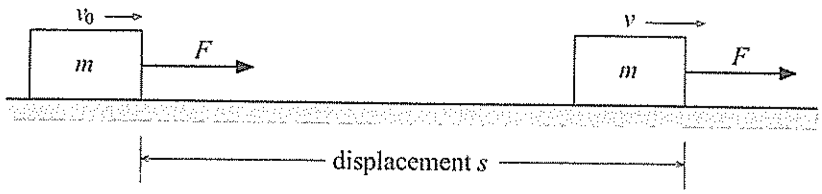
1. Kinetic energy, $K$
2. Potential energy, $U$
3. Total mechanical energy, $E = K + U$

As we saw at an earlier point in our study of physics, the expression *kinetic* makes reference to motion. All moving bodies have *kinetic energy*. Bodies that are at rest do not have kinetic energy. To give a body motion requires an unbalanced force and that force causes an acceleration. Consider the following diagram where a body of mass $m$ is acted upon by a force $F$ that results in a horizontal displacement $s$. The work done is defined as $W = Fs\cos\theta$. Note that in the diagram both the force vector and the displacement vector are parallel. This means that the angle between $F$ and $s$ is 0° and the cosine of 0°, $\cos 0° = 1$, is 1. Then $W = Fs\cos\theta$ takes the form $W = Fs$.

This is *always* the case when $F$ and $s$ have the same direction.

**AP Tip**

When the force and displacement vectors are parallel, the $\cos 0° = 1$ making the work done on a body $W = Fs$.




From Newton's second law, the resultant force $F = ma$. The body is accelerated from some initial velocity, $v_0$, to some final velocity, $v$, over some displacement, $s$. The work done is $W = Fs$ where $F = ma$, and then $W = mas$.

Although Newton's laws of motion provide a very powerful method of attack on problems in mechanics, they do not give the only one. In problems where time is not specifically mentioned, the concept of energy provides another approach. We have no idea how long the acceleration will take and we did not bother to define the time period involved. This means that in order to continue we need to use the time-independent equation $v^2 = v_0^2 + 2as$. If the body starts from rest we set $v_0 = 0$. Then we write $v^2 = 2as$. Solving for the product of $a$ and $s$ yields $as = \frac{v^2}{2}$. Substituting into $W = mas$ gives $W = m\left(\frac{v^2}{2}\right)$, or better yet $W = \frac{1}{2}mv^2$.

The work done accelerating a body from rest to some velocity, $v$, is then determin7ed by $W = \frac{1}{2}mv^2$. The work done to accelerate a body to some velocity, $v$, is called the *kinetic energy, K,* of the body.

$$K = \frac{1}{2}mv^2$$

**AP Tip**

The work done by some agent on a body to give it speed $v$ equals the kinetic energy of that body.

## SAMPLE PROBLEM 5

A 0.03 kg bullet is fired horizontally from a rifle giving it a muzzle velocity of 300.0 $\mathrm{m/s}$. The rifle barrel has a length of 75.0 cm.

(a) What is the kinetic energy of the bullet as it exits the muzzle of the rifle?

(b) What work is done on the bullet by the expanding gases as it travels the length of the barrel?

(c) What acceleration does the bullet experience while in the barrel?

(d) How long does the bullet spend in the rifle barrel?

(e) Ignoring air resistance, how much work will the bullet do when striking a thick tree trunk 100 m from the rifle?

## SOLUTION TO PROBLEM 5

(a) The kinetic energy of the bullet is

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(0.03\text{ kg})\left(300.0\ \frac{\text{m}}{\text{s}}\right)^2 = \mathbf{1.35\ kJ}$$

(b) The expanding hot gases drive the bullet the length of the barrel. The gases are the agent doing work on the bullet. The work done to give the bullet a kinetic energy of **1.35 kJ** is the same, **1.35 kJ**.

(c) The work done on the bullet is $W = Fs$. The force exerted on the bullet by the gases is $F = \frac{W}{s} = ma$. The acceleration of the bullet is then

$$a = \frac{W}{ms} = \frac{1.35\times10^3\text{ J}}{(0.03\text{ kg})(0.75\text{ m})} = \mathbf{60\times10^3\ m/s^2}$$

(d) Acceleration is defined by $a = \frac{v - v_0}{t} = \frac{v-0}{t}$. The time period is

$$t = \frac{v}{a} = \frac{\left(300.0\ \mathrm{m/s}\right)}{\left(60\times10^3\ \mathrm{m/s^2}\right)} = \mathbf{5.0\ ms}$$

(e) Since the bullet has 1.35 kJ of kinetic energy it will do **1.35 kJ** of work when it hits the tree trunk in coming to rest.

Like work, kinetic energy is a scalar quantity and is measured in the same units as work.

**AP Tip**

Unlike work, kinetic energy is never negative.

If the body has some initial speed, $v_0$, other than zero, then its final kinetic energy is

$$K = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

Note that the above equation may also be written as

$$\Delta K = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = K - K_0$$

The quantity $\Delta K$ is the change in kinetic energy.

## THE WORK-KINETIC ENERGY THEOREM

(*College Physics* 9th ed. pages 129–132/10th ed. pages 132–135)

If the body in the above diagram has some initial velocity other than zero, $v^2 = v_0^2 + 2as$ and solving for the product of acceleration and displacement, $as$, gives $as = \frac{v^2 - v_0^2}{2}$ and substituting into $W = mas$ yields: $W = m\left(\frac{v^2 - v_0^2}{2}\right) = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$. We call this relationship the *work-kinetic energy theorem.*

The work done on a moving system changes the kinetic energy of that system.

In Sample Problem 5(e) the question is "Ignoring air resistance, how much work will the bullet do when striking a thick tree trunk 100 m away from the rifle?" Since air resistance was ignored the bullet strikes the tree trunk with a speed equivalent to the muzzle velocity, 300.0 $\mathrm{m/s}$. The bullet hits the tree trunk and penetrates it to some depth before coming to rest. The tree trunk is the agent stopping the bullet and the work done is found by the work-kinetic energy theorem, or

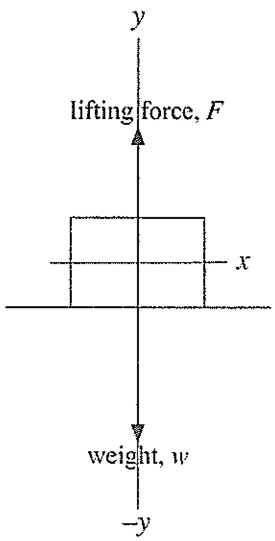
$$\begin{aligned} W &= \Delta K = K - K_0 \\ &= \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 \\ &= \frac{1}{2}m(0)^2 - \frac{1}{2}(0.03\ \text{kg})\left(300.0\ \mathrm{m/s}\right)^2 \\ &= \mathbf{-1.35\ kJ} \end{aligned}$$

The work the tree trunk does on the bullet is negative. The tree trunk stops the bullet. It takes kinetic energy away.

## POTENTIAL ENERGY

(*College Physics* 9th ed. pages 132–134/10th ed. pages 135–138)

Consider lifting a body initially at rest from the floor. In lifting the body, work is done against gravity. Lifting the body with some constant vertical velocity implies that the body is in translational equilibrium and the lifting force, *F*, equals to the weight, *w*, of the body.




The lifting force = weight

or

$F = w$

If a body weighs 98 N, a minimal lifting force of 98 N is used to assure the body is lifted with constant velocity. If a lifting force greater than 98 N is used, the body accelerates upward since a resultant upward force is then acting.

Consider a body, of mass *m*, being lifted through a vertical displacement, *y*, with a constant velocity.

At times we use *h* to represent this vertical distance. In either case work is done against gravity lifting the mass. The lifter is the *agent doing the work*, and the *agent does work against* gravity. Work is defined as $W = Fs\cos\theta$. Here, the displacement is *y* (or *h*) and it is directed vertically upward. The lifting force is *F* and it is also directed vertically upward. These vectors are parallel and that means the cos 0° = 1 and $W = Fs = Fy = wy$ since the lifting force $F = w = mg$. In doing work against gravity, the work is: $W = mgy = mgh$.

When the mass is lifted to a position above floor or ground level, the mass is then in a position where it can do work. It can fall! Any mass that is in a position where it can do work is said to have *potential energy, U,* or more specifically, *gravitational potential energy, U.* The body has been given gravitational potential energy or

$$U = mgy = mgh$$

The joule, J, is the SI unit of potential energy.

Gravitational fields, like the one generated by the mass of the earth, have a very special property that relates to *conservation*. Gravitational force is called a *conservative force,* and this makes potential energy conservative. What does this mean? Well, we're going to have to show you as we go along with our study of work and energy.

When we deal with potential energy, we need to establish a rule. We define the ground as having zero potential energy. For reasons we will explore later, we will state that the work done in a conservative field, work done by conservative forces like gravity, is defined as

$$W_g = -\Delta U$$

The work done in lifting a mass in the earth's gravitational field is equal to the negative change in potential energy. This is written as

$$\Delta U = U - U_0$$

Where the change in potential energy, $\Delta U$, is the difference between the final state, $U$, of the mass and the initial state, $U_0$.

The major feature of a conservative field, like the earth's gravitational field, is that the work done in moving a mass is totally independent of the path taken from the ground to the final position. The change in potential energy, the work done, is only dependent on the vertical displacement. We say that in general a force is conservative if the work done by that force acting on a body moving between two points is independent of the path the body takes between the points. A conservative force has the property that the ***total work*** done by the conservative force is zero when the body moves around any closed path and returns to its initial position.

## THE LAW OF CONSERVATION OF MECHANICAL ENERGY

(*College Physics* 9th ed. pages 145–147/10th ed. pages 148–150)

In a conservative field, the total energy is always a constant. This means that the total initial energy in a closed system before an event will always equal the total final energy in that same system after the event. Or symbolically

$$\Sigma E_0 = \Sigma E$$

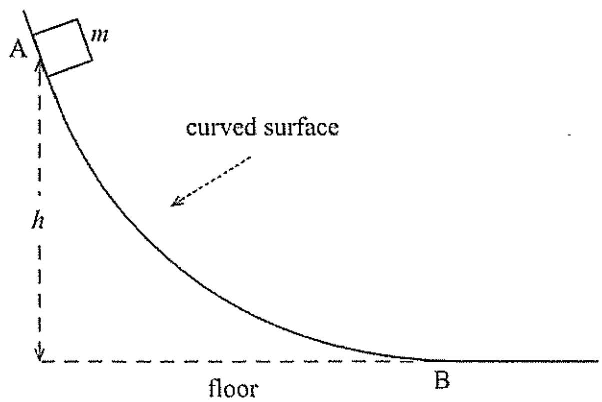
where $\Sigma E_0 = K_0 + U_0$ and $\Sigma E = K + U$ which means that

$$K_0 + U_0 = K + U$$

We call this mathematical statement the *law of conservation of mechanical energy*.

### SAMPLE PROBLEM 6

Consider the following diagram where a crate of mass $m$ is held at rest at point A. The crate is released and slides along the frictionless curved surface to point B. What is the velocity of the crate when it reaches point B?




### SOLUTION TO PROBLEM 6

Since friction is ignored, the system is a conservative system. The total energy at point A is equal to the total energy at point B, or

$$K_0 + U_0 = K + U$$

At point A, initially the crate is at rest and its kinetic energy is zero. The initial gravitational potential energy at A is $U_0 = mgh$. At ground-level the gravitational potential energy becomes zero and the kinetic energy of the crate is $K = \frac{1}{2}mv_B^2$. Writing $K_0 + U_0 = K + U$ and substituting gives $0 + mgh = \frac{1}{2}mv_B^2 + 0$. Solving for $v_B$ yields $v_B = \sqrt{2gh}$.

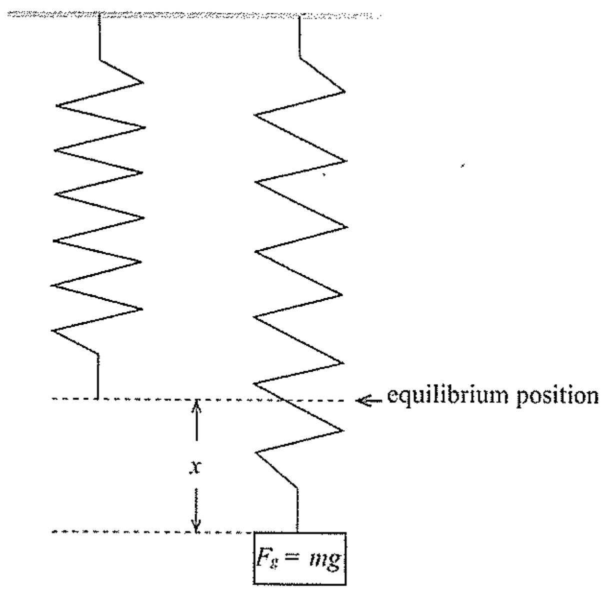
## THE HOOKEAN SPRING AS A CONSERVATIVE SYSTEM

(*College Physics* 9th ed. pages 140–145/10th ed. pages 143–148)

Springs obey a rather simple law discovered by Robert Hook in the eighteenth century. Hook's law states that the force of restitution acting in a spring is directly proportional to the amount of stretching or compressing. Or

$$F = -kx$$

The negative sign (–) reminds us that $F$ is a force of restitution, $k$ is the spring constant unique to a given spring, and $x$ is the amount of stretching or the amount of compression in the spring. Stretch a spring within reason or compress it and it wants to return to its original shape. The free end of a spring in the relaxed position is called the *equilibrium position*.




The work required to stretch a Hookean spring is found by

$$W = \frac{1}{2}kx^2$$

The force of restitution in Hookean springs is conservative. Since the work done by a conservative force equals the change in potential energy, the elastic potential energy, $U_s$, a stretched or compressed spring is determined by

$$U_s = \frac{1}{2}kx^2$$

## SAMPLE PROBLEM 7

A spring is attached to a rod as shown above. The spring has a length of 0.22 m. A 0.44 kg mass is attached to the free end of the spring, stretching it to a new length of 0.28 m.

(a) What is the spring constant of the spring?

(b) How much work was done on the spring elongating it?

## SOLUTION TO PROBLEM 7

(a) The spring is stretched by $x = x_{loaded} - x_{releaxed} = 0.28\text{ m} - 0.22\text{ m} = 0.06\text{ m}$. The stretching force is the weight of the load attached to the spring $F = F_g = mg = (0.44\text{ kg})\left(9.8\ \text{m}/\text{s}^2\right) = 4.31\text{ N}$. Hooke's law is $F = kx$ and $k = \frac{F}{x} = \frac{4.31\text{ N}}{0.06\text{ m}} = \mathbf{71.87\ N/m}$.

(b) The work done is $W = \frac{1}{2}kx^2 = \frac{1}{2}\left(71.87\ \text{N}/\text{m}\right)(0.06\text{ m})^2 = \mathbf{0.13\ J}$.

## NON–CONSERVATIVE FORCES

(*College Physics* 9th ed. pages 128, 131–132/10th ed. pages 131, 134–136)

A force is non-conservative if the work done by the force on a body moving between two points depends on the path taken. Friction, $f$, is such a force. Friction is *degrading force* since it takes away kinetic energy and converts it to another energy form, *thermal energy, Q*. Thermal energy or heat is a wasteful energy form, a dissipative form, and it cannot be recovered into the mechanical system. Heat escapes into the environment of the system, warming it.

The work, $W_{nc}$, done by all non-conservative forces in a system equals the change in the total mechanical energy of the system.

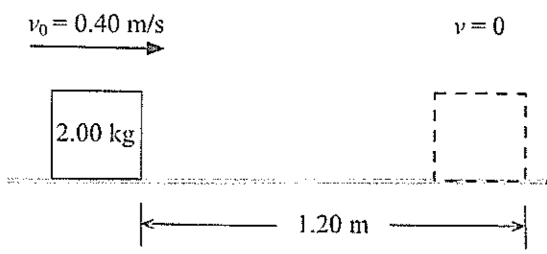
$$-W_{nc} = \Delta K + \Delta U$$

or

$$-W_{nc} = (K + U) - (K_0 + U_0).$$

### SAMPLE PROBLEM 8

A 2.00 kg block of wood slides across a horizontal floor with an initial velocity of 0.40 $^{\mathrm{m}}/_{\mathrm{s}}$ and comes to rest after sliding 1.20 m. Using energy considerations, calculate the average frictional force acting on the block.




### SOLUTION TO PROBLEM 8

The block moves along the horizontal making the change in gravitational potential energy zero.

Since friction brings the block to rest, this is a non–conservative system and $-W_{nc} = \Delta K + \Delta U = K - K_0 + 0$. The final kinetic energy is zero since the block comes to rest and $-W_{nc} = -fx = -K_0 = -\frac{1}{2}mv_0^2$. The average frictional force is

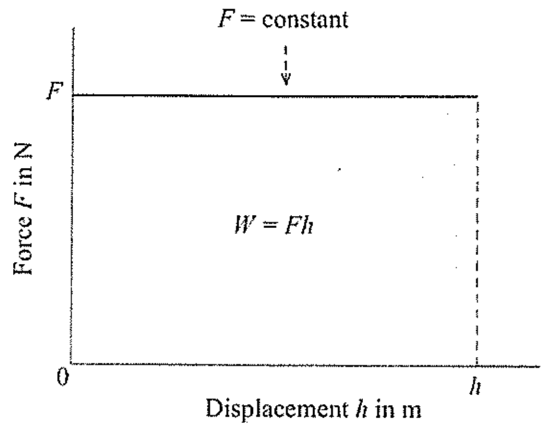
$$f = \frac{mv_0^2}{2x} = \frac{(2.00\ \mathrm{kg})\left(0.40\ ^{\mathrm{m}}/_{\mathrm{s}}\right)^2}{2(1.20\ \mathrm{m})} = \mathbf{0.13\ N}$$

## WORK DONE BY A CONSTANT FORCE

(*College Physics* 9th ed. pages 124–125/10th ed. pages 128–129)

Lifting a mass $m$ through a vertical displacement $h$ is an example of work done by a *constant force*. In this simple case, we can write $F$ = constant and the work done by the lifting agent is $W = Fh$.

If we draw a graph with the force $F$ plotted along the vertical axis and the distance $h$ through which the force acts, we get a straight horizontal line as shown in the graph below.

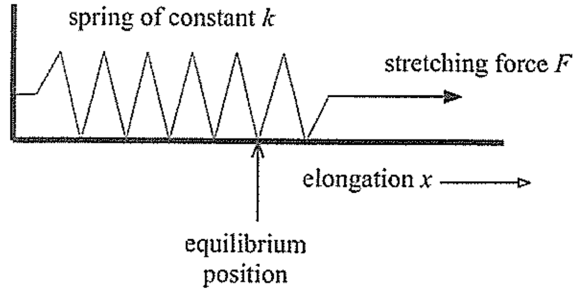



For any given $F$ and $h$, the work done is simply equal to the shaded area in the graph. This idea that *the area under a curve can represent work done* is extremely useful. It can be extended to practical cases where the force may not be constant, but varies.

## WORK DONE BY A VARIABLE FORCE

(*College Physics* 9th ed. pages 152–154/10th ed. pages 155–157)

Up to this point in the treatment of work done and energy expended, we have assumed that an applied force is constant at all points along the path over which it acts. As we will see later, there are numerous situations where a force is far from being constant. One such case is in the stretching of a spring. The spring shown below is elongated through a displacement $x$ by a horizontal force $F$. Data is collected and a $F$ vs. $x$ graph is plotted. The stretching force is not a constant; it varies with displacement.



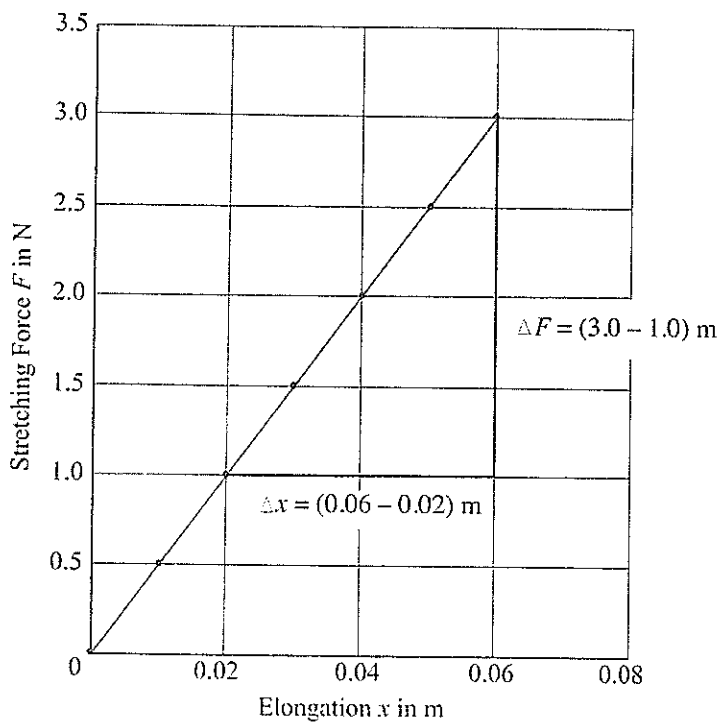
The curve is the straight, inclined line that is shown below. The interpretation of the graphical result is that of a direct proportionality between $F$ and $x$. The curve passes through the origin and we can write

$$F = kx$$

This result is Hooke's Law!

Before we do anything else, we need to find the slope of the curve. The slope is the spring constant, $k$. Earlier, when we were making a study of motion, we define slope as

$$\text{slope} = \frac{\text{change in the vertical}}{\text{change in the horizontal}}$$




and we can write

$$\text{slope} = k = \frac{\Delta F}{\Delta x} = \frac{F - F_0}{x - x_0} = \frac{3.0\text{ N} - 1.0\text{ N}}{0.06\text{ m} - 0.02\text{ m}} = 50.0\ \text{N}/\text{m}$$

We said above that the area beneath a $F$ vs. $x$ graph is the work done by the force $F$. Note in the following graph that the shaded area represents the work done in stretching the spring by 0.06 m.

Recall that the area bounded by a triangle, which is the work done by the variable force, is one-half the base multiplied by the height, or area $= W = \frac{1}{2}(x)(F)$ and since $F = kx$, then $W = \frac{1}{2}(x)(kx)$ or

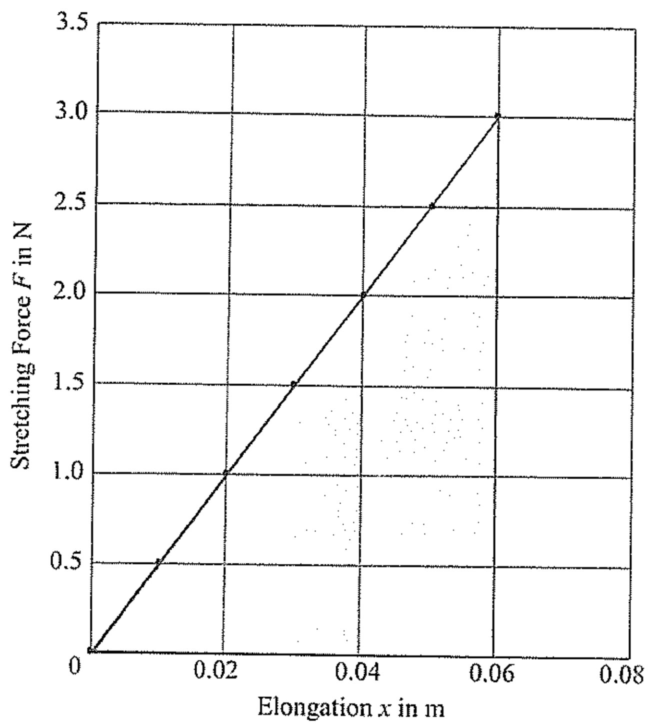
$$W = \frac{1}{2}kx^2$$

The work done in stretching the spring by 0.06 m is then

$$W = \frac{1}{2}kx^2 = \frac{1}{2}\left(50.0\ \mathrm{N/m}\right)(0.06\ \mathrm{m})^2 = 0.09\ \mathrm{J}$$

Or taking one-half the base times the height,

$$\text{area} = \frac{1}{2}(0.06\ \mathrm{m})(3.0\ \mathrm{N}) = 0.09\ \mathrm{J}$$




## POWER

(*College Physics* 9th ed. pages 147–152/10th ed. pages 150–155)

We define power as the work done by some agent per unit time.

$$P = \frac{W}{t}$$

Power, like work, is a scalar quantity. In the SI, the unit of power is the watt (W), and we define 1 W as

$$1.00\ \mathrm{W} = 1.00\ \frac{\mathrm{J}}{\mathrm{s}}$$

Sometimes, the kilowatt, kW, is more advantageous to use and 1 kW = 1000 W.

The English system unit of power is the horsepower, hp, and it is defined as

$$1\ \mathrm{hp} = 0.746\ \mathrm{kW} = 746\ \mathrm{W}.$$

Power may also be expressed as the product of the average force acting on the body and the average speed of a body:

$$P = Fv$$

## SAMPLE PROBLEM 9

An 1100 kg car accelerates from 5.0 $\mathrm{m/s}$ to a speed of 25.0 $\mathrm{m/s}$ in a time interval of 6.0 s. Ignoring frictional losses, what average horsepower must the drive train produce to cause this acceleration?

## SOLUTION TO PROBLEM 9

The work done in accelerating the car is

$$W = \Delta K = K - K_0 = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = \frac{1}{2}m\left(v^2 - v_0^2\right).$$

Power is defined as

$$\begin{aligned} P &= \frac{W}{t} \\ &= \frac{m\left(v^2 - v_0^2\right)}{2t} = \frac{(1100\ \mathrm{kg})\left[\left(25.0\ \mathrm{m/s}\right)^2 - \left(5.0\ \mathrm{m/s}\right)^2\right]}{2(6.0\ \mathrm{s})}. \\ &= 55.0\ \mathrm{kW} \end{aligned}$$

Converting to hp,

$$55.0 \times 10^3\ \mathrm{W} \times \frac{1\ \mathrm{hp}}{746\ \mathrm{W}} = \mathbf{73.7\ hp}.$$

## SAMPLE PROBLEM 10

A 1.50 hp electric motor at a construction site can vertically lift a load at the rate of 0.10 $\mathrm{m/s}$. What maximum mass of building materials can it lift at this constant speed?

## SOLUTION TO PROBLEM 10

The horsepower output of the electric motor is

$$1.50\ \mathrm{hp} \times \frac{746\ \mathrm{W}}{1.00\ \mathrm{hp}} = 1.12 \times 10^3\ \mathrm{W}.$$

In 1.0 s, the load $mg$ is lifted a vertical distance of 0.10 m. The work done in 1.0 s is $W = mgh$.

By definition, $P = \frac{W}{t} = \frac{mgh}{t}$. Solving for $m$ yields

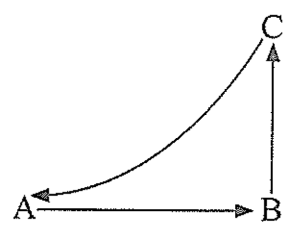
$$m = \frac{Pt}{gh} = \frac{\left(1.12 \times 10^3\ \mathrm{W}\right)(1.0\ \mathrm{s})}{\left(9.8\ \mathrm{m/s^2}\right)(0.10\ \mathrm{m})} = \mathbf{1.14 \times 10^3\ kg}$$

## WORK, ENERGY, AND POWER: STUDENT OBJECTIVES FOR THE AP EXAM

- You should be able to define work.
- You should be able to define energy.
- You should be able to differentiate between total mechanical energy, kinetic energy, and gravitational potential energy.
- You should be able to state the work–kinetic energy theorem.
- You should be able to state the law of conservation of mechanical energy.
- You should be able to calculate the work done in stretching a spring.
- You should be able to explain why friction is called a dissipative force.
- You should be able to explain what will happen to the kinetic energy of a body if the net work done on it is negative.

## MULTIPLE-CHOICE QUESTIONS

1. A 4.00 kg block moving with a velocity of 1.5 m/s on a flat horizontal surface enters a region where the coefficient of friction has increased. The kinetic energy of the block will
   (A) increase as the block enters the region
   (B) decrease as the block enters the region
   (C) remain constant in the region
   (D) decrease then increase as the block leaves the region
2. A 5.00 kg body is lifted vertically a distance of 1.20 m and then carried a horizontal distance of 4.00 m. The work done by gravity on the body is
   (A) −245 J
   (B) −196 J
   (C) −58.8 J
   (D) −24.0 J
3. A block moves from point A to B to C and back to A along the path shown.




The path is conservative if the
(A) final kinetic energy is the same as the initial kinetic energy
(B) final gravitational potential energy is the same as the initial gravitational potential energy
(C) the loss of gravitational potential energy will equal the loss in kinetic energy
(D) the sum of the total mechanical energy remains the same