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.**

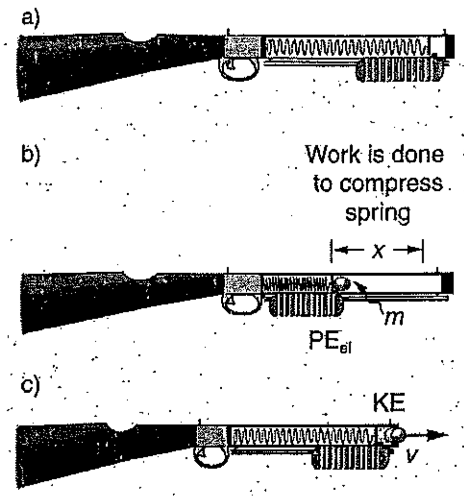
III. **In any system that undergoes energy transformation, the total work done is never zero and is always equal the change in total energy.**

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:

$$W = \Delta E_K$$

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

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

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

$$= \sqrt{\frac{2(2.5\,N)(.25\,m)}{0.01\,kg}}$$

$$\boxed{v_f = 11.2\,\frac{m}{s}}$$

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.

$$W = U + K$$

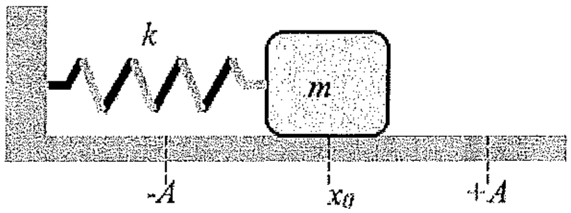
$$Fd = mgh + \frac{1}{2}mv^2$$

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

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

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

Question:



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. $\sqrt{\frac{2kA}{m}}$

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

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

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

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

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:
Which of the following is *not* a unit of energy?

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

b. kJ

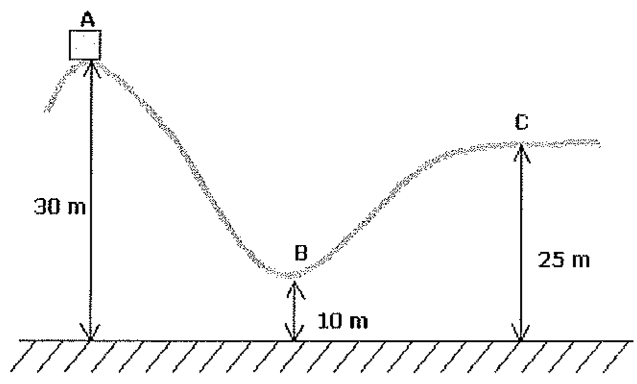
c. $\frac{N \bullet m^2}{s}$

d. $W \bullet s$

e. $N \bullet m$

Answer:
The correct answer is *c*. Energy can be determined in any number of ways, including using the concept of *Work*, calculating *kinetic* or *potential* energies, and considering energy as a function of *Power.*
Using $Work = Force \bullet displacement$, we can see that the units of Work (and thus, Energy), are the $Newton \bullet meter$, or $N \bullet m$. The derived unit for energy is the Joule, *J*.
Given that the Newton is a $\frac{kg \bullet m}{s^2}$, we can see that another possible unit for Energy is
$\frac{[kg][m]}{[s]^2} \bullet [m] = \frac{[kg][m]^2}{[s]^2}$.
Or considering that $Power = \frac{Work}{time}$, we can see that $W = P \bullet t$. Therefore, another unit of energy is $Watt \bullet seconds$, or $W \bullet s$.
The only answer that is not possibly an energy unit is *c*.

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:

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

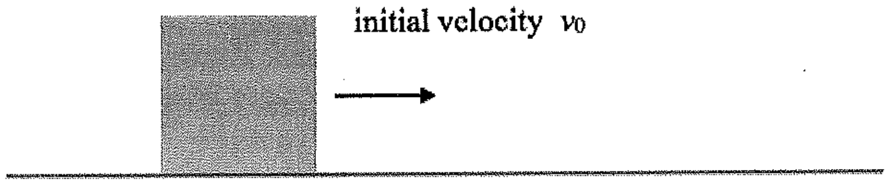
$$= mgh_C - mgh_A$$

$$= mg(h_C - h_A)$$

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

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:



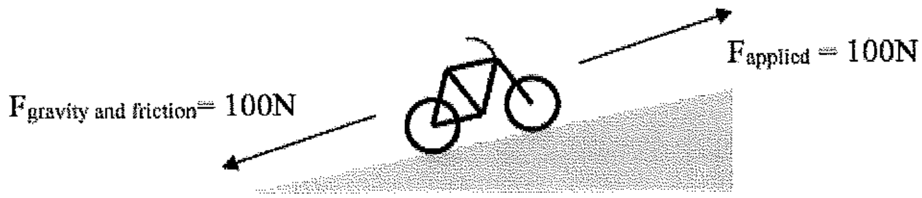
A box on the floor is briefly pushed to give it an initial velocity v_0 to the right, as shown. There is friction between the box and the floor. Which of the following statements is *false* ?

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 student applies a constant force of 100 N while pushing a bicycle up a hill, while gravity and wheel friction cause a constant 100 N force in the opposite direction. In this situation

a. the student-applied force of 100 N means the bicycle must be accelerating.
b. the net force on the bicycle is 0 N, which means the bicycle is not accelerating.
c. the combined forces of gravity and wheel friction mean the bicycle must be decelerating.
d. the student is not doing any Work on the bicycle as she pushes it up the hill.
e. the bicycle can't be moving up the hill because the forces on it are balanced.

Answer:
The correct answer is *b*. The net force on the bicycle is 0, so with no net external force, the bicycle will continue in straight-line motion at constant speed—it will not be accelerating.

Note that *e* is not a correct answer. Although an initial force from the student of greater than 100 N may have been necessary to get the bicycle moving from a standstill, once it is moving (as it is in this problem), the student only needs to apply 100 N of force to keep it moving. If the student applies more than 100 N, the bike will begin to accelerate up the hill, and if the student applies less than 100 N, the bike will begin to slow down.

You may not yet know about the concept of Work, which is mentioned in answer *d*. Work occurs when something applies a Force along some distance. In this case, the student is doing Work as she pushes the bike up the hill, which results in an increase in the bicycle's gravitational potential energy. If you don't know about these concepts yet, you will soon!

Question:

A student does Work by applying a horizontal force F to a table and moving it a horizontal distance d in a certain time t. In which situation would the student do *more* work?

a. applying the same force over the same distance in a shorter time
b. applying the same force over the same distance for a longer time
c. applying half as much force for twice the distance
d. applying the same force for a greater distance
e. the question can't be answered without knowing if there is friction between the floor and the table

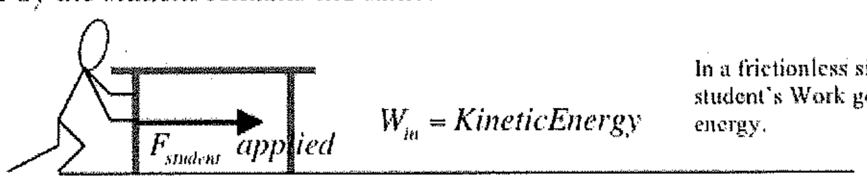
Answer:

The correct answer is ***d***. The amount of Work done by the student on the table is calculated according to $Work = Force \bullet distance$, where the Force and the distance are acting in the same direction. (A more complex version of this formula is $W = Fx\cos\theta$, where θ is the angle between the direction of Force and the direction of the displacement.) Regardless of the time that it takes to accomplish the Work, if the same Force is applied over the same distance, the same amount of Work is done by that Force.

The amount of time that it takes to accomplish the Work is related to the *Power* used, where

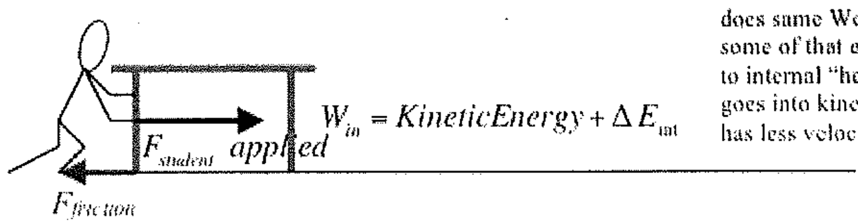
$$Power = \frac{Work}{time}.$$

And while it's true that the presence of friction between the floor and the table will ultimately affect the table's speed, the Work done by the student remains $Work_{student} = Force_{student} \bullet distance$. This Work might translate direction into kinetic energy (if there is no "loss" of energy to friction), or a friction force may do "negative Work" on the table, reducing the amount of energy that is converted to kinetic. Either way, the Work done by the student remains the same.



In a frictionless situation, all of student's Work goes into kinetic energy.

In a situation with friction, student does same Work on the table, but some of that energy is converted to internal "heat," so less energy goes into kinetic energy, and table has less velocity at the end.



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:

An elevator with a mass of 1000 kg has to be accelerated from rest, upwards at 4.0 m/s^2. How much Power is required to achieve this acceleration?

a. 28000 W
b. 14400 W
c. 4000 W
d. 2800 W
e. 1444 W

Answer:

The correct answer is ***a***. We can calculate the Power necessary to accelerate the elevator upwards by using the equation $Power = \frac{Work}{time}$. This is a multi-step problem that can be solved in a number of ways. Here's one way, using an energy approach:

Work done on the elevator goes to change its energy, both its gravitational and kinetic energies in this case: $Work = GPE + KE$. Put this into the Power equation to get $Power = \frac{GPE + KE}{time} = \frac{mgh + \frac{1}{2}mv^2}{t}$. We can get the Power if we can determine the final velocity of the elevator and the height it was raised in a time *t* seconds. Let's just assume that the elevator accelerated for 1 second, and see what the final velocity and height reached are, using kinematics:

$v_f = v_i + at;\ \ v_f = 0 + (4m/s^2)(1s) = 4m/s$

$d = \frac{1}{2}at^2 = \frac{1}{2}(4m/s^2)(1s)^2 = 2m$

Plug these in to our Power equation above to get $28000 Watts$, or 28 kW.

Here's another way, using a Force and acceleration approach.

$Work = Force \times distance$, giving us the relationship $Power = \frac{Force \times distance}{time}$. So, what Force is being applied to the elevator during this acceleration?

$F_{net} = ma$

$F_{cable} - F_{gravity} = (1000kg)(4m/s^2)$

$F_{gravity} = mg = (1000kg)(\sim 10m/s^2) = 10000N$

$F_{cable} = 4000N + F_{gravity} = 4000N + 10000N = 14000N$

Now we just need to get the *distance* that the elevator travels in a given *time*. Let's use a distance-time-acceleration formula to get that, and see how far the elevator goes in, say, one second:

$d = \frac{1}{2}at^2 = \frac{1}{2}(4m/s^2)(1s)^2 = 2m$

Putting all the pieces together, then:

$$Power = \frac{Force \times distance}{time} = \frac{14000N \times 2m}{1s} = 28000 Watts$$

Question:

A rock is dropped from the edge of a cliff, where it has 80 Joules of gravitational potential energy relative to the ground below. 30 meters below its point of release, the rock has 40 Joules of kinetic energy. If energy losses due to air friction are negligible, what is the total height of the cliff?

a. 20m
b. 40m
c. 60m
d. 80m
e. 100m

Answer:

The correct answer is c. This is a conservation of energy problem, where gravitational potential energy diminishes as kinetic energy decreases. The rock has lost half of its potential energy at a point 30 meters from the top of the click, so it must be halfway down the cliff at this point. The total cliff height, then, is 60 m.

More quantitatively:

$$U_{g-i} + K_i = U_{g-f} + K_f$$

$$80J + 0 = U_{g-f} + 40J$$

$$U_{g-f} = 40J$$

$$mgh_i = 80J,\ mgh_f = 40J$$

$$h_i = 2h_f = 2(30m) = 60m$$

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

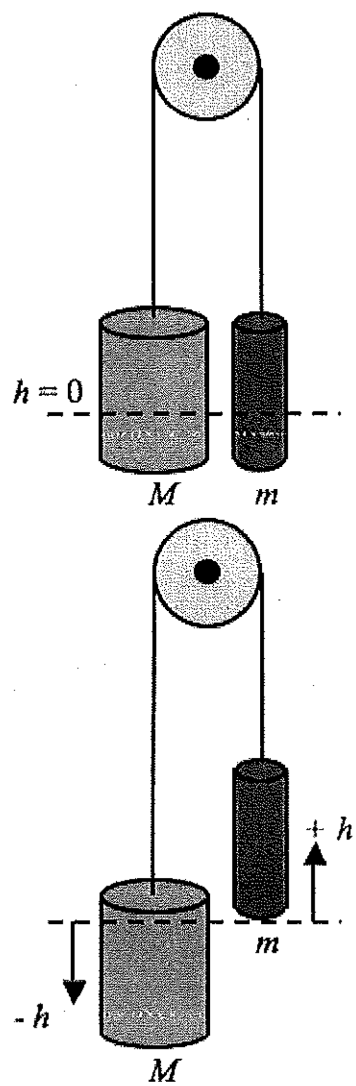
c. $2gh\left(\frac{m - M}{m + M}\right)$

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.



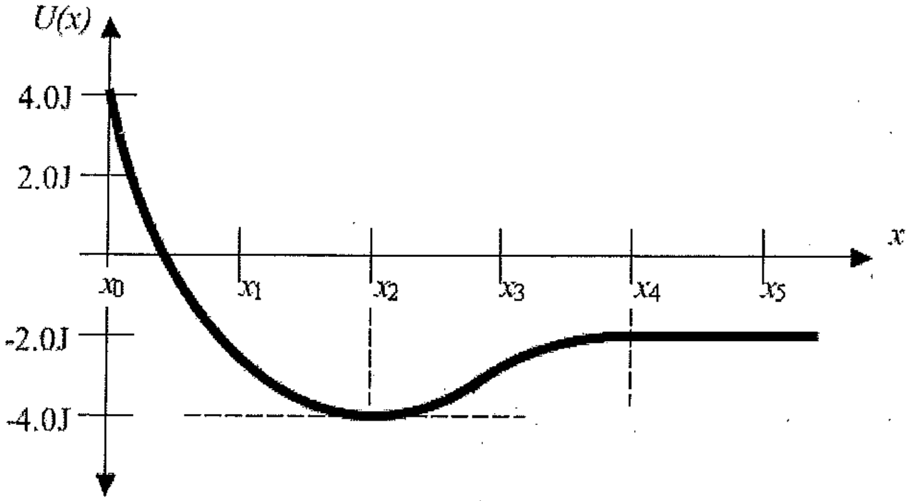
$$U_{initial:M} + U_{initial:m} + K_{initial:M} + K_{final:m} = U_{final:M} + U_{final:m} + K_{final:M} + K_{final:m}$$

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

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

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

Question:



The potential energy 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:

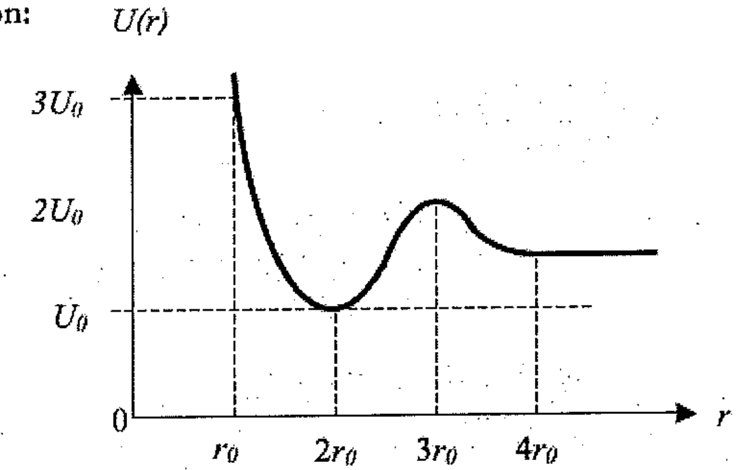
The correct answer is ***b***. This is a conservation of energy problem, and the total mechanical energy of the system remains constant:

$$U_i + K_i = U_f + K_f$$

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

$$K_f = 7.0J$$

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.

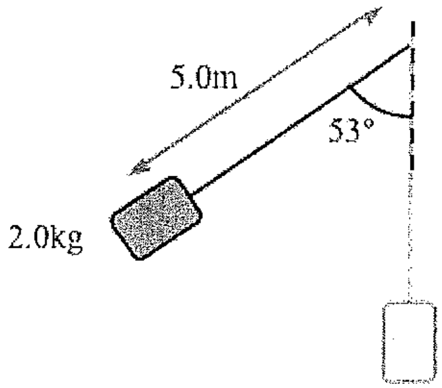
$$K_i+U_i=K_f+U_f$$

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

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

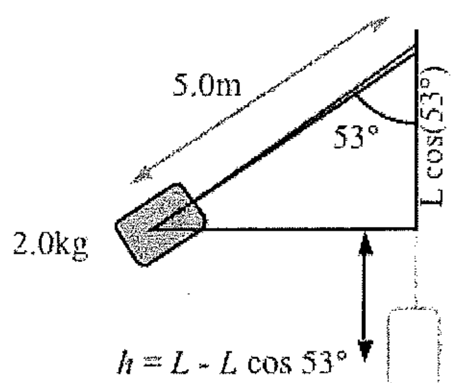
Answer:

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:

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