Question:

Two students—Albert with mass 100kg and Bob with mass 50kg—walk up a long flight of stairs. Bob takes half as long to go up the stairs as Albert. Which of the following statements is true?

a. They did the same Work, but Albert used more Power because of his greater mass.
b. They did the same Work, but Albert used more Power because he took less time.
c. Albert did more Work because of his greater mass, but they used the same Power.
d. Bob did more Work because he used less time, but they used the same Power.
e. They did the same Work and the same Power.

Answer:

The correct answer is *c*. Albert has twice as much gravitational potential energy at the top of the stairs—gravitational potential energy = *mgh*—so he did twice as much Work to get up there. Bob did half the Work, but did it in half the time, so the Power he used turns out to be the same as Albert used:

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

$$Power_{Bob} = \frac{\frac{1}{2} Work_{Albert}}{\frac{1}{2} time_{Albert}} = Power_{Albert}$$

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:

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 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:

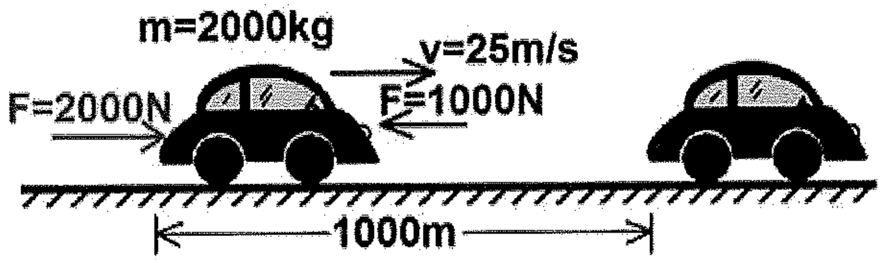
The correct answer is *c*. Use the definitions of Work and Power with the variables given to solve:

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

$$W = F \bullet d$$

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

Question:



Calculate the

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

Answer:

a. 1.00 x 10^6 Nm
b. 2.50 x 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 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:

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 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:

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