Question:

The physics quantity ***Work*** can be calculated by considering

a. how quickly a moving object changes its position
b. how much Force is applied to an object, and how much time that Force is applied
c. how much an object accelerates, divided by its mass
d. how much Force is applied to an object, and how much displacement that Force is applied over
e. how quickly a moving object changes its acceleration

Answer:

The correct answer is ***d***. By definition, the amount of ***Work*** done on an object is calculated according to the formula $Work = Force \bullet displacement$, or $W = Fd$.

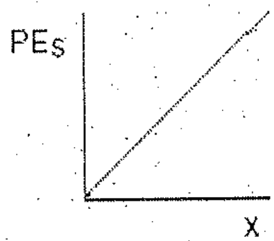
There are two "tricks" to Work that you need to understand right away.

First of all, the word ***Work*** in Physics is different from how the word ***work*** is commonly used in English. Physics ***Work*** has a specific definition, and is used along with the concept of ***energy*** to better understand how the world works. If I say "I'm doing Work on the chair," means something very specific to a physics student, as opposed to, say, "I have a lot of work to do tonight." The two words are used in very different ways to mean very different things.

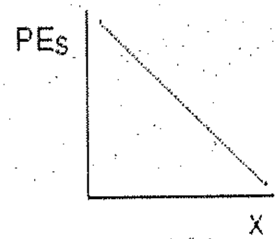
Second, when calculating Work, one needs to be sure to use the Force applied ***in a direction*** multiplied by the displacement that the object moves ***in the same direction.*** In Conceptual Physics we typically don't dig very far into this idea because the idea leads to some pretty tricky math that you probably aren't ready for just yet.

Question:

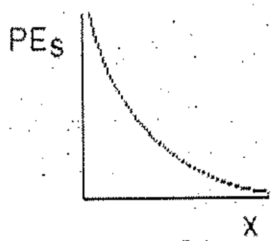
Which of the following graphs correspond to the elastic potential energy versus displacement for a spring?



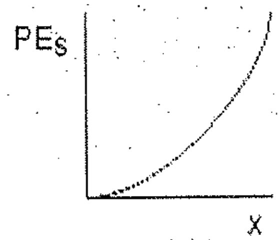
(1)



(3)



(2)



(4)

5 None of the above

Answer:

Graph 4: Elastic potential energy varies quadratically with displacement.

Question:

How much does a spring with **k = 500 N/m** need to be compressed in order to store **7.0** J of elastic potential energy?

Solution:

$$E_e = \frac{1}{2} k x^2$$

$$x = \sqrt{\frac{2E_e}{k}}$$

$$= \sqrt{\frac{2(7.0 Nm)}{500 N/m}}$$

$$x = 0.167 m$$

Question:

Which of the following statements regarding Work and Energy is *false*?

a. Work done by a force on an object *may* increase only its Kinetic Energy.
b. Work done by a force on an object *may* increase only its Potential Energy.
c. Work done by a force on an object *may* increase both its Kinetic and Potential Energies.
d. Work done by a force on an object *may* cause no change in its energy.
e. Work done by a force on an object requires that the object change its position.

Answer:

The correct answer is *d*. Work done by a Force on an object results in a change in the energy of the object; this concept is called the *Work-Energy Theorem*. A force acting over a distance may lift an object in the air, increasing the gravitational potential energy, or it may act to speed up (or slow down) a moving object. Work done by a force on an object will always cause a change in its energy.

Note that the *net*, or *overall* Work done on an object may be zero. This would be the case if, for example, a student is pushing a desk across a floor, with a force equal to the force of friction acting between the desk and the floor. Here, Work done by the student increases the Kinetic Energy of the desk, but that energy is immediately converted to *heat* (internal Energy) by the force of friction. Both the student and the force of friction are doing Work on the desk, even if the overall energy of the desk remains constant.

Question:

A block of wood, initially moving along a rough surface, is pushed with an applied horizontal force $F_{applied}$ that is less than the friction force $F_{friction}$. Which of the following statements is *false*?

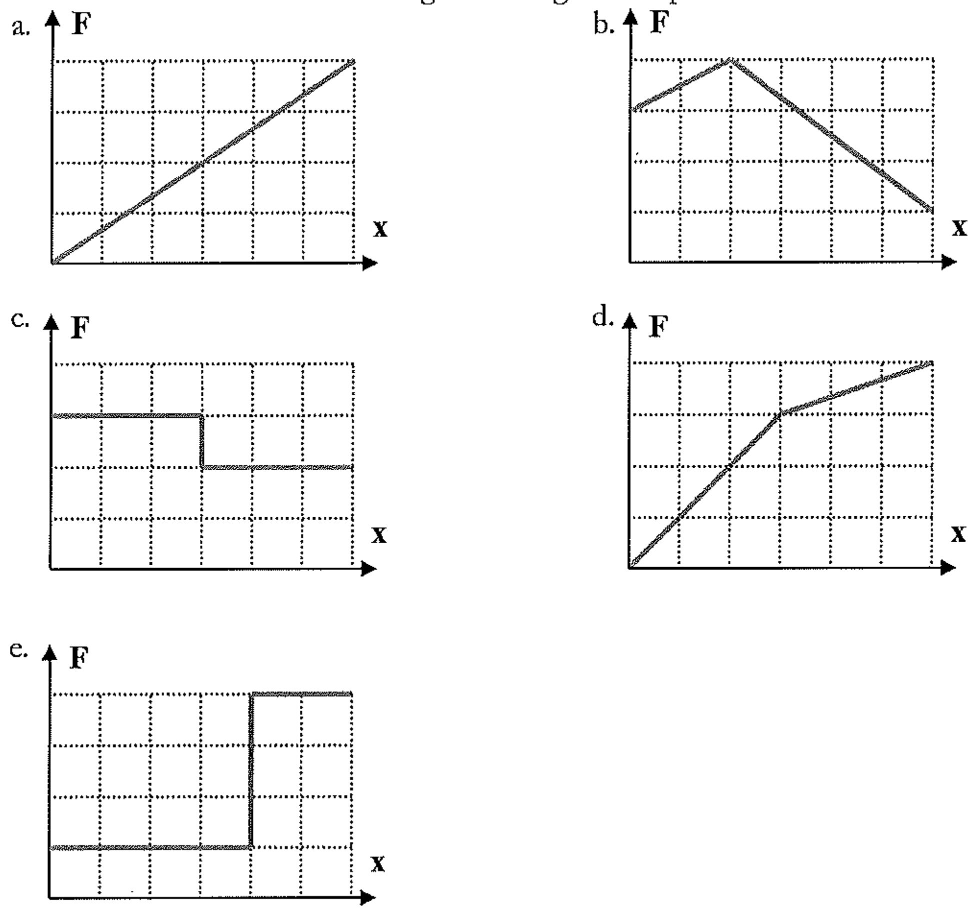
a. The Work being done by the applied force is negative.
b. The net Work being done on the block is negative.
c. The block is slowing down.
d. The net Work being done on the box decreases its kinetic energy K.
e. There is an increase in internal energy due to friction.

Answer:

The correct answer is ***a***. Statement ***a*** is false because the work done by any single agent is $W = Fx\cos\theta$. Here, with the applied Force and the displacement of the box being in the same direction (or $\cos\theta = \cos(0) = 1$), the Work being done by the applied force is positive, and goes toward increasing the box's kinetic energy.

Of course, the ***net***, or overall, Work being done on the box has to include the force of Friction, which is acting in a direction opposite that of the box's displacement. Thus, Work done by friction is negative, which has the effect of converting some of the box's kinetic energy to internal energy via heat.

Question:
A box at rest on a horizontal frictionless surface is subjected to a net horizontal force in the *x*-direction. If the force varies with displacement *x* as described in the graphs below, after which situation will the block be traveling with the greatest speed?



Answer:
The correct answer is *b.* This is a Work-Energy problem, in which Work being done on the box by the applied Force is going directly into increasing the kinetic energy *K* of the box: the greater the Work done by the Force, the greater the *K*–and thus the velocity–of the box. Work is calculated as $W = F \bullet x = Fx\cos\theta$ when the Force is a constant one. In this case, the force varies, so we need to use the calculus version of the formula: $W = \int F_x \bullet dx$. The integral means that we can use the area under the Force-displacement curve to determine the Work done.
In this case, the function that has the greatest area under the curve is *b.*

Question:

Mass m is placed at the top of a frictionless ramp of initial height h and released. A different mass M is placed at the top of a different frictionless ramp of initial height H and released. If both masses have the same kinetic energy at the bottom of their respective ramps, the velocity V of mass M is

a. $\sqrt{\frac{m}{M}}\,v$

b. $\sqrt{\frac{M}{m}}\,v$

c. $\frac{m}{M}v$

d. $\frac{M}{m}v$

e. $\frac{m}{M}\sqrt{v}$

Answer:

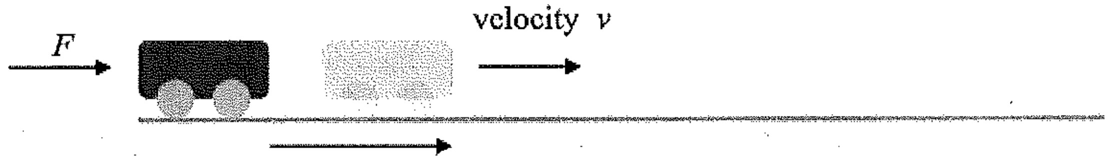
The correct answer is ***a***. The kinetic energy of each mass can be calculated and compared according to $K=\frac{1}{2}mv^2$:

$$K_m = K_M$$

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

$$V = \sqrt{\frac{m}{M}v^2} = \sqrt{\frac{m}{M}}\,v$$

Question:



F applied for distance d, then wagon released

F applied for distance $2d$, then wagon released

A small wagon with frictionless wheels is pushed with a horizontal force F applied over a distance d, giving it a velocity v when it is released. The same wagon now has the same force applied to it over a distance $2d$. What is the velocity of the wagon when it is released now?

a. $\frac{1}{2}v$

b. $v\sqrt{2}$

c. $2v$

d. $4v$

e. none of these

Answer:

The correct answer is *b*. The relationship between the Force applied to the cart and its resulting velocity can be easily determined using a Work-Energy analysis.

$$W = KE$$

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

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

If d is increased by a factor of 2, then v is going to be increased by a factor of $\sqrt{2}$.

[Note that this question requires a mathematical analysis that may go beyond the curriculum in some Conceptual Physics courses.]

Question:
A bucket of water with a total weight of 50 Newtons is lifted at constant velocity up a 10 meter deep well. If it takes 20 seconds to raise the bucket this distance, the Power required to lift the bucket is:

a. 25 W
b. 25 J
c. 2.5 J
d. 500 J
e. 500 W

Answer:
The correct answer is *a*. Work done by a Force on an object is calculated according to the Work formula W=*F*•*x*, or W=*Fx* cos Ø. In this case:

$$W = F \bullet x$$

$$W = 50N \bullet 10m = 500J$$

To get the Power used, use the Power formula:

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

$$P = \frac{500J}{20s} = 25W$$

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:

An object of mass *m* moves horizontally, increasing in speed from 0 to *v* in a time *t*. The Power necessary to accelerate the object during this time period is:

a. $\frac{mv^2t}{2}$

b. $\frac{mv^2}{2}$

c. $2mv^2$

d. $v\sqrt{\frac{m}{2t}}$

e. $\frac{mv^2}{2t}$

Answer:

The correct answer is *e*. Power is defined as Work/time, and the Work here can be determined by looking at the change in kinetic energy:

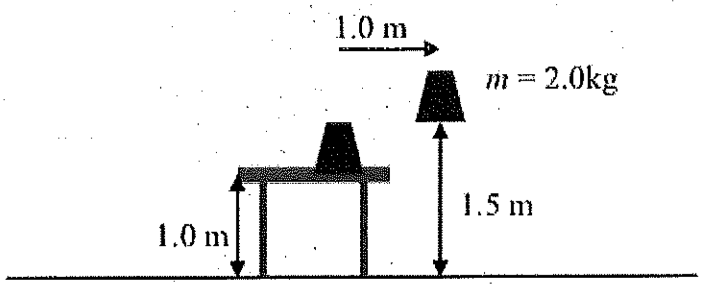
$$P = \frac{W}{t}$$

$$P = \frac{K_f - K_i}{t}$$

$$P = \frac{\frac{1}{2}mv^2 - 0}{t}$$

$$P = \frac{mv^2}{2t}$$

Question:



A teacher takes a 2.0 kilogram mass and lifts it 0.50 m above a table, that is itself 1.0 m above the floor. The teacher then moves the mass 1.0 meter to the side so that it is directly over the floor, 1.50 m below. Which statement is true?

a. The teacher did 10.0 J of Work in lifting the mass.
b. The mass has 30.0 J of GPE relative to the floor.
c. The mass has 10.0 J of GPE relative to the table.
d. The teacher did no Work against gravity when moving the mass 1.0 m to the side.
e. All of the above are true.

Answer:

The correct answer is *e*. This problem points out the fact that Gravitational Potential Energy is measured relative to some height. We typically indicate GPE relative to the ground, or the lowest surface nearby, but we can actually indicate GPE relative to *any* height.

$$W_{done\ by\ teacher} = GPE$$

$$W_{done\ by\ teacher} = mgh$$

$$W_{done\ by\ teacher} = (2.0kg)(10m/s^2)(0.5m)$$

$$W_{done\ by\ teacher} = 10J$$

How can this be? 10.0 J and 30.0 J are not the same amount of GPE! Remember that GPE can also be thought of as a measure of how much Work was done to move the mass to that position. So it took the teacher 10.0 J of Work to lift the mass from the surface of the table, and it would have taken 30.0 J of Work to lift the mass from the floor, if that had been where it was located.

When we talk about Work, we're really talking about *changing* an object's GPE from one value to another. For this reason, it's often convenient to write ΔGPE, which represents $GPE_{final} - GPE_{initial}$.

Question:

A heavy cardboard box is pushed across a floor at constant velocity. If the horizontal force applied by the push is a constant 150 N, and the box has an average velocity of 3.0 m/s, how much Power is required to move the box?

a. 450 W
b. 150 W
c. 100 W
d. 50 W
e. 30 W

Answer:

The correct answer is ***a***. Power is a measure of Work applied over time, which can also be calculated using $Force \times velocity$:

$$P = \frac{Work}{time} = \frac{Force \times \text{distance}}{\text{time}}$$

$$P = Force \times \frac{\text{distance}}{\text{time}} = Force \times velocity$$

In this case:

$$P = Fv$$

$$P = (150N)(3.0m/s) = 450W$$

Question:

A 300-Watt electric wheelchair has a mass of 50kg, and carries its 50kg occupant at constant velocity up a long ramp. About how much time does it take the wheelchair to reach the top of the 10-meter high ramp?

a. 3 s
b. 17 s
c. 10 s
d. 333 s
e. 33 s

Answer:

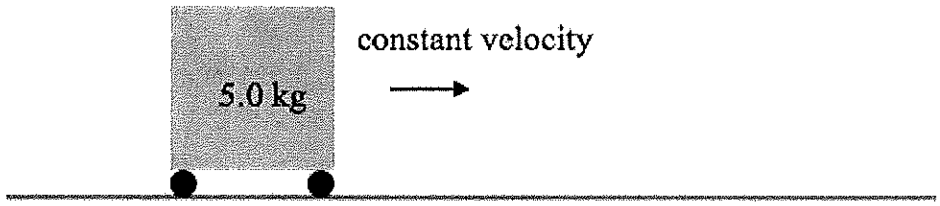
The correct answer is *e*. The wheelchair carries a total mass of 100kg up to a height of 10m, with 300J of Work being done by the wheelchair each second. The time for the total Work does is calculated as follows:

$$P = \frac{Work}{time}$$

$$time = \frac{Work}{Power} = \frac{mgh}{P}$$

$$time = \frac{(100kg)(10m/s^2)(10m)}{300J/s} = \frac{10000}{300} = 33s$$

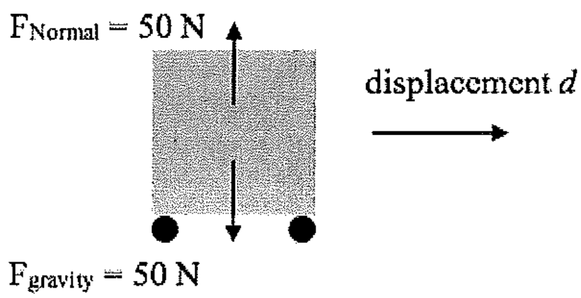
Question:



A set of frictionless wheels are attached to the bottom of a box, which is then measured and found to have a mass of 5.0 kg. The box is placed on the floor, and a student uses a brief horizontal force of 100 N to push the box sideways, after which the box rolls across the floor with constant velocity. How much Work does the floor do on the box as it rolls along?

a. 0 Joules
b. About 50 Joules
c. The answer can't be found without knowing how far the box traveled.
d. The answer can't be found without knowing how far the student pushed the box.
e. The answer can't be found without knowing the box's velocity.

Answer:
The correct answer is *a*.



Remember that the Work done on an object is found by multiplying the Force applied and the displacement of the object *in the same direction as the Force that was applied.*

Here, the forces acting on the box as it moves can be seen by drawing a free-body diagram of the box. Note that the Force applied by the floor–the Normal force–is upwards, while the displacement of the box is sideways. Because they are not in the same direction, there is no Work done by the floor on the box.

Another way of thinking about it is this: what is the displacement of the box *in the direction of the Force applied by the floor?* The floor is pushing up, but the box is clearly not moving up. Therefore, the floor is doing no Work on the box.

Question:

A computer and its monitor require 200-Watts of Power to operate. If the electric company charges 10 cents ($0.10) per kiloWatt-hour, how much does it cost to leave the computer on for a full 24-hour day?

a. About a quarter ($0.25)
b. About fifty cents ($0.50)
c. About a dollar ($1.00)
d. About two dollars ($2.00)
e. About five dollars ($5.00)

Answer:

The correct answer is ***b***. To solve this problem, we need to figure out how much energy the computer uses in one day, based on how much Power it uses.

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

Rearranging: $Energy = Power \times time$

What do the units for this new equation look like? The labels with square brackets around them below show two types of units for this relationship:

$$Energy = Power \times time$$

$$[Joules] = [Watts][seconds]$$

$$[kiloWatt \bullet hours] = [kiloWatts][hours]$$

We can calculate "energy in Joules" if we multiply "Power in Watts" times "time in seconds." OR, because the energy company charges us by the kiloWatt-hour, we can use the second set of units:

$$Energy = Power \times time$$

$$[kiloWatt \bullet hours] = [kiloWatts][hours]$$

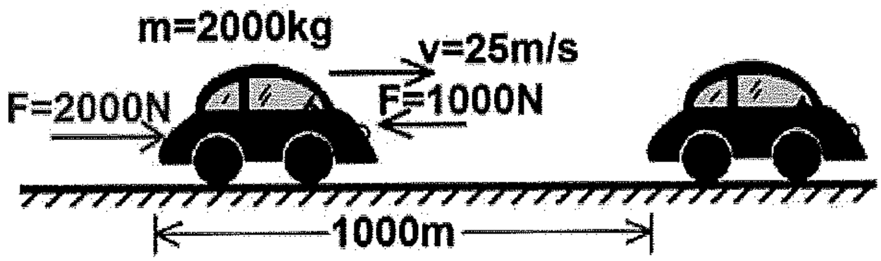
$$Energy = \left(200W \times \frac{1kW}{1000W}\right)\left(1day \times \frac{24hrs}{1day}\right)$$

$$Energy = 4.8kW \bullet hrs$$

At 10-cents per kWh, that comes out to be:

$$\frac{4.8kWh}{1} \times \frac{\$0.10}{1kWh} = \$0.48$$

Question:



Calculate the

a) total work done on the car.
b) power exerted by the car.

Answer:

a. 1.00×10^6 Nm
b. 2.50×10^4 Watts

Question:

A bucket of water with a total weight of 50 Newtons is lifted at constant velocity up a 10 meter deep well. If it takes 20 seconds to raise the bucket this distance, the Work done by the lifting force is:

a. 25 W
b. 25 J
c. 0 J
d. 50 J
e. 500 J

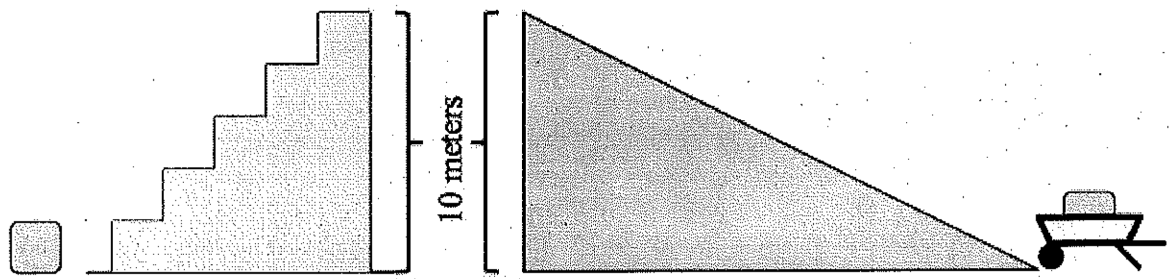
Answer:

The correct answer is *e*. Work done by a Force on an object is calculated according to the Work formula W=*F*•*x*, or W=*Fx* cos Ø. In this case:

$$W = F \bullet x$$

$$W = 50N \bullet 10m = 500J$$

Question:



Two large masses—the gray boxes in the diagram above—need to be lifted to the top of a 10-meter high platform. One student takes his box up the green stairs while another student uses a wheelbarrow to roll her box up a ramp. Which of the following statements is true?

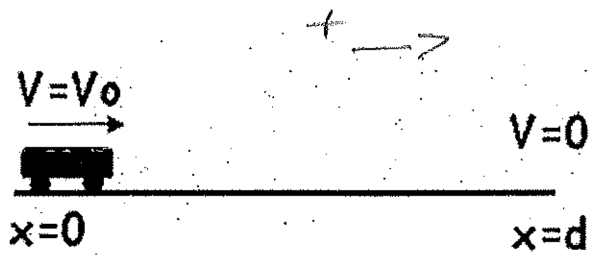
a. The student on the left does more Work because he applies a greater Force lifting up against gravity.
b. The student on the right does more Work because she has to travel a greater distance.
c. The student on the left does less Work because she travels a shorter distance overall.
d. Both students do the same Work because they apply the same Force in moving the masses.
e. Both students do the same Work because their different Forces act over different distances.

Answer:
The correct answer is *e*. The student going up the green stairs has to apply a greater force upwards against gravity while lifting the sack upwards 10 vertical meters. The student on the red ramp has to travel farther up the ramp, but is applying a smaller force in the process of pushing the wheelbarrow along the ramp. In the end, however, the amount of Work done by both students is the same.

$$\underbrace{\mathit{Work} = \mathbf{\mathit{Force}} \times \mathit{distance}}_{\text{Green stairs}} = \underbrace{\mathit{Force} \times \mathbf{\mathit{distance}}}_{\text{Red ramp}}$$

You can verify this by asking yourself how much gravitational potential energy each box has at the end. Because they have the same potential energy, the Work done to get them up there must be the same.

Question:



At the position of **X = 0** a 2 kg cart with an initial velocity of 5 m/s is acted upon by a frictional force between the wheels and horizontal surface causing the cart to stop after moving a distance **d**, as shown in the figure above. Apply the work-energy principle to find the stopping distance **d.**

The coefficient of friction is 0.20

Solution:

$$W = \Delta E_K \qquad (\Delta E_K \rightarrow -)$$

$$F_f d = E_{K_f}^{\nearrow 0} - E_{iK}$$

$$-F_f d = -\frac{1}{2} m v^2$$

$$-\mu F_N d = -\frac{1}{2} m v^2 \qquad (F_N = mg)$$

$$-\mu m g d = -\frac{1}{2} m v^2$$

$$d = \frac{\frac{1}{2} v^2}{\mu g}$$

$$d = 6.38\,m$$

Question:

Which of the following includes forms of mechanical energy only?

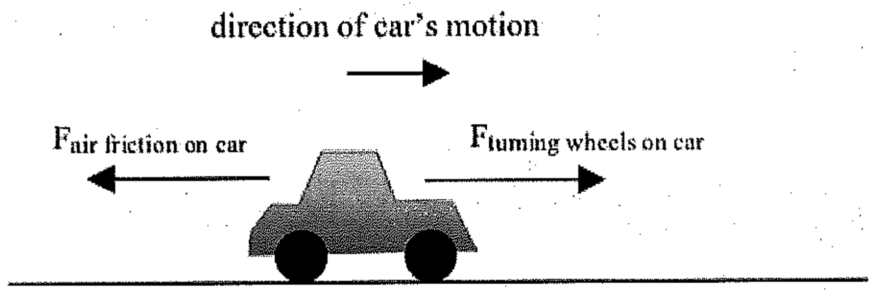
a. nuclear, gravitational potential, electric
b. magnetic, kinetic, elastic potential
c. kinetic, gravitational potential, chemical
d. thermal, kinetic, elastic potential
e. None of the above

Answer:

e. The three forms of mechanical energy include:

Kinetic – Gravitational Potential – Elastic Potential

Question:



A car is traveling in the positive-x direction as shown, driven forward by the Force of the road on the wheels, with air friction acting on the car to oppose its motion. If the car is traveling at a constant velocity, which statement is *false*?

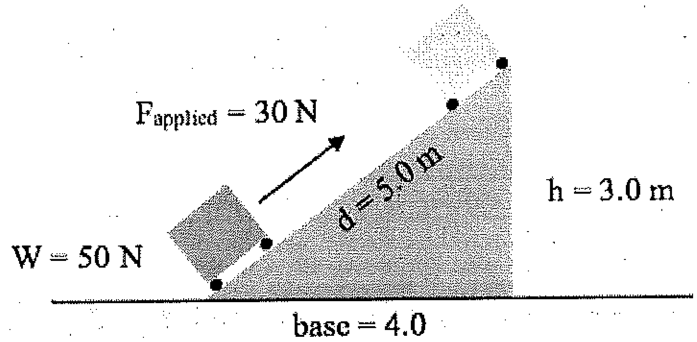
a. The force of the wheels on the car is greater than the force of air friction–that's why the car is moving.
b. The force of the road on the wheels is doing positive Work on the car.
c. The force of gravity is doing no Work on the car.
d. The kinetic energy of the car is constant.
e. There is no net Work being done on the car.

Answer:

The correct answer is ***a***. If the car is traveling at constant velocity, the forces acting on it must be balanced. Therefore, the Force between the tires and the road that propels the car forward and the opposing Force of air friction are, at this moment equal to each other.

The other statements are all true. The force of the road on the wheels is in the positive-x direction, and causing a displacement of the car in that same direction. Gravity is doing no Work on the car because gravity is pulling *down* while the car is displacing sideways. The kinetic energy of the car is constant because it is moving at constant velocity. Finally the road (via the wheels is doing positive Work on the car, but the force of air friction is doing negative Work on the car–thus the net Work being done on the car is zero.

Question:



A small cart with frictionless wheels has a weight of 50 N. A student uses a Force of 30 N to roll the cart up the ramp shown above. How much Work was done by the student in moving the cart to the top of the ramp?

a. 90 J
b. 150 J
c. 250 J
d. 120 J
e. 200 J

Answer:

The correct answer is ***b***. The student applied a force of 30 N while moving the cart in the direction of that force 5.0m. Therefore:

$$W = Fd$$

$$W = (30N)(5.0m)$$

$$W = 150J$$

Notice that this value is the same as the amount of GPE the cart has as it's sitting 3.0 meters above the ground:

$$GPE = mgh$$

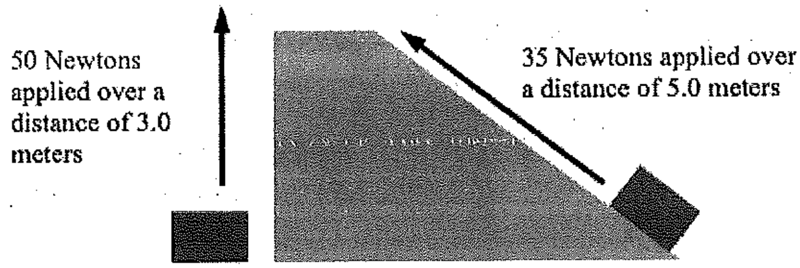
$$GPE = (mg)h = Wh$$

$$GPE = (50N)(3.0m)$$

$$GPE = 150J$$

There's an important lesson here: we do the same amount of Work when raising the box to that height above the ground, whether we lift it straight up or roll it up a ramp. One of the reasons we like to use ramps, though, is that *less force* is required–30 N here applied over a longer distance, instead of 50 N to lift straight up a shorter distance. Either way, the same amount of Work gets done, and the box has the same amount of gravitational potential energy based on the Work that we've done.

Question:



A 5.0-kilogram box is to be raised to the top of a 3.0-meter high platform. One student chooses to lift the block using a rope, applying a 50 Newton force over the 3.0 meter distance. The other student decides to push the box up a nearby ramp. There's some friction on the ramp, but a force of only 35 Newtons is required to move the box a distance of 5.0 meters. Which of the following statements is true?

a. Each student did the same amount of Work getting the box to the top of the ramp.
b. The student on the left did more Work because a greater Force was applied during the lifting.
c. The student on the left did less Work because the box was moved a shorter distance.
d. The student on the right did less Work because the ramp provides a mechanical advantage.
e. The student on the right did more Work because some energy was converted to heat via friction.

Answer:

The correct answer is *e*. The student on the left does less Work—a total of 150 Joules, based on $Work = Force \times distance$—and the student on the right does 175 Joules of Work. The ramp does provide a Mechanical Advantage to the student on the right—the Force that student has to apply to push the box up the ramp is reduced—but that student does end up doing a little more Work in the end, because some of it is "lost" to frictional heat.

Question:

A student applies a constant force of 30 Newtons while lifting a heavy physics book up into the air a distance of 1.5 meters. How much Work does the student do on the book?

a. 0 Joules, because gravity pulled down on the book
b. 4.5 Joules
c. 45 Joules
d. The answer can't be found without knowing the mass of the book
e. The answer can't be found without knowing the net Force on the book

Answer:

The correct answer is *c*. The Work done by a Force is calculated by multiplying the force applied in a direction, and the distance the object travels in that same direction.

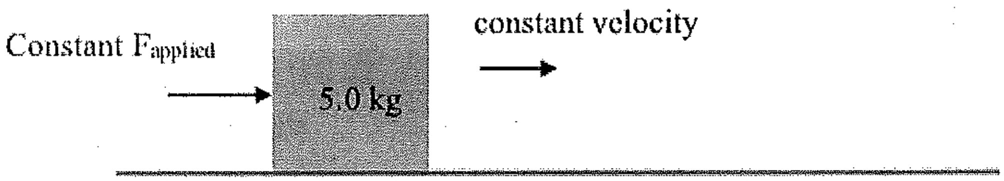
Here, we would calculate:

$$W = Fd$$

$$W_{done\ by\ student} = F_{applied\ by\ student}d$$

$$W_{student} = (30N)(1.5m) = 45J$$

Question:



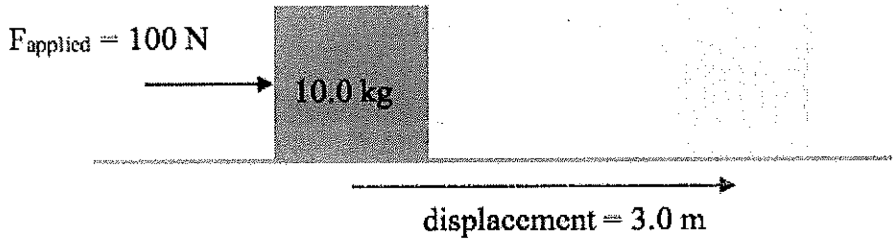
A 5.0 kg box resting on the floor is pushed with a constant horizontal force $F_{applied}$, and the box moves to the right with a constant velocity. Which statement below is *false*?

a. The net horizontal force on the box is zero.
b. There are forces acting in the vertical direction.
c. The magnitude of the force applied must equal the magnitude of the force of friction.
d. There is net Work being done on the box.
e. There is a friction force acting on the floor to the ~~right~~ left

Answer:
The correct answer is ***d***. There is no net Work being done on the box because there are no net Forces acting on the box. Another clue that there is no net Work being done is the fact that the box's kinetic energy KE is constant (because it's moving at constant velocity).

While it's true that the $F_{applied}$ is doing Work, the force of friction between the box and the floor is doing Work on the box as well, and "losing energy" via heat in the process.

Question:



A student uses a horizontal force of 100 N to push a 10.0 kg box across the floor for a total distance of 3.0 meters. The work done on the box by the student is

a. 1000 Joules
b. 300 Joules
c. 30 Joules
d. 10 Joules
e. You can't tell without knowing if there was friction in this problem.

Answer:
The correct answer is ***b***. The Work done on the box by the student can be calculated by multiplying the Force applied on the box and the distance the box moved in the direction the Force was applied.

$$W = Fd$$

$$W = (100N)(3.0m)$$

$$W = 300J$$

It's true that we don't know if there was any friction in this problem, so there are a few things about the box's motion that we can't yet figure out, like the box's acceleration or final velocity. But we ***are*** able to figure out how much Work the student is doing on the box–how much ***energy*** the student is transferring to the box–and that's what we've calculated here.

Question:

One *horsepower* is equal to 746 Watts. Based on rough estimates of appropriate values, what do you think is the maximum possible Power of a human being, in horsepower units?

a. A little more than one horsepower
b. About one horsepower
c. One-half horsepower
d. One-tenth horsepower
e. One-hundredth horsepower

Answer:

The correct answer is ***a***, at least according to the calculations down below. You may have come up with your own estimates. When it comes to solving problems like this, the important thing is to be able to make justifiable estimations that you can use to come up with an answer. Let's estimate some numbers and see.

A human being has a mass of about 50 kilograms (approximately), and can run 100 meters in approximately 10 seconds.

What's the average speed of the person? $v = d/t = (100m)/(10s) = 10m/s$

What's the final speed of the person? $v_{avg} = (v_i + v_f)/2;\ v_f = 20m/s$

What's the final Kinetic Energy of the person? $K = \frac{1}{2}mv^2 = \frac{1}{2}(50)(20)^2 = 10000J$

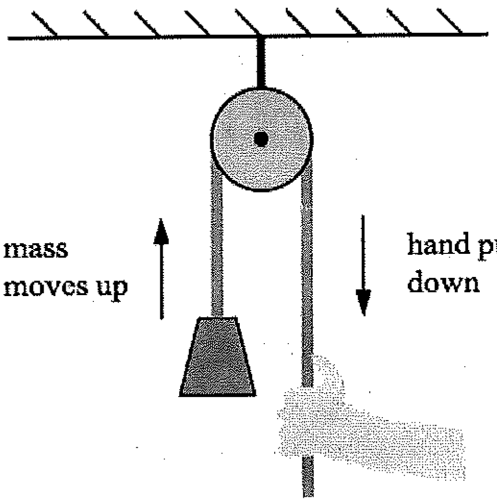
How much Work did their legs have to do to achieve this kinetic energy? $\sim 10000J$

How much Power did they use? $P = \frac{Work}{time} = \frac{10000J}{10s} = 1000W$

How does that relate to the Power of the horse? *It's a little* more *than one horsepower!*

In my example, the human being certainly couldn't keep up this speed for any great length of time, and if you did estimates based on the time it takes someone to run a 10,000 meter distance, your answer would have been quite a bit different from this one.

Question:



A light, frictionless pulley is suspended from the ceiling and a rope is wrapped over the pull. A large mass is attached to one end, and a student applies a force to the opposite end of the rope, pulling down in order to lift the mass up. Which of the following statements is *false*?

a. The force of the mass pulling down on the left rope is equal to the force of tension in that that rope pulling up on the mass.
b. The force of the hand pulling down on the right rope is equal to the force of tension in that rope pulling up on the mass.
c. The pulley in this case changes the direction of the force applied by the hand, but not the magnitude of the force.
d. The Work done by the hand is equal to the change in gravitational potential energy for the mass as it rises.
e. The tension in the right side rope is greater than the tension in the left side rope.

Answer:

The correct answer is *e*. That statement is false; the tension in the ropes on either side of the pulley are equal.

All of the other statements are true. The tension in ropes is what allows them to transmit forces from one place to another, and Newton's Third Law of Motion describes the "equal and opposite" nature of these forces. On the left side, the force of the rope up on the mass and the force of the mass down on the rope are "equal in magnitude, opposite in direction." The same thing is true of the right side: the hand pulls down on the rope, and the rope pulls up on the hand. The tension that occurs in the right-hand rope (due to the hand pulling down on it) is transmitted to the left-hand rope where it is applied to the mass. The strength of that tension force hasn't changed—it's only pulling up now where on the right side of the pulley it was pulling down.

Question:

A student carries a large rock up a hill, and in the process does 500 J of Work on the rock. The student then releases the rock from the top of the hill and watches it roll down the mountain. How much Work does gravity do on the rock as it's rolling down the hill?

a. -500 J
b. 500 J
c. 500 J – the energy lost to friction
d. 500 J – the rotational kinetic energy of the rock
e. none of these

Answer:
The correct answer is ***b***. The Work done by the gravity as the rock moves down the hill is exactly equal to the Work done in carrying it up the mountain, according to $W = F \bullet x$. It's true that the translational Kinetic energy of the rock after it has rolled down the hill will be somewhat less than it would be otherwise, due to both frictional "loss" of energy and the rotation of the rock, but this doesn't change the amount of work done by gravity.

Question:
A mass *m* is raised a vertical distance *d* in a time *t*, at constant speed *v*. How much Power was required to raise the mass?

a. $mgdt$

b. mgd

c. $\frac{mgd}{t}$

d. mg

e. $\frac{mgv}{t}$

Answer:
The correct answer is *c*. Use the definitions of Work and Power with the variables given to solve:

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

$$W = F \bullet d$$

$$P = \frac{F \bullet d}{t} = \frac{mgd}{t}$$

Question:

An elevator with a mass of 1000 kg has to be accelerated from rest, upwards at 4.0 m/s². 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 $28000Watts$, 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:

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

Question:

Which of the following is *not* a unit of Energy?

a. *kiloWatt•hour*
b. *Joule*
c. *Newton•meter*
d. $\frac{kilogram \bullet meter^2}{second^2}$
e. $\frac{kilogram^2 \bullet meter}{second}$

Answer:

The correct answer is *e*. A *Joule* is the SI unit for energy, typically calculated using the definition of Work-Energy:

$$Work = Force \bullet displacement$$

$$[Joule] = [N][m]$$

The *kiloWatt•hour* is *Power•time*, which can be seen to represent energy:

$$P = \frac{Work}{time} = \frac{Energy}{time} \Rightarrow Energy = Power \bullet time$$

All of the answers except for *e* can be reduced to the fundamental units that represent Energy.

$$Energy = Force \times displacement$$

$$Energy = [N][m] = \frac{[kg][m][m]}{[s]^2} = \frac{[kg][m]^2}{[s]^2}$$

Question:

A 1.0-kilogram ball and a 4.0-kilogram ball have the same kinetic energy. Which one is traveling faster, and by how much?

a. The 4.0-kilogram ball has twice the velocity of the 1.0-kilogram ball.
b. The 4.0-kilogram ball has four times the velocity of the 1.0-kilogram ball.
c. The 4.0-kilogram ball has half the velocity of the 1.0-kilogram ball.
d. The 4.0-kilogram ball has one-fourth the velocity of the 1.0-kilogram ball.
e. The 4.0-kilogram ball has one-ninth the velocity of the 1.0-kilogram ball.

Answer:

The correct answer is *c*. If the two balls have the same kinetic energy, but one has four times the mass of the other, then the *velocity-squared* of the more massive ball has to be one-fourth of the other's. In other words, it has to be traveling half as fast.

We can solve this analytically by setting up an equation using the kinetic energies of the balls.

$$K_4 = K_1$$

$$\frac{1}{2}m_4 v_4^2 = \frac{1}{2}m_1 v_1^2$$

$$\frac{1}{2}(4kg)v_4^2 = \frac{1}{2}(1kg)v_1^2$$

$$4v_4^2 = v_1^2$$

$$\sqrt{4v_4^2} = \sqrt{v_1^2}$$

$$2v_4 = v_1$$

Question:

An object of mass *m* moves horizontally, increasing in speed from 0 to *v* in a time *t*. The Power necessary to accelerate the object during this time period is:

a. $\frac{mv^2t}{2}$

b. $\frac{mv^2}{2}$

c. $2mv^2$

d. $v\sqrt{\frac{m}{2t}}$

e. $\frac{mv^2}{2t}$

Answer:

The correct answer is *e*. Power is defined as Work/time, and the Work here can be determined by looking at the change in kinetic energy:

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

$$P = \frac{K_f - K_i}{t}$$

$$P = \frac{\frac{1}{2}mv^2 - 0}{t}$$

$$P = \frac{mv^2}{2t}$$