Question:

Which statement concerning energy principles is correct?

- I. **A conservative force property is such that does not return mechanical energy to a system when the path of motion of an object is reversed.**
- II. **Total energy, but not mechanical energy is always conserved for a Case II energy system.**
- III. **Work done by non-conservative forces always transforms mechanical energy into non-mechanical energy forms.**

a. **I only**
b. **II only**
c. **III only**
d. **I and III only**
e. **II and III only**

Answer:

e.

Question:

Which of the following statements concerning energy conservation is correct?

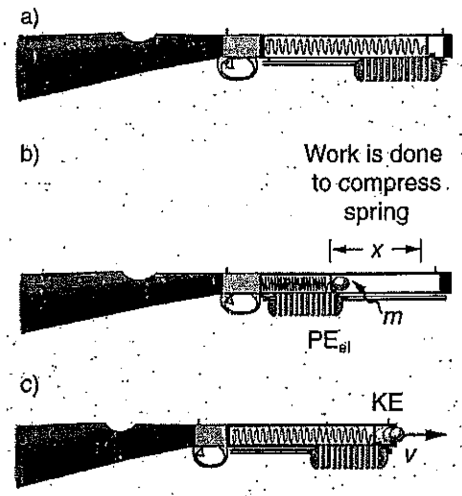
- **I. For Case II situations in which non-conservative forces act, total mechanical energy of the system remains constant but total energy decreases.**
- **II. For Case I situations in which no non-conservative forces act, both total energy and total mechanical energy decrease.**
- **III. In any system that undergoes energy transformation, the total work done is never zero and is always equal the change in total energy.**

- **a.** I only
- **b.** II only
- **c.** III only
- **d.** II and III
- **e.** I, II and III

Answer:

c.

Question:



A force of **2.5 N** is used to compress the spring of a toy gun that shoots small **10 g** foam ball projectiles as shown in the figure above. If the spring has **k = 50 N/m** and is compressed **25 cm**, what will be the speed ***v*** of the projectiles as they emerge from the gun's barrel?

Solution:

$$W = \Delta E_K$$

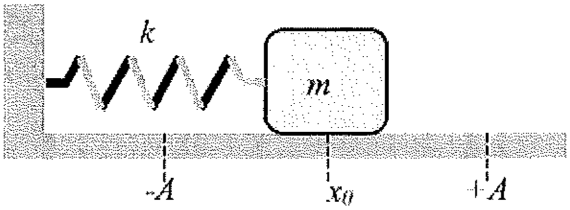
$$F_a x = E_f - E_i^{\,\nearrow 0}$$

$$F_a x = \frac{1}{2} m v_f^2$$

$$v_f = \sqrt{\frac{2 F_a x}{m}}$$

$$= \sqrt{\frac{2(2.5\,N)(.25\,m)}{0.01\,kg}} \qquad \boxed{v_f = 11.2\,\frac{m}{s}}$$

Question:



A spring with negligible mass and spring constant k is attached on one end to a block of mass m, and fastened at the other end to a wall. The block is pulled back a distance A from its equilibrium position and released so that it oscillates on the frictionless, horizontal surface. What is the velocity v of the mass as it passes the equilibrium position x_0?

a. $\sqrt{\dfrac{2kA}{m}}$

b. $\dfrac{k}{m}x^2$

c. $\dfrac{k}{m}A^2$

d. $A\sqrt{\dfrac{k}{m}}$

e. $A\sqrt{\dfrac{2k}{m}}$

Answer:

The correct answer is ***d***. This is a conservation of energy problem, with the mass-spring's elastic potential energy at the endpoints, $U_{spring} = \frac{1}{2}kx^2$, converting completely to kinetic energy at the midpoint, $K = \frac{1}{2}mv^2$.

$$U_s = K_0$$

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

$$v = \sqrt{\frac{kA^2}{m}} = A\sqrt{\frac{k}{m}}$$

Question:
A 10-meter long, vertical cannon is used to accelerate a 1.0-kg ball straight up into the air. A constant force of 13.2-Newtons is used to accelerate the bowling ball up the length of the cannon. What is the ball's approximate velocity as it leaves the cannon (assuming no energy loss to friction)?

a. 29 m/s
b. 16 m/s
c. 14 m/s
d. 9 m/s
e. 8 m/s

Answer:
The correct answer is *e*. This is a conservation of energy problem, with Work done on the ball contributing to increased potential and kinetic energies.

$$W = U + K$$

$$Fd = mgh + \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2(Fd - mgh)}{m}}$$

$$v = \sqrt{\frac{2(13.2 \cdot 10 - 1 \cdot 10 \cdot 10)}{1}}$$

$$v = \sqrt{\frac{2(32)}{1}} = 8m/s$$

Question:

Which of the following is not a unit of energy?

a. J

b. $\frac{N}{m}$

c. $kg \bullet \left(\frac{m}{s}\right)^2$

d. $W \bullet s$

e. $\frac{kg \bullet m^2}{s^2}$

Answer:

The correct answer is ***b***. The *Joule* is the standard unit, but energy can be expressed in other units as well–choice *b*, however, is not an acceptable unit.

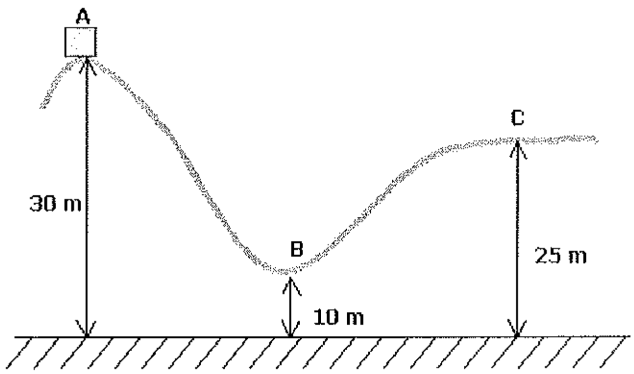
To answer this question, it helps to remember some of the ways we can calculate Work or Energy:

$W = Fd = [N][m]$, which is what choice *b* should have been, if it were correct.

$KE = \frac{1}{2}mv^2 = [kg]\left[\frac{m}{s}\right]^2$, which is choice *c*, and also choice *e*.

$Power = \frac{Work}{time} \rightarrow Work = Power \bullet time = [W][s]$, which is choice *d*.

Question:



Two children are riding on a roller coaster as shown above. The children and coaster car have a combined mass of 280 kg. Calculate the change in the gravitational potential energy of the children and car as they move from Point A to Point C?

Answer:

$$\Delta \vec{E}_g = \vec{E}_{gC} - \vec{E}_{gA}$$

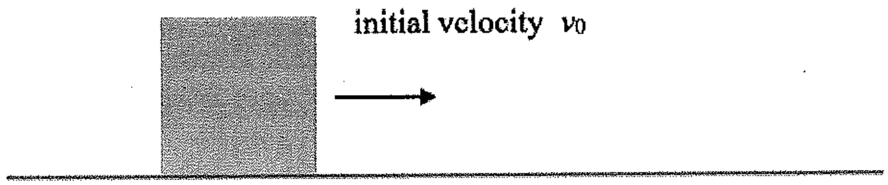
$$= mgh_C - mgh_A$$

$$= mg(h_C - h_A)$$

$$\Delta \vec{E}_g = \underline{-14\,kJ}$$

The ΔE_g is equal to the difference between the gravitational potential energies at point A and point C. Since the gravitational potential energy at Point C is less than the gravitational potential energy at Point A, the change is negative.

Question:



A box on the floor is briefly pushed to give it an initial velocity v_0 to the right, as shown. There is friction between the box and the floor. Which of the following statements is *false* ?

a. The box is accelerating to the left.
b. The velocity of the box will decrease as it slides.
c. The kinetic energy of the box will decrease as it slides.
d. There is no net force acting on the box as it slides.
e. Mechanical energy is being converted to thermal energy via heat as the box slides.

Answer:
The correct answer is ***d***. There *is* a net force acting on the box as it slides: the force of frcition, which acts to the left in the opposite direction of the box's motion.

The other statements are all true. In *a*, although the box is moving to the right, its direction of acceleration is opposite that motion, which is why it is slowing down. (In the same way, an object thrown up in the air is moving upwards, but slowing down due to the downwards accleration due to gravity). Choices *b* and *c* are both true because the box is slowing down. Choice *e* is true because of the Work being done by friction. In this process, kinetic energy is converted via heat to ***thermal energy***, sometimes called ***internal energy***: the random motion of the atoms and molecules in the box and the floor.

Question:

A glider moving on a frictionless air track has a mass *m*, velocity *v*, and a total energy $E = \frac{1}{2}mv^2$ just before it hits a bumper at the end of the track. The glider bounces back from the bumper with a velocity *v*/4. The energy converted to heat in the collision with the bumper is

a. $\frac{1}{16}E$

b. $\frac{1}{4}E$

c. $\frac{1}{2}E$

d. $\frac{3}{4}E$

e. $\frac{15}{16}E$

Answer:

The correct answer is *e*. This is a conservation of energy problem that we can analyze as follows:

$$E_{initial} - \Delta E_{internal} = E_{final}$$

$$\frac{1}{2}mv^2 - \Delta E_{internal} = \frac{1}{2}m\left(\frac{-v}{4}\right)^2$$

$$\Delta E_{internal} = \frac{1}{2}mv^2 - \frac{1}{16}\left(\frac{1}{2}mv^2\right)$$

$$\Delta E_{internal} = \frac{15}{16}\left(\frac{1}{2}mv^2\right) = \frac{15}{16}E$$

Question:

Two masses, $M > m$, are connected by a light string hanging over a pulley of negligible mass. The masses are released from rest. When the masses have moved a distance h, they are traveling with a speed of:

a. $(m+M)gh$

b. $\sqrt{2gh(m+M)}$

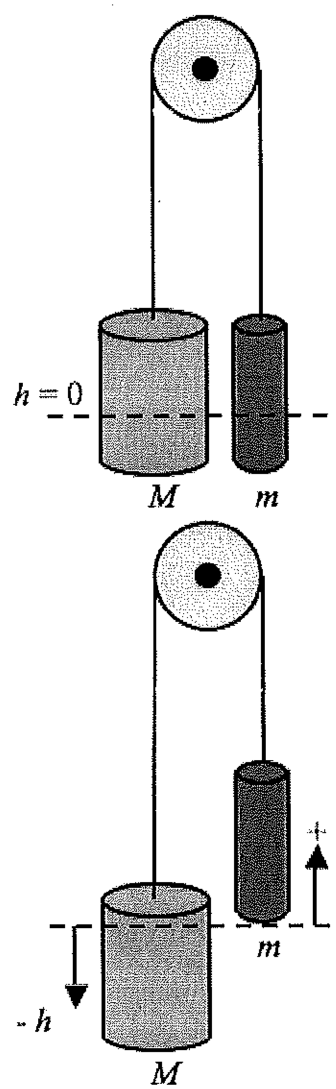
c. $2gh\left(\frac{m-M}{m+M}\right)$

d. $\sqrt{2gh\left(\frac{m-M}{m+M}\right)}$

e. $\sqrt{2gh\left(\frac{M-m}{M+m}\right)}$

Answer:

The correct answer is *e*. This problem can be solved with a kinematics analysis because the masses have a constant acceleration, but it's often more convenient to solve these kinds of problems with an energy analysis. The kinetic energy of the masses at the end of the problem appears as gravitational potential energy for the system is lost. We need to choose a "reference height" where the position of the masses is 0. I'm going to use the initial position of each mass as 0.



$$U_{initial:M} + U_{initial:m} + K_{initial:M} + K_{final:m} =$$
$$U_{final:M} + U_{final:m} + K_{final:M} + K_{final:m}$$

$$0+0+0+0 = Mg(-h) + mg(h) + \frac{1}{2}Mv^2 + \frac{1}{2}mv^2$$

$$v^2(M+m) = 2gh(M-m)$$

$$v = \sqrt{2gh\left(\frac{M-m}{M+m}\right)}$$

Question:

The potential energy of a particle is given by the expression $U(r) = 2r^{5/2} + 3$, where r is the position of the particle. What is the function that describes the conservative force F acting on this particle?

a. $\frac{4}{7}r^{7/2} + 3r$

b. $-\frac{4}{7}r^{7/2} - 3r$

c. $5r^{3/2}$

d. $-5r^{3/2}$

e. $5r^{3/2} + 3r$

Answer:

The correct answer is ***d***. For conservative forces, potential energy is described using the work integral, $\Delta U = -\int_{x_i}^{x_f} F \bullet dx$. The force F, then, can be described by the integral $F = -\frac{dU}{dx}$. In this case:

$$F = -\frac{dU}{dx}$$

$$F = -\frac{d}{dx}\left(2r^{5/2} + 3\right)$$

$$F = -5r^{3/2}$$

Question:

Stretching a non-linear spring requires an amount of Work given by the equation $U = 15x^2 - 10x^3$, where U is in Joules and x is in meters. How much force is required to hold this spring stretched out 2.0m from its equilibrium position?

a. 5N
b. 20N
c. 60N
d. 120N
e. 400N

Answer:

The correct answer is *c*. The potential energy function U is related to the conservative force F by the function $F = -\frac{dU}{dx}$, so

$$F = -\frac{dU}{dx}$$

$$F = -\frac{d}{dx}\left(15x^2 - 10x^3\right)$$

$$F = 30x^2 - 30x$$

Using the given displacement of 2.0m allows us to determine the Force required to extend (or compress) the spring by that amount.

$$F = 30x^2 - 30x$$

$$F = 30(2)^2 - 30(2)$$

$$F = 60N$$

Question:

The behavior of a non-linear spring is described by the relationship $F = -2kx^3$, where x is the displacement from the equlibrium position and F is the force exerted by the spring. How much potential energy is stored in the spring when it is displaced a distance x from equilibrium?

a. $\frac{1}{2}kx^4$

b. $6kx^2$

c. $\frac{1}{3}kx^4$

d. $\frac{1}{3}kx^3$

e. $\frac{2}{3}kx^2$

Answer:

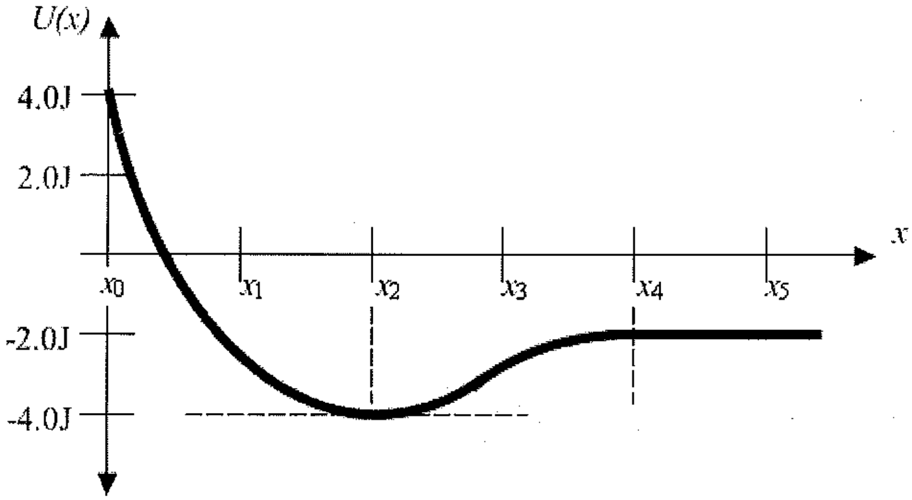
The correct answer is *a*. The potential energy stored in the spring is calculated using the Work integral:

$$U = -\int_{x_i}^{x_f} F \bullet dx$$

$$U = -\int_{0}^{x} -2kx^3 \bullet dx$$

$$U = 2k \left. \frac{x^4}{4} \right|_0^x = \frac{1}{2}kx^4$$

Question:



The potential energy function *U(x)* is associated with a conservative force *F* and described by the graph given here. If a particle being acted upon by this force has a kinetic energy of 1.0 J at position x_0, what is the particle's kinetic energy at position x_4?

a. 6.0 J
b. 7.0 J
c. 2.0 J
d. -2.0 J
e. -7.0 J

Answer:

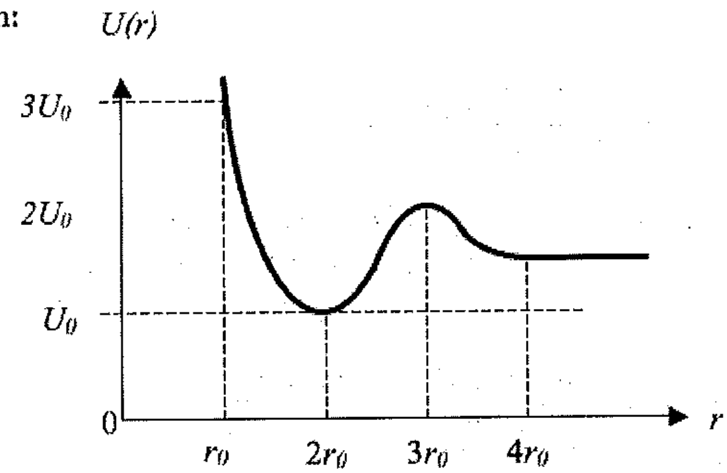
The correct answer is ***b***. This is a conservation of energy problem, and the total mechanical energy of the system remains constant:

$$U_i + K_i = U_f + K_f$$

$$4.0J + 1.0J = -2.0J + K_f$$

$$K_f = 7.0J$$

Question:



The graph above represents the potential energy U as a function of position r for a particle of mass m. If the particle is released from rest at position r_0, what will its speed be at position $3r_0$?

a. $\sqrt{\frac{8U_0}{m}}$

b. $\sqrt{\frac{4U_0}{m}}$

c. $\sqrt{\frac{2U_0}{m}}$

d. $\sqrt{\frac{6U_0}{m}}$

e. The particle will never reach position $3r_0$.

Answer:

The correct answer is *c*. This is a conservation of energy problem, in which we examine the relationship between the particle's potential and kinetic energies.

$$U_i + K_i = U_f + K_f$$

$$3U_0 + 0 = 2U_0 + \tfrac{1}{2}mv^2$$

$$U_0 = \tfrac{1}{2}mv^2$$

$$v = \sqrt{\frac{2U_0}{m}}$$

Question:
From the top of a tall cliff of height y, a soccer ball is kicked horizontally so that it leaves the cliff with a velocity v. Assuming air friction is negligible, the speed of the ball just before it hits the ground is:

a. $2gy$

b. $\sqrt{2gy}$

c. $v^2 + 2gy$

d. $\sqrt{v^2 + 2gy}$

e. $\sqrt{v^2 - 2gy}$

Answer:
The correct answer is *d*. The speed of the ball just before it hits the ground is based on the combined effects of its horizontal and vertical velocities. This problem can be solved by using kinematics to determine velocities in both the x direction and the y direction, and then combining those using the Pythagorean theorem.

It's also relatively easy to solve using an energy analysis, where the initial kinetic and gravitational potential energies of the ball are converted to a final kinetic energy, where the potential energy of the ball has decreased to 0 at ground level.

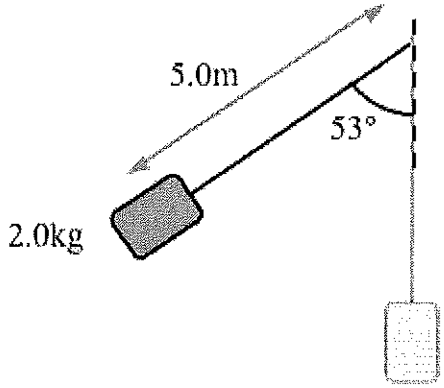
$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv_i^2 + mgy = \frac{1}{2}mv_f^2 + mg(0)$$

Rearranging and solving:

$$v_f = \sqrt{v^2 + 2gy}$$

Question:



A mass of 2.0 kg is attached to the end of a light cord to make a pendulum 5.0 meters in length. The mass is raised to an angle of 53° relative to the vertical, as shown, and released. The speed of the mass at the bottom of its swing is:

a. 60 m/s
b. 7.7 m/s
c. 40 m/s
d. 6.3 m/s
e. 10 m/s

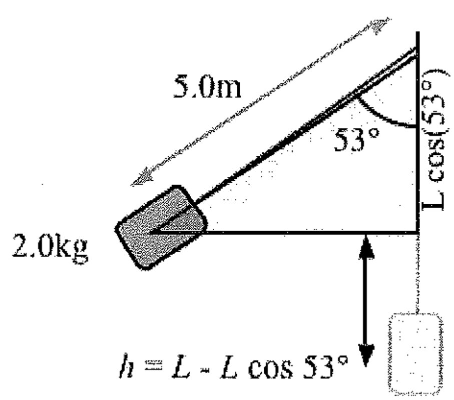
Answer:

The correct answer is *d*. This is a conservation of energy problem, with the gravitational potential energy *U* of the pendulum bob converted to kinetic energy *K* as it swings down. Let's consider the lowest position of the pendulum to be $h = 0$:

$$U_i + K_i = U_f + K_f$$

$$mgh + 0 = 0 + \frac{1}{2}mv^2$$

$$v = \sqrt{2gh}$$



We can find the height of the pendulum bob relative to the bottom of its swing by using trigonometry. The length of the short side of the triangle (shown in red) is $L \cos 53°$. The height h is the full length L less this leg of the triangle.

$$h = L - L\cos\theta = 5 - 5\cos 53° = 2m$$

We can then use this information in our original formula to determine the velocity at this point:

$$v = \sqrt{2gh} = \sqrt{2(10m/s^2)(2m)} = 6.3m/s$$