#205530

A geo-stationary satellite is orbiting around earth at height of 30,000 km in circular orbit. The radius of the earth is taken as 6000 km. The geo-stationary satellite comes back to its position after one revolution in exactly 24 hours. Let the acceleration due to gravity (g) be $10m/s^2$ and mass of satellite be 1000 kg; calculate the work done in 12 hours when moving under gravitational force.

A $3.6\pi \times 10^{14} J$

B $2\pi \times 7.2 \times 10^{14} J$

C $1.8\pi \times 10^{14} J$

D $0J$

Solution

Since F_g is perpendicular to displacement at each instant due to circular motion of satellite so,

Work done $= F.ds = 0$,

#419842

An electron and a proton are detected in a cosmic ray experiment, the first with kinetic energy $10keV$, and the second with $100keV$. Which is faster the electron or the proton? Obtain the ratio of their speeds. $(m_e = 9.1 \times 10^{-31} kg,\ m_p = 1.67 \times 10^{-27} kg, 1eV = 1.6 \times 10^{-19})J$

Solution

Electron is faster; Ratio of speeds is 13.54 : 1

Mass of the electron, $m_e = 9.11 \times 10^{-31} kg$

Mass of the proton, $m_p = 1.67 \times 10^{-27} kg$

Kinetic energy of the electron is

$E_e = 10keV = 10^4 eV$

$E_e = 10^4 \times 1.6 \times 10^{-19} = 1.60 \times 10^{-15} J$

Kinetic energy of the proton

$E_p = 100keV = 10^5 eV = 1.60 \times 10^{-14} J$

For the velocity of an electron v_e, its kinetic energy is given by the relation:

$$E_e = \frac{1}{2} mv_e^2 \Rightarrow v_e = \frac{2 \times 1.6 \times 10^{-15}}{9.11 \times 10^{-31}} = 5.93 \times 10^7 m/s$$

For the velocity of a proton v_p, its kinetic energy is given by the relation:

$$E_p = \frac{1}{2} mv_p^2$$

$v_p = 4.38 \times 10^6 m/s$

As the velocity of electron is more than that of proton, so electron is faster than proton.

The ratio of their speeds is $\frac{v_e}{v_p} = \frac{5.93 \times 10^7}{4.38 \times 10^6} = \frac{13.54}{1}$

#419845

A pump on the ground floor of a building can pump up water to fill a tank of volume 30 m^3 in 15 min. If the tank is 40 m above the ground, and the efficiency of the pump is 30%, how much electric power is consumed by the pump ?

Solution

Volume of the tank, $V = 30m^3$

Time of operation, $t = 15min = 15 \times 60 = 900s$

Height of the tank, $h = 40m$

Efficiency of the pump, $= 30\,\%$

Density of water, = $10^3 kg/m^3$

Mass of water, $m = 30 \times 10^3 kg$

Output power can be obtained as:

$P_0 = \text{Work done / Time} = mgh/t$

$= 30 \times 10^3 \times 9.8 \times 40/900 = 13.067 \times 10^3 W$

For input power P_i, efficiency is given by the relation:

=$P_o/P_i = 30\%$

$Pi = 13.067 \times 100 \times 10^3/30$

$= 43.6kW$

#419857

The blades of a windmill sweep out a circle of area A.

(a) If the wind flows at a velocity v perpendicular to the circle, what is the mass of the air passing through it in time t?

(b) What is the kinetic energy of the air?

(c) Assume that the windmill converts 25% of the winds energy into electrical energy, and that A = 30 m^2, v = 36 km/h and the density of air is 1.2 kg m^3. What is the electrical power produced?

Solution

(a)

Density of air $= \rho \ \ kg/m^3$

Time taken = t sec

Velocity of air = v m/s

Mass of the air = density $\times$ volume $= \rho Avt$

(b)

$$KE = \frac{1}{2}mv^2$$
$$= \frac{1}{2}(\rho Avt)v^2$$
$$= \frac{1}{2}(\rho Av^3 t)$$

(c)

Velocity, v= 36 km/hr = 10 m/s

$\rho = 1.2kg/m^3$

$A = 30m^2$

Work done = change in kinetic energy

$= \frac{1}{2} \times 1.2 \times 30 \times 10^3 t\ Nm$

$= 18000t\ J$

Power = $work/t = 18000W$

Efficiency = 25%

Actual power= $18000 \times 25/100 = 4500W$

#419876

A family uses 8 kW of power.

(a) Direct solar energy is incident on the horizontal surface at an average rate of 200 W per square meter. If 20% of this energy can be converted to useful electrical energy, ho

large an area is needed to supply 8 kW?

(b) Compare this area to that of the roof of a typical house.

Solution

(a) Usable power per square meter=$8 \times 10^3 W$

Solar energy received per square metre = $200W$

Efficiency of conversion from solar to electricity energy = 20%

Area required to generate the desired electricity is A.

As per the information given in the question, we have

$$8 \times 10^3 = \frac{20}{100} A \times 200$$

$$A = 200m^2$$

(b) The area of a solar plate required to generate 8 kW of electricity is almost equivalent to the area of the roof of a building having dimensions 14 m x 14 m. (close to 200 sq m)

#464552

Look at the activities listed below. Reason out whether or not work is done in the light of your understanding of the term 'work'.

- Suma is swimming in a pond.
- A donkey is carrying a load on its back.
- A wind-mill is lifting water from a well.
- A green plant is carrying out photosynthesis.
- An engine is pulling a train.
- Food grains are getting dried in the sun.
- A sailboat is moving due to wind energy.

Solution

Work done $W = \vec{F}.\vec{S} = FScos\theta$ where θ is the angle between $\vec{F}$ and $\vec{S}$

(A) : While swimming, Suma pushes the water in the backward direction and as a result of Newton's 3rd law of motion, the water applies an equal force on Suma in forward direction. Hence Suma swims in the forward direction.

$\therefore$ In this case, $\theta = 0^o$ $\implies W = FScos0^o = FS$

(B) : Donkey applies a force in the vertical direction to carry the load and its displacement is in the horizontal direction, thus $\theta = 90^o$ in this case.

$\implies W = FScos90^o = 0$

(C) : Wind-mill applies a force in the vertical direction to lift the water from well and the water also moves in the vertical direction.

$\therefore$ In this case, $\theta = 0^o$ $\implies W = FScos0^o = FS$

(D) : During photosysnthesis, all the matabolic reactions take place inside the leaf of the plant, but there is no displacement either of the plant or the leaves.

$\therefore S = 0$ $\implies W = 0$

(E) : While pulling, the engine applies a force in the forward direction on the train and the train also moves in the forward direction.

$\therefore$ In this case, $\theta = 0^o$ $\implies W = FScos0^o = FS$

(F) : When the food grains are getting dried in the sun, they remain still at their position i.e the food grains do not get displaced.

$\therefore S = 0$ $\implies W = 0$

(G) : Wind applies a force on the sailboat in the forward direction making the boat to move in the direction of force.

$\therefore$ In this case, $\theta = 0^o$ $\implies W = FScos0^o = FS$

#464553

An object thrown at a certain angle to the ground moves in a curved path and falls back to the ground. The initial and the final points of the path of the object lie on the same horizontal line. What is the work done by the force of gravity on the object?

Solution

Work done by the force of gravity on the object is equal to the negative of the change of potential energy of the object.

$W_g = -\Delta P.E$

$W_g = -(mgh_2 - mgh_1)$ OR $W_g = -mg(h_2 - h_1)$

But as the object lies on the same horizontal line of the ground i.e $h_1 = h_2 = 0$

$\implies W_g = 0$

Thus work done by gravity force on the object is zero.

#464554

A battery lights a bulb. Describe the energy changes involved in the process.

Solution

While lighting a bulb through a battery, the chemical energy of the battery gets converted into the electric energy which further gets converted into light energy along with hea energy. That is why after lighting a bulb for some time, it gets heated up.

One form of energy can be transformed to another form but it cannot be created or destroyed.

$\text{Chemical energy} \rightarrow \text{Electric energy} \rightarrow \text{Light energy} + \text{Heat energy}$

#464555

Certain force acting on a 20 kg mass changes its velocity from $5\ ms^{-1}$ to $2\ ms^{-1}$. Calculate the work done by the force.

Solution

Given : Initial velocity $u = 5\ ms^{-1}$

Final velocity $v = 2\ ms^{-1}$

From work-energy theorem, $W = \Delta K.E$

$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$W = \frac{1}{2} \times 20 \times 2^2 - \frac{1}{2} \times 20 \times 5^2$

$\implies W = -210\,J$

#464556

A mass of 10 kg is at a point A on a table. It is moved to a point B. If the line joining A and B is horizontal, what is the work done on the object by the gravitational force? Explair your answer.

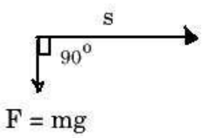
Solution

Workdone $W = \vec{F}.\vec{S} = FScos\theta$

But here the displacement is perpendicular to the gravitational force i.e $\theta = 90^o$

$\therefore W = FS\,cos90^o$

$\implies W = 0$



#464557

The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy? Why?

Solution

No, it does not violate the law of conservation of energy.

According to conservation of energy, $E_{Total} = P.E + K.E$

Thus for a freely falling object, its potential energy decreases but kinetic energy increases in such a way that its total mechanical energy remains constant.

Moreover, potential energy of a freely falling object is converted into its kinetic energy.

No, because we know that loss in potential energy is equal to gain in kinetic energy and if the object will fall freely it's potential energy will reduce but simultaneously its kinetic energy will increase. Therefore we can say the total mechanical energy will be conserved during the entire process.

According to law of conservation of energy, ENERGY CAN NEITHER BE CREATED NOR BE DESTROYED.

We Know, that Potential Enery $= m \times g \times h$

So, from above we can see that as the object falls its Height decreases and hence its P.E decreases, However There is also kinetic energy,

K.E $= \frac{1}{2} \times m \times v^2$

Hence as the object falls its velocity increases and therefore K.E also increases.

So, we can conclude that for a freely falling object the P>.E decreases and K.E increases, and therefore law of conservation of energy is not violated.

#464558

What are the various energy transformations that occur when you are riding a bicycle?

Solution

When a rider is riding a bicycle, he is using his muscular energy to drive the bicycle, which gains some speed, also heat is generated in the body due to use of muscular energy(physical activity)

So, we can conclude that Muscular Energy of our body is converted to Heat energy and Kinetic energy

When a person is riding a bicycle, the muscular energy gets converted into heat energy of the body of the person as well as in kinetic energy of the bicycle. The kinetic energ makes the bicycle to move whereas the heat energy heats up the body of the person.

$$Muscular\, energy \rightarrow \; Kinetic\;\; energy \; + \;\; Heat\;energy$$

#464559

Does the transfer of energy take place when you push a huge rock with all your might and fail to move it? Where is the energy you spend going?

Solution

When a person tries to push a huge rock but fails to move it, then no energy of the person is transferred to the rock as it remains still and thus do not gain any kinetic energy. Actually the muscular energy of person is converted into heat energy which heats up the person's body. Thus he gets exhausted.

When we push a huge rock and fail to move it, then no transfer of energy takes place.

The muscular energy used by our body fails to move the rock, however that energy is used to heat the body.

No, the transfer of energy will not take place when we push a huge rock and fail to move it.

No loss of energy will take place because the applied muscular energy will be converted into heat energy which will heat up the body.

#464560

A certain household has consumed 250 units of energy during a month. How much energy is this in joules?

Solution

Energy consumed by certain households in a month $E = 250$ units $= 250\, kWh$

$\therefore E = 250 \times 3.6 \times 10^6\, J$ $(\because 1kWh = 3.6 \times 10^6 J)$

$\implies E = 9 \times 10^8$Joules

We know that $1Unit = 1KWh$

So, $250unit = 250kwh$

Also we know that, $1kwh = 3.6 \times 10^6 J$

$\Rightarrow 250kwh = 250 \times 3.6 \times 10^6 J$

$\Rightarrow 9 \times 10^8 J$

$1\ unit = 1kWh$

$1kWh = 3.6 \times 10^6 J$

Energy consumed for 250 units=$250 \times 3.6 \times 10^6 = 9 \times 10^8 J$

#464561

An object of mass 40 kg is raised to a height of 5 m above the ground. What is its potential energy? If the object is allowed to fall, find its kinetic energy when it is half-way dow

Solution

Given : Mass of the object $M = 40kg$

Height upto which it is raised $h = 5$ m

Potential energy $P.E = Mgh$

$P.E = 40 \times 10 \times 5 = 2000J$

Let its kinetic energy be E_k when it is half way down i.e $h' = \frac{h}{2}$

According to conservation of energy, $K.E_i + P.E_i = K.E_f + P.E_f$

$0 + 2000 = E_k + Mg\frac{h}{2}$

$\therefore\ 2000 = E_k + 40 \times 10 \times \frac{5}{2}$

$\implies E_k = 1000J$

Given:

mass=40kg

height=5m

$P.E = mgh = 40 \times 9.8 \times 5 = 1960J$

We know that loss in potential energy is equals to gain in kinetic energy.

$mgh - mgh/2 = K.E.$

$K.E. = mgh/2 = 980\ J$

We know that P.E $= m \times g \times h$

Where $m = mass$

$g = accelerationduetogravity = 9.8m/s^2$

$h = height$

So, P.E $= 40 \times 9.8 \times 5 = 1960J$

So, when object is at half way , $h = 2.5m$

So, P.E at 2.5 m $= 40 \times 9.8 \times 2.5 = 980J$

Since according to conservation of energy we know, Total energy will remain the same at any given point.

So the rest of the energy is converted to K.E.

So, K.E at 2.5 m $= 1960 - 980 = 980J$

#464562

What is the work done by the force of gravity on a satellite moving round the earth? Justify your answer.

Solution

We know that Work Done$= F \times s \times \cos\theta$

As a satellite revolves around the earth

(a) It has a force of gravity acting at the center of the earth

(b) Also, it moves in a horizontal path.

So, the direction of satellite of force of gravity are perpendicular to each other.

So, $\cos\theta = \cos 90^o = 0$

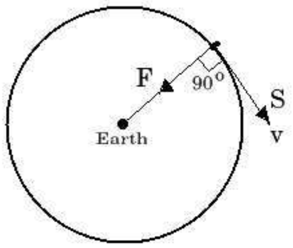
So, Work done also $= 0$

When a satellite revolves around the earth in circular orbit, the earth applies a gravitational force on the satellite in direction towards the centre of earth but the satellite moves tangential direction to the orbit. Thus the force and displacement vectors are perpendicular to each other i.e $\theta = 90^o$

Work done by gravitational force $W = \vec{F}.\vec{S} = FScos\theta$

$W = FScos90^0$ $W = 0$

Hence the work done by force of gravity on the satellite is Zero.



#464563

Can there be displacement of an object in the absence of any force acting on it? Think. Discuss this question with your friends and teacher.

Solution

For an object moving with uniform velocity, the displacement takes place in the body along the direction of motion but net force acting on it must be zero. This is according to Newton's first law of motion.

When a object moves with a constant velocity (v), then it gets displaced in the direction of motion but the net external force experienced by the object is zero.

$F_{external} = ma$

But $a = 0$ $\implies F_{external} = 0$

Using $s = ut + \frac{1}{2}at^2$

$\implies$ Displacement $s = ut$ $(\because a = 0)$

Hence, an object can have a displacement in the absence of any external force acting on it.

#464564

A person holds a bundle of hay over his head for 30 minutes and gets tired. Has he done some work or not? Justify your answer.

Solution

A person standing still carrying a bundle of hay over his head applies a force on the bundle in the upward direction but the displacement of the bundle is zero, thus the work done by the person is zero.

$W = \vec{F}.\vec{S} = FS\ cos\theta$ where θ is the angle between $\vec{F}$ and $\vec{S}$

But as $S = 0$ $\implies W = 0$

Moreover, the muscular energy of the person gets converted into the heat energy which heats up his body and the person gets tired.

Here, when a person holds a hay over his head,

The displacement of the hay, $s = 0$

So, Work Done$= Fs\cos\theta = 0$

#464565

An electric heater is rated 1500 W. How much energy does it use in 10 hours?

Solution

$1500W = 1.5KW$

So, Energy consumed $= 1.5KWH \times 10Hr$

$\Rightarrow 15KWh$

Time for which the heater is used $t = 10$ hours $= 10 \times 3600$ s $= 36000$ s

Energy consumed by the heater $E = P \times t$ where P is the power of the heater

$\therefore$ $E = (1500)$ W $\times 36000$ s

$\implies E = 5.4 \times 10^7$ J

$E = 15\ \ kWh$ $(\because 1kWh = 3.6 \times 10^6 J)$

#464566

Illustrate the law of conservation of energy by discussing the energy changes which occur when we draw a pendulum bob to one side and allow it to oscillate. Why does the bob eventually come to rest? What happens to its energy eventually? Is it a violation of the law of conservation of energy?

Solution

We, know that according to law of conservation of energy, energy can neither be created nor be destroyed, but it can be converted from one form to another.

In case of a pendulum.

(a) When the bob moves from Position P to B, it attains some height increasing the P.E , meanwhile the kinetic energy gradually decreases and becomes Zero at B. SO, at B onl P.E is present.

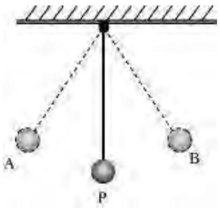
(B) now when the bob starts moving from B to P its P.E decreases gradually and at P all of potential energy is converted to K.E.

(c) At Point A same as Point B.

The bob comes to a rest as while it is yin motion there is the resistance of the air i.e air friction that keeps decreasing the K.E and eventually it comes to a stop.

The K.E of the pendulum is passed on the surrounding environment as its movement is affected by Air Friction.

So, there is no violation of Conservation of energy



Law of conservation of energy state that energy can neither be created nor be destroyed it can only be converted into one form to another form.

Now, let us consider a pendulum in which to and fro motion will take place. When pendulum bob moves from its rest position (mean position) to another extreme position its kinetic energy will be converted into potential energy when it is raised at some height 'h'. Now when it come back to its mean position, then its potential energy will be converted into kinetic energy and this phenomenon will take place again and again.

The bob will eventually come to rest due to the frictional resistance offered by air on the surface of bob and pendulum loses its kinetic energy to overcome this friction and finally comes to rest.

The law of conservation of energy is not violated because the kinetic energy loss by pendulum to overcome the friction is gained by surrounding, So total energy of system wil remain conserved.

#464567

An object of mass, m is moving with a constant velocity, v. How much work should be done on the object in order to bring the object to rest?

Solution

When a object is moving with a constant velocity, it possess K.E

$K.E = \frac{1}{2} \times m \times v^2$

So, in order to bring the object to rest i.e its same magnitude of energy is required so, as the final final energy comes to zero.

So, magnitude of work that needs to be done $= \frac{1}{2} \times m \times v^2$

Initial velocity of the object $= v$

Final velocity of the object $= 0$

Using work-energy theorem : $W_{all forces} = \Delta K.E$

$$W = \frac{1}{2}m(0)^2 - \frac{1}{2}mv^2$$
$$\implies W = -\frac{1}{2}mv^2$$

#464568

Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h?

Solution

When a object is moving with a constant velocity, it possess K.E

$K.E = \frac{1}{2} \times m \times v^2$

So, in order to bring the object to rest i.e its same magnitude of energy is required so, as the final final energy comes to zero.

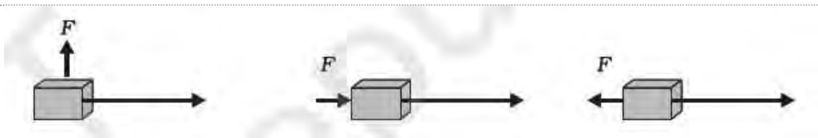
So, magnitude of work that needs to be done $= \frac{1}{2} \times m \times v^2$

$60km/hr = 16.66m/s$

So, work required to stop the car $= \frac{1}{2} \times 1500 \times 16.66^2$

$\Rightarrow = 208166.7J = 208.17kJ$

#464569



In each of the following a force, F is acting on an object of mass, m. The direction of displacement is from west to east shown by the longer arrow. Observe the diagrams carefully and state whether the work done by the force is negative, positive or zero.

Solution

Workdone $W = \vec{F}.\vec{S} = FScos\theta$ where θ is the angle between $\vec{F}$ and $\vec{S}$

For (a) : $\theta = 90^o$

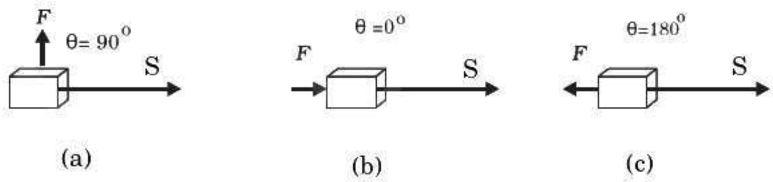
$\therefore W = FS\,cos90^o = 0$

For (b) : $\theta = 0^o$

$\therefore W = FS\,cos0^o = FS > 0$

For (c) : $\theta = 180^o$

$\therefore W = FS\,cos180^o = -FS < 0$



#464571

Find the energy in kWh consumed in 10 hours by four devices of power 500 W each.

Solution

$500W = 0.5KW$

As there are 4 devices , so tital power consumed =$= 0.5 \times 4 = 2KW$

S. total energy consumed $= 2 \times 10 = 20KWh$

Power of each device, $P = 500\ W = 0.5\ kW$

Time for which the devices are used, $t = 10\ hours$

Thus energy consumed by 4 devices, $E = 4 \times P \times t$

$E = 4 \times 0.500 \times 10\ kWh$

$\implies E = 20\ kWh$

#464572

A freely falling object eventually stops on reaching the ground. What happens to its kinetic energy?

Solution

We know that,

$P.E = m \times g \times h$

$K.E = \frac{1}{2} \times m \times v^2$

So, when a body is at a height it possess only potential enegy.

As it starts falling down, its potential energy decreases and kinetic energy increases. So, at the ground level it has maximum kinetic energy and potential energy becomes zerc

As the object hits the ground its Kinetic energy is converted to heat and sound energy and Some energy is used it changing the shape of the object or ground(depends on typ of ground).

We know that energy can neither be created nor be destroyed. It can only be transformed from one form to another.

When an object falls freely, its potential energy gets converted into kinetic energy and when the object hits the ground its kinetic energy gets converted into heat energy and sound energy.