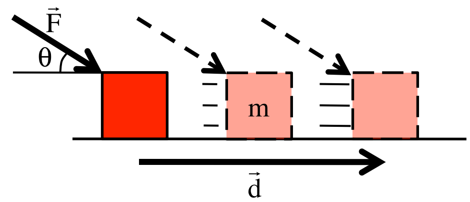
7-Series Problem

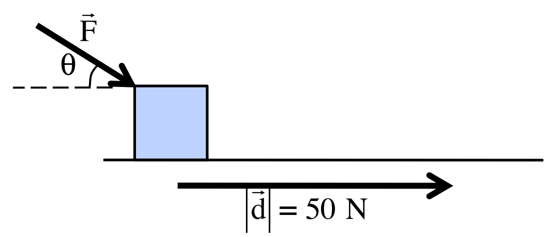
7.1) A block of mass $m = 2.50$ kg sits on a flat, frictionless table. A constant force $|\vec{F}| = 16.0$ N acts at an angle of $\theta = 25°$ as shown in the sketch. If the force is applied over a distance $|\vec{d}| = 2.20$ meters:



a.) Derive an expression for the work done by the force *F* as the block moves over $\vec{d}$.
b.) Derive an expression for the work done by the normal force as the block moves over $\vec{d}$.
c.) Derive an expression for the work done by the gravitational force as the block moves over $\vec{d}$.
d.) Derive an expression for the work done by the net force on the block as the block moves over $\vec{d}$.

7.2.) A large particle of falling soot of mass $m = 3.35x10^{-5}$ kg hits terminal velocity and falls with constant velocity under the influence of gravity and air friction over a 100 meter distance.
a.) Derive an expression for the work done on the soot over the 100-meter distance by gravity.
b.) Derive an expression for the work done on the soot over the 100-meter distance by air friction.

7.5) A 35.0 N force is applied by a shopper at $25°$ below the horizontal. If the cart moves with constant velocity:

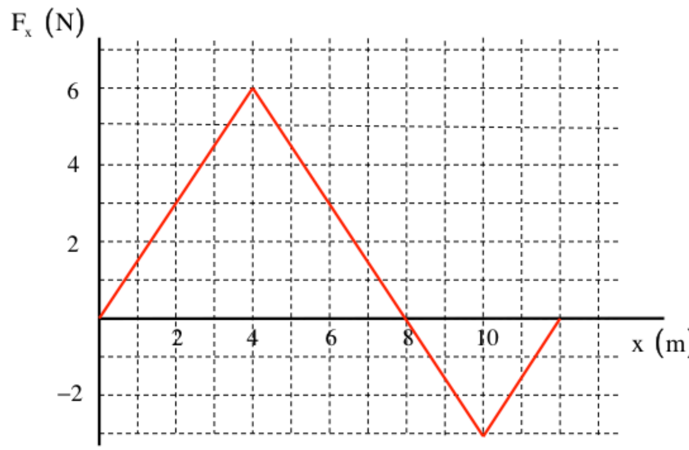


a.) How much work does the shopper do during the motion?
b.) What is the net work done by all the forces acting on the cart throughout the motion?
c.) If, for the same situation, the force had been *horizontal,* how would *F* have differed? Assume the frictional force doesn't change between the two situations.
d.) How would the net work done by the shopper change, given the situation in *Part c*?

7.9) A force acts on a particle over a displacement. Both are characterized in *unit vector notation*: $\vec{F} = \left(6\hat{i} - 2\hat{j}\right)\text{N}$ and $\Delta\vec{r} = \left(3\hat{i} + \hat{j}\right)\text{m}$
a.) How much work does the force due during the displacement?
b.) Determine the angle between $\vec{F}$ and $\vec{d}$.

7.14) A varying force acts on a moving particle, as depicted in the graph. How much work does the force do as the particle moves from:

a.) x = 0 to x = 8.00 meters;
b.) x = 8.00 to x = 10.00 meters;
c.) x = 0 to x = 10.00 meters;

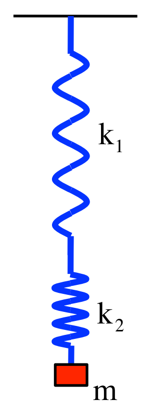


7.17) An ideal spring (obey's Hooke's Law) is attached to a hook on the ceiling. A 4.00 kg mass attached to the spring will elongate the spring a total distance of .025 meters (assuming the elongation is done slowly).

a.) If the 4.00 kg mass is swapped for a 1.50 kg mass, by how much will the spring elongate?
b.) With the mass removed, *how much work* would you have to do in elongating the spring from its equilibrium position out .04 meters?

7.21) Two light springs of different spring constant (k_1 and k_2) hang one connected to the other as shown.

a.) Determine the total extension of the two-spring system if a mass *m* is attached to the bottom spring.
b.) Derive an expression for the effective spring constant for the two-spring system.



7.31) At a *Point A,* a 0.600 kg mass is moving with speed 2.00 m/s. At a second *Point B*, its kinetic energy is 7.50 joules.

a.) Determine its kinetic energy at *Point A.*
b.) Determine its speed at *Point B*.
c.) Determine how much work must have been done by external agents as the mass moved from *Point A* to *Point B.*

7.32) A 35.0 kg crate is pushed for 12.0 meters with constant speed over a horizontal floor. The push is provided by a constant, horizontal force *F,* which does 350 joules of work in the process.

a.) Determine *F.*

b.) How will the motion change if *F* is *increased* and the run repeated?

c.) How will the motion change if *F* is *decreased* and the run repeated?

7.33) A 3.00 kg mass is found to have a velocity of $\left(6.00\hat{i} - 1.00\hat{j}\right)$ m/s.

a.) Determine its kinetic energy.

b.) How much work must be done to change the body's velocity to $\left(8.00\hat{i} + 4.00\hat{j}\right)$ m/s?

7.35) A $2.10\text{x}10^3$ kg pile-driver drops 5.00 meters before coming into contact with a steel I-beam, which it then pounds into the ground a distance of .12 m (12 cm) per drive. Determine the force the beam exerts on the pile driver in bringing the pile driver to rest with each stroke. Approach this problem using *conservation of energy.*

7.42) 2.00-meter long ropes make up a swing in which rides a 400 newton child. Relative to the child's lowest position during a swing, determine the child's gravitational potential energy:

a.) when the ropes are in the horizontal (I know, this is insanely high, but deal with it);

b.) when the ropes make a 30° angle with the vertical; and

c.) when the child is at the bottom of the arc.

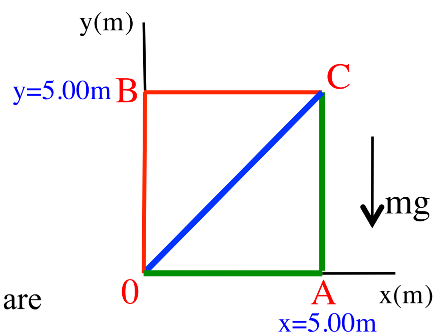
7.43) Assuming gravity is oriented toward the bottom of the page (and noting that *Point C* has coordinates (5.00, 5.00) meters), use $W = \vec{F} \bullet \vec{d}$ to determine the work gravity does on a 4.00 kg mass as it moves from the origin at *0* to *Point C* along:

a.) The green path (that is, from *0* to *A* to *C*).

b.) The red path (that is, from *0* to *B* to *C*).

c.) The blue path (that is, straight from *0* to *C*).

d.) How do the calculated values compare? Comment (that is, why are they as they are?)



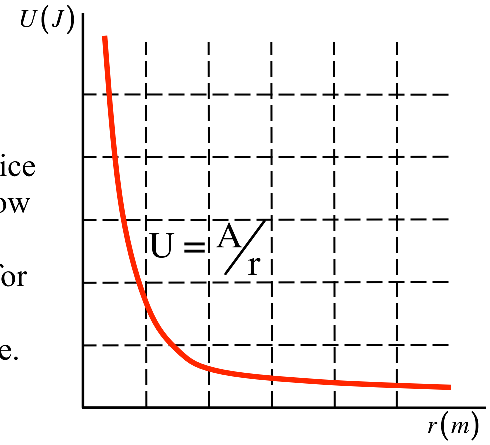
7.45) A considerably more fun problem using the sketch in *Problem 7.43* maintains that a position-dependent force $\vec{F} = \left(2y\hat{i} + x^2\hat{j}\right)$ newtons is applied to a mass as it moves from the origin at *0* to *Point C*. How much work does the force do if the body's path is:

a.) The green path (that is, from *0* to *A* to *C*). (Clearly we are ignoring gravity in this calculation.)

b.) The red path (that is, from *0* to *B* to *C*).

c.) The blue path (that is, straight from *0* to *C*).

d.) Is this force conservative or non-conservative. What led you conclude as you did (and no, flipping a coin isn't going to cut it).



7.47) The graph shows the *potential energy function* for a two-particle system. In the system, the force one particle exerts on the other (and vice versa) is radial (i.e., it acts on line between the particles) and is somehow related to the distance *r* between the two particles.

a.) Knowing the *potential energy function*, derive an expression for the *force function* for this situation.

b.) Does this *force function* look like anything you've seen to date. If so, what is that force and what, apparently, is its potential energy function?

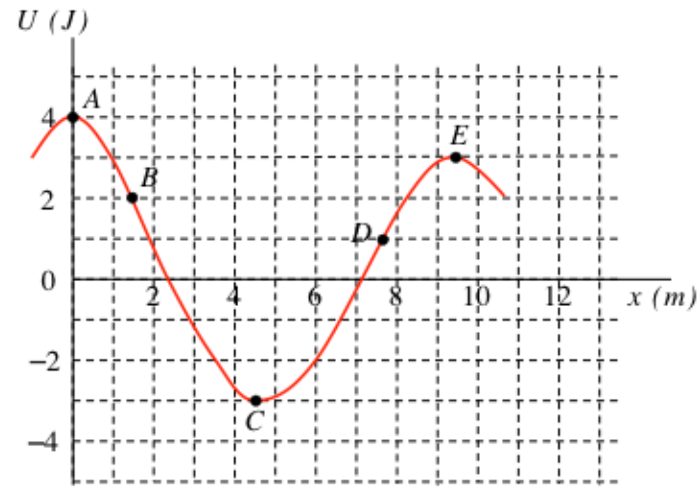
7.49) A 5.00 kg mass sits within a system of particles. Due to the presence of the system, a single, conservative, position-dependent force $\vec{F} = (2x + 4)\hat{i}$ acts on the mass, where *x* is in meters and the force is in Newtons. Our mass is observed to move from *x = 1.00* to *x = 5.00 meters* along the *x-axis*.

a.) Determine the work done by the force over this displacement;

b.) Determine the system's *potential energy change* during the displacement;

c.) If the mass was moving with speed 3.00 m/s at the beginning of the run, what was its kinetic energy at the *x = 5.00 meter* mark?

7.52) Consider the *potential energy curve* shown in the sketch. Assume the force is along the *x-direction*.



a.) Looking at the points marked. Determine whether the force is *positive, negative* or *zero* at each point.

b.) Stable equilibrium means the system, when in equilibrium, can be displaced slightly and will migrate back to equilibrium at its original point (a ball at the bottom of an arc). Unstable equilibrium means the system, when in equilibrium, can be displaced slightly and will NOT migrate back to equilibrium (a ball on top of a hill). Neutral equilibrium means the system, when in equilibrium, can be displaced slightly and stay in equilibrium where it ends up without migrating back to its start point (ball on a flat tabletop). Identify any states of stable, unstable or neutral equilibrium in this system.

c.) Draw the *force versus position* curve for the interval *x = 0* to *x = 9.5*.