PHYS 101

Ch. 6

Work and Kinetic Energy

Chapter 6

Chapter Six
Work and Kinetic Energy

- ***Work***
- ***Kinetic Energy and the Work-Energy Theorem***
- ***Work and Energy with Varying Forces***
- ***Power***

Work

Work

Work W is energy transferred to or from an object by means of a force acting on the object. Energy transferred to the object is positive work, and energy transferred from the object is negative work.

Finding an Expression for Work

To calculate the work a force does on an object as the object moves through some displacement, we use only the force component along the object's displacement. The force component perpendicular to the displacement does zero work.

$$W = Fd\cos\phi \qquad \text{(work done by a constant force).}$$

$$W = \vec{F}\cdot\vec{d} \qquad \text{(work done by a constant force),}$$

Kinetic En. and the Work-En. Theo.

Example 1:

A particle moves 10 m in the positive x direction while being acted upon by a constant force $\vec{F} = (4\hat{\mathrm{i}} + 4\hat{\mathrm{k}})\mathrm{N}$. The work done on the particle by this force is:

Solution:

(C)

(A) 20 J
(B) 10 J
(C) 40 J
(D) -20 J

Kinetic En. and the Work-En. Theo.

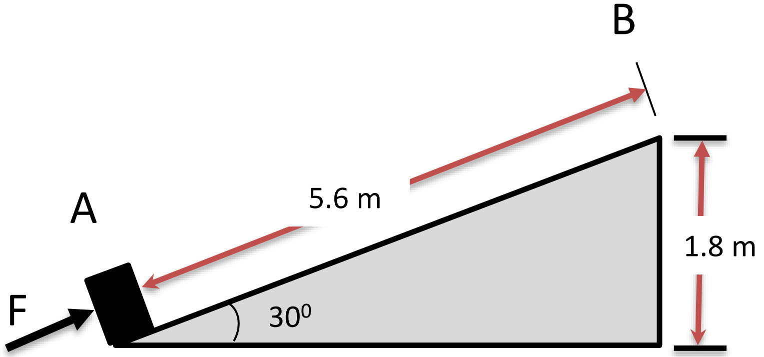
Example 2:

A force F causes the 2 kg box to slide up from point A to point B. The work done by the normal force on the box is:

Solution:

(C)

(A) 49 J
(B) 110.84 J
(C) Zero
(D) 98 J



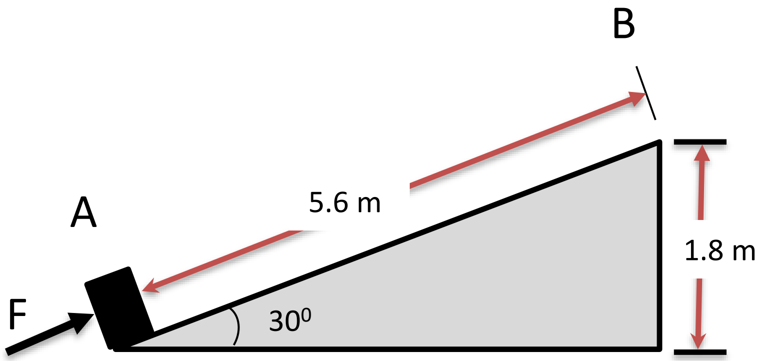
Example 3:

Referring to Example 2, if F=100 N and the distance between point A to point B is 5.6 m, the work done by the applied force on the box is:

Solution:

(A)

(A) 560 J
(B) -117.6 J
(C) 98 J
(D) 980 J



Kinetic En. and the Work-En. Theo.

Kinetic Energy

Kinetic energy K is energy associated with the *state of motion* of an object. The faster the object moves, the greater is its kinetic energy. When the object is stationary, its kinetic energy is zero.

For an object of mass m whose speed v is

$$K = \tfrac{1}{2}mv^2 \qquad \text{(kinetic energy).}$$

The SI unit of kinetic energy (and every other type of energy) is the **joule** (J),

$$1 \text{ joule} = 1 \text{ J} = 1 \text{ kg} \cdot \text{m}^2/\text{s}^2.$$

Kinetic En. and the Work-En. Theo.

Example 4:

An object that has kinetic energy must be:

Solution:

(A)

(A) moving
(B) falling
(C) at rest
(D) non of these

Example 5:

A moving particle of mass 2 kg, has kinetic energy of 10 J. It speed is:

Solution:

(D)

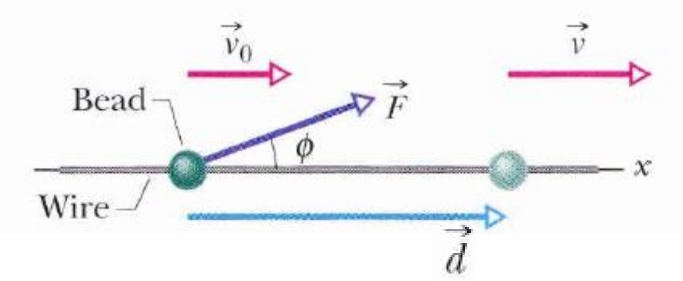
(A) 980 m/s
(B) 9.8 m/s
(C) 10 m/s
(D) 3.16 m/s

Kinetic En. and the Work-En. Theo.

Work–Kinetic Energy Theorem

$$\Delta K = K_f - K_i = W,$$

$$K_f = K_i + W,$$



Kinetic En. and the Work-En. Theo.

Example 6:

A 4 kg cart starts up an incline with a speed of 3 m/s and comes to rest 2 m up the incline. The total work done on the cart is:

Solution:

(D)

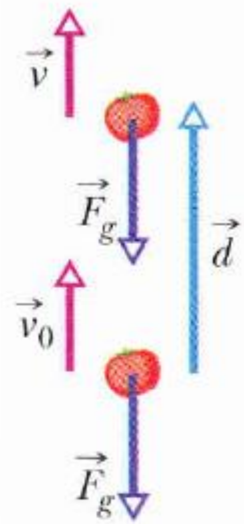
(A) -6 J
(B) -8 J
(C) -12 J
(D) -18 J

Kinetic En. and the Work-En. Theo.

Work Done by the Gravitational Force

the work W_g done by the gravitational force $\vec{F}_g$ is

$$W_g = mgd\cos\phi \qquad \text{(work done by gravitational force).}$$



For a rising object, force $\vec{F}_g$ is directed opposite the displacement $\vec{d}$,

$$W_g = mgd\cos 180^\circ = mgd(-1) = -mgd.$$

After the object has reached its maximum height and is falling back down,

$$W_g = mgd\cos 0^\circ = mgd(+1) = +mgd.$$

Kinetic En. and the Work-En. Theo.

Example 7:

A man of mass 102 kg climbs a stair of 5 m height at constant speed. The work done by the man is:

Solution:

(C)

(A) 999.6 J
(B) 510 J
(C) 4998 J
(D) 2499 J

Work and En. with Varying Forces

Work Done by a Spring Force

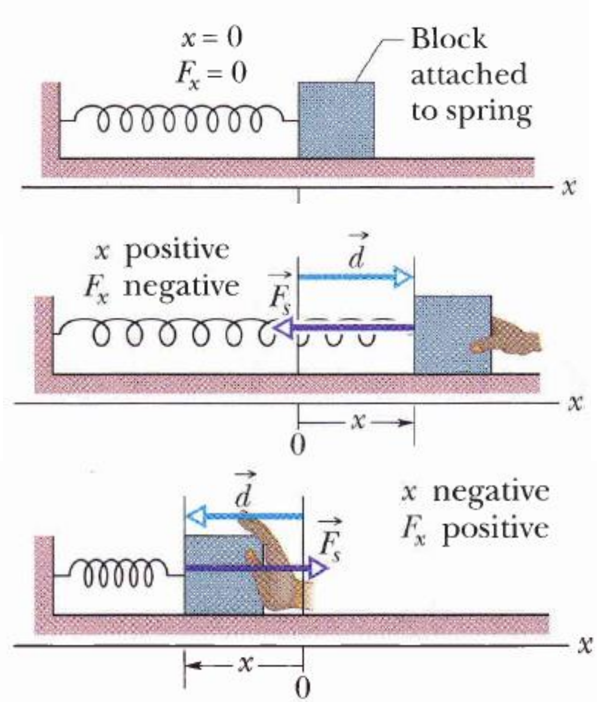
The Spring Force

The *spring force* is given by

$$F_x = -kx \qquad \text{(Hooke's law)},$$

The constant k is called the **spring constant**

If x is positive then F_x is negative



The Work Done by a Spring Force

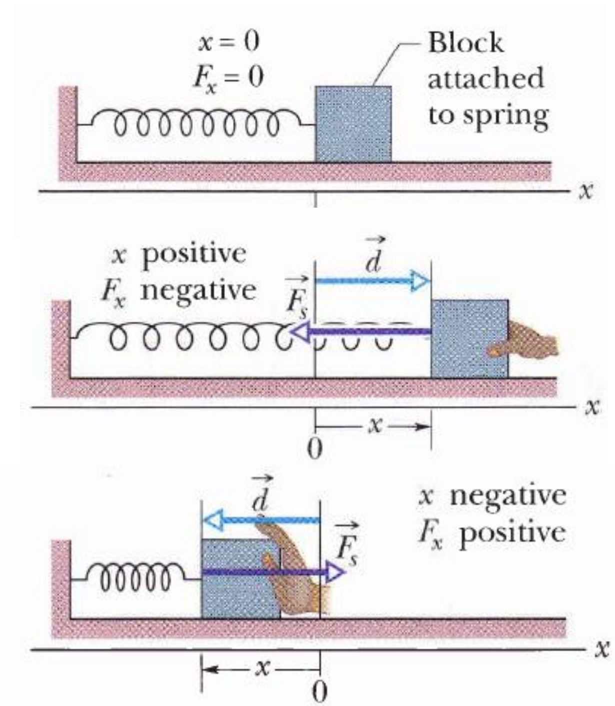
work W_s done by the spring force

$$W_s = \tfrac{1}{2}kx_i^2 - \tfrac{1}{2}kx_f^2 \qquad \text{(work by a spring force)}.$$

Work and En. with Varying Forces

If $x_i = 0$ and if we call the final position x, then

$$W_s = -\tfrac{1}{2}kx^2$$



The Work Done by an Applied Force

$$\Delta K = K_f - K_i = W_a + W_s,$$

$$W_a = -W_s.$$

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Work and En. with Varying Forces

Example 8:

If the restoring force at distance 0.5 m is 15 N, then the work done in stretching spring a distance of 0.5 m is:

Solution:

(A)

(A) -3.75 J
(B) -6 J
(C) -9 J
(D) -12 J

Work and En. with Varying Forces

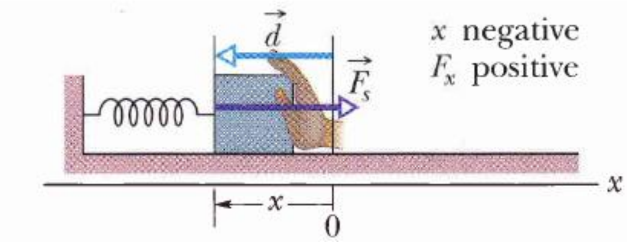
Example 9:

A force acts on a spring with length 30 cm. This force compressed it to be 25 cm. If the spring constant is 50 N/m, the work done by the spring is:

Solution:

(A)

(A) -0.0625 J
(B) -0.0825 J
(C) -0.0932 J
(D) -1.236 J



Power

Power

The time rate at which work is done by a force is said to be the **power** due to the force.

If a force does an amount of work W in an amount of time Δt, the **average power** due to the force during that time interval is

$$P_{avg} = \frac{W}{\Delta t} \quad \text{(average power).}$$

The **instantaneous power** P is the instantaneous time rate of doing work, we can write as

$$P = \frac{dW}{dt} \quad \text{(instantaneous power).}$$

Power

The SI unit of power is the joule per second.

the **watt** (W),

$$1 \text{ watt} = 1 \text{ W} = 1 \text{ J/s}$$

$$1 \text{ horsepower} = 1 \text{ hp} = 746 \text{ W}.$$

We can also express the rate at which a force does work on a particle in terms of that force and the particle's velocity.

$$P = Fv \cos \phi.$$

$$P = \vec{F} \cdot \vec{v} \qquad \text{(instantaneous power)}.$$

Power

Example 10:

If the work done on a particle is 32 J in 4 s. The power is:

Solution:

(B)

(A) 36 W
(B) 8 W
(C) 1 W
(D) 6 W

Power

Example 11:

A box was pushed 3 m across the floor in 12 s by a horizontal force of 200 N. The amount of power is:

Solution:

(C)

(A) 25 W
(B) 100 W
(C) 50 W
(D) 150 W