

Chapter 1. Force, Work, Energy and Power

PAGE NO-10:

Solution 1

A force is that physical force which changes or tends to change the state of rest or state of motion of the body. It can start or stop the body. It can change the speed or direction or both of body. It can bring about change in dimensions of the body.

Solution 2

Contact forces are forces which come into play when the bodies come into physical contact with each other, e.g. frictional forces, force of normal reaction. These forces are produced by way of action and reaction.

Solution 3

Non-contact forces are forces which act on the bodies through the empty space without coming into any physical contact. Also known as action at a distance force or field forces, for example: gravitational forces, electrostatic forces.

Solution 4

- (i) We push a door to close it.
- (ii) A railway engine pulls a train
- (iii) The force that a passenger applies to put a luggage on the platform into the train is a lifting force.
- (iv) When we try to move heavy roller, it resists our effort to move it.

Solution 5

When a normal spring held between the hands is pulled outward, we stretch it.

Solution 6

we push a piston fitted inside a cylinder containing gas, we compress the gas.

Solution 7

1 kgf = 9.8 newton

Solution 8

The SI unit of force is 'newton'.

One newton is the force which when acts on a body of mass 1kg, produces an acceleration of



1ms^{-2} , i.e.

$1\text{ newton} = 1\text{ kg} \times 1\text{ms}^{-2}$

Solution 9

In CGS system, the unit of force is 'dyne'.

$1\text{ newton} = 1\text{kg} \times 1\text{ ms}^{-2}$

$= 1000\text{ g} \times 100\text{ cms}^{-2}$

$= 10^5\text{ dyne}$

Solution 10

$1\text{ kgf} = 9.8\text{ newton}$

Solution 11

When a balloon is inflated the force of air inside changes its shape or size.

Solution 12

The magnitude of a non-contact force depends upon the distance between the two objects.

Solution 13

When the resultant of a group of forces acting on the same object is zero, the forces are said to be balanced. Balanced forces do not change the speed of stationary objects. They may deform objects.

e.g. An iron ball suspended from a hook by a wire, a book kept on a table.

Solution 14

When the resultant of a group of forces acting on the same object is not equal to zero, the forces are said to be unbalanced. An unbalanced force changes the state of constant velocity including zero velocity of a body on which it acts.

e.g. If you push a ball, it starts to roll; Applying a force to stop a cricket ball.

Solution 15

(i) Contact force

(ii) Non-contact force

(iii) Contact force

(iv) Non-contact force

(v) Non-contact force

Solution 16

$1\text{ kgf} = \text{force due to gravity on } 1\text{ kg mass}$

= 1 kg mass x acceleration due to gravity g in ms^{-2}
= g newton
1 kgf = 9.8 newton

Solution 17

It means that 1 kgf or one kilogramme force is the force due to gravity on 1 kilogram mass.

Solution 18

Effects a force can produce and examples:

1. Change the state of rest; e.g. pushing a door to open it or close it.
2. Change the state of motion; e.g. applying a force to stop the cricket ball.
3. Change the direction of motion and not speed; e.g. when a force is applied to move a body in a circular path with uniform speed there is only a change in direction of motion but speed remains constant.
4. Change both speed and direction of motion; e.g. when a body is swirled in the vertical circle its direction of motion and speed changes at every point.
5. Change the dimension; when a balloon is inflated the force of air inside changes its shape or size.

PAGE NO-21:

Solution 1

The turning effect produced by a force on a rigid body about a point, pivot or fulcrum is called the moment of force or torque. It is measured by the product of force and the perpendicular distance of the pivot from the line of action of force. $\text{Moment of a force} = \text{Force} \times \text{perpendicular distance of the pivot from the force}$. Its SI unit is newton-metre (Nm).

Solution 2

The moment of force is a vector quantity.

Solution 3

Torque

Solution 4

When some force is applied on a rigid body free to move and the body starts moving along a straight path in the direction of force. This is known as linear or translational motion. Points on the rigid body, undergo displacements forming parallel lines and magnitude of displacement is the same for individual point. e.g. the motion of a bullet fired from a gun, a ball thrown straight up and falling back straight down.



Solution 5

If a rigid body is pivoted at a point, then the applied force will rotate the body about the fixed point or about the axis passing through the fixed point. This motion is called rotational motion. e.g. Earth's rotation about its axis, wheels of car in motion.

Solution 6

$$1 \text{ Nm} = 10^7 \text{ dyne cm}$$

Solution 7

The factors on which the moment of force about a point depends are: 1. The magnitude of force applied. 2. The distance of the line of action of the force from the axis of rotation.

Solution 8

If the turning effect on the body is clockwise, moment of force is called the clockwise moment and is taken as negative. If the turning effect on the body is anticlockwise, moment of force is called the anticlockwise moment and is taken as positive.

Solution 9

(i) If a rigid body is free to move, the applied force will cause translational motion. (ii) If a rigid body moves around a center or is pivoted at a point, the applied force will cause rotational motion.

Solution 10

This is so because near the free end, the distance of the point of application of force from the axis of rotation becomes maximum, so the torque ($= \text{Force} \times \text{perpendicular distance of the pivot from the force}$) is very large and hence it is easier to open the door.

Solution 11

A long handle facilitates increased torque with small application of force; hence a spanner has a long handle.

Solution 12

A body is said to be in equilibrium under the action of a number of forces, if the forces are not able to produce any change in the state of rest or of uniform motion or uniform rotation. Equilibrium is a state of zero acceleration.

Solution 13

(i) The conditions for static equilibrium are:

(a) The sum of the (vector) forces must equal zero, i.e. $\sum F = 0$

(b) The sum of the torques must equal zero; i.e. $\sum \tau = 0$.

(ii) The conditions for dynamic equilibrium are:

(a) The body should have a broad base.

(b) Centre of gravity of the body should be as low as possible.

(c) Vertical line drawn from the centre of gravity should fall within the base of the support.

Examples: Static equilibrium: a box at rest on a floor; there is a gravitational force pulling the object to the earth, but there is also an equal and opposite force applied by the floor to the box (pushing up).

Dynamic equilibrium: A rock travelling across the cosmos, far enough away from any other object (so as not to be affected by gravity – in other words, in zero gravity conditions); the rock continues to travel in a straight line at uniform velocity either for eternity, or until acted upon by an external unbalanced force.

Solution 14

Conditions for equilibrium:

(a) Vector sum of forces acting on the body should be zero.

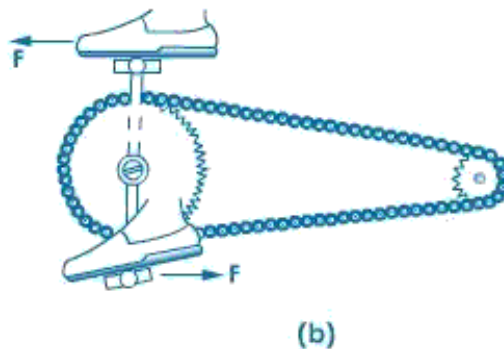
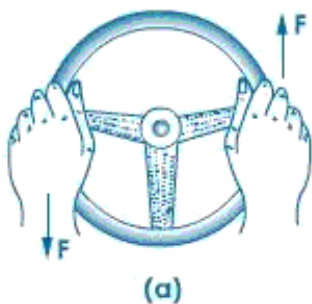
(b) Algebraic sum of moments acting on the body should be zero.

Solution 15

Principle of moments: If a body is in equilibrium under the action of number of force, then the sum of clockwise moments is equal to the sum of anticlockwise moments.

Solution 16

Rotating forces : couples



Solution 17

Examples of couple action in daily life:

(i) Opening and closing the cap of a bottle

(ii) Turning a key in a lock

Solution 18

(i) Force 'R' has the least moment about 'O' because its perpendicular distance is least from

'O'.

(ii) Force 'P' has the maximum moment about 'O' because its perpendicular distance is maximum from 'O'.

PAGE NO-22:

Solution 19

Two equal and opposite parallel forces acting along different lines on a body constitute a couple. Effect of couple: It produces angular acceleration.

Solution 20

The turning effect of a couple is called the moment of couple and is calculated by the product of either of the forces and the perpendicular distance between them. Its SI unit is Nm.

Solution 21

Given, applied force, $F = 20 \text{ N}$

Distance from the pivot, $d = 40 \text{ cm} = 0.4 \text{ m}$

Torque $= F \times d = 20 \times 0.4 = 8 \text{ Nm}$

Solution 22

Moment of force, torque, $\tau = 4 \text{ Nm}$

Applied force, $F = 10 \text{ N}$

Distance from pivot, $d = ?$

$\tau = F \times d$

$\Rightarrow d = \tau / F = 4 / 10 = 0.4 \text{ m}$

Solution 23

Given force applied by a mechanic, $F = 200 \text{ N}$

length of lever, $d = 50 \text{ cm} = 0.5 \text{ m}$

\therefore Torque, $\tau = F \times d = 200 \times 0.5 = 100 \text{ Nm}$

Now, if the mechanic applies a force, $F' = 50 \text{ N}$

let d' be the length of the lever to produce the same torque.

then, $\tau = F' \times d'$

$$\Rightarrow d' = \frac{100}{50} = 2 \text{ m}$$

Solution 24

Conditions of equilibrium for a rigid body:

1. The body should have a broad base.
2. Center of gravity of the body should be as low as possible.
3. Vertical line drawn from the center of gravity should fall within the base of support.
4. Vector sum of forces acting on the body should be zero.
5. Algebraic sum of moments acting on the body should be zero.

PAGE NO-25:

Solution 1

When a particle moves with a constant speed in a circular path, its motion is said to be the uniform circular motion.

Solution 2

In uniform circular motion, a particle travels equal distances along the circular path in equal intervals of time, so the speed of particle is uniform. But the direction of motion of the particle changes at each point of circular path. Due to continuous change in direction of motion, the velocity of the particle is not uniform (or velocity is variable) i.e., the motion is accelerated.

Solution 3

Centripetal force: The force acting on a body moving in a circular path. It acts along the radius of the circle and towards its centre.

Solution 4

The SI unit of centripetal force is newton (N).



Solution 5

Centrifugal force is not a real force, but it is considered to describe (understand) a certain motion. It should not be considered as the force of reaction of centripetal force, although its magnitude is same as that of centripetal force.

Solution 6

In uniform linear motion, the velocity is constant and acceleration is zero i.e., the uniform linear motion is an un-accelerated motion, while in a uniform circular motion the velocity is variable (although speed is uniform), so it is an accelerated motion.

Solution 7

The force needed for circular motion is 'centripetal force'. This force is always directed towards the centre of circle at each point of its path.

Solution 8

(b) speed

Solution 9

Yes, it is an accelerated motion.

Solution 10

No, the earth moves round the sun with a variable velocity. Since the direction of motion changes at each and every point the velocity becomes variable.

Solution 11

Centripetal force has a reaction force in accordance with the Newton's third law of motion. This oppositely directed force is called centrifugal force.

Solution 12

Centrifugal force acts away from the centre of circular path.

PAGE NO-38:

Solution 1

A fixed pulley is used to change the direction of effort to a convenient direction.



Solution 2

A machine whose efficiency is 100% is referred to as an ideal machine.

Solution 3

$$\text{Efficiency} = \frac{\text{Mechanical advantage}}{\text{Velocity ratio}}$$

Solution 4

No, a machine cannot be 100% efficient because mechanical advantage is always less than theoretical mechanical advantage due to friction and the weight of the moving parts.

Solution 5

Velocity ratio is defined as the ratio of velocity of the effort (V_E) to the velocity of the resistance force (load) (V_L).

It is also defined as the ratio of the displacement of the effort to the displacement of the load. Mathematically, we have:

$$V.R. = \frac{V_E}{V_L} = \frac{d_E}{d_L}$$

Since velocity ratio is the ratio of two similar quantities, therefore, it does not have a unit.

Solution 6

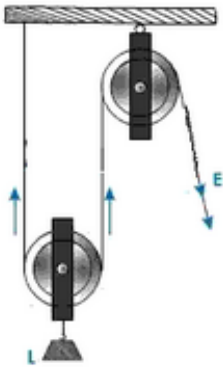
The purpose of a machine is: (i) To multiply force (ii) To obtain a gain or decrease in speed (iii) To change to direction of application of force in a convenient direction

Solution 7

(i) A jack is used to multiply force. (ii) A lever is used to change the point of application of force. (iii) A pulley is used to change the direction of application of force. (iii) Gears are used to multiply speed.

Solution 8

(i)



(ii) The purpose of the pulley Q is to change the direction of application of effort to a convenient direction.

(iii) In the given diagram, $T = E$.

(iv) If the free end of the string moves, through the distance x , the load will rise by a distance $x/2$.

Therefore, V.R. = distance moved by the effort arm / distance moved by the load = $\frac{x}{x/2} = 2$

(v) In equilibrium, $L = 2T$ and $E = T$

Efficiency = M.A. / V.R.

$$\text{Or, } 1 = \frac{M.A.}{2}$$
$$\Rightarrow M.A. = 2$$

$$\text{(vi) } M.A. = \frac{L}{E}$$
$$\Rightarrow E = \frac{L}{M.A.} = \frac{100}{2} = 50N$$

Solution 9

A block and tackle system of pulleys consists of two blocks of pulleys, each block having one or more than one pulley. The upper block of pulleys is fixed to a rigid support and the lower block of pulleys is movable. The number of pulleys in the movable block is either equal to or one less than the number of pulleys in the fixed block.

Solution 10

When a single pulley is used with a mechanical advantage greater than 1, the effort has to be applied in the upward direction.

Solution 11

In a single fixed pulley, if the effort moves by a distance 'y' downwards, the load moves by a distance 'y' upwards because the velocity ratio of a single fixed pulley is 1.

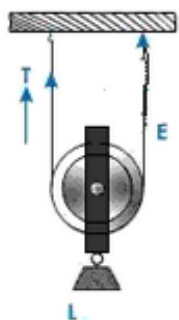


Solution 12

A pulley whose axis of rotation is not fixed in position or space is called a movable pulley. Ideally, its M.A. is 2.

Solution 13

Single movable pulley acts as a force multiplier.



Solution 14

(i) In a single fixed pulley, some effort is wasted in overcoming friction between the strings and the grooves of the pulley; so the effort needed is greater than the load and hence the mechanical advantage is less than the velocity ratio.

(ii) The two reasons are:

(a) Some effort is wasted in overcoming the friction between the strings and the grooves of the pulley.

(b) Some effort is wasted in lifting up the movable block along with the load.

On account of the above two reasons, the M.A. is always less than the V.R. Hence efficiency is always less than 100%.

(iii) In a block and tackle system, if the total number of pulleys used in both the blocks is 'n' and the effort is being applied in the downward direction, then the tension in n segments of string supports the load. therefore,

$$L = n T \quad \text{and} \quad E = T$$

$$\text{M.A.} = \frac{\text{load}}{\text{effort}} = \frac{nT}{T} = n$$

Thus in a block and tackle system, the M.A. is equal to the number of pulleys and it increases with the increase in the number of pulley.

PAGE NO-39:

Solution 15

(a) A jack is used to multiply force.



- (b) Gears are used to multiply speed.
- (c) A pulley is used to change the direction of application of force.

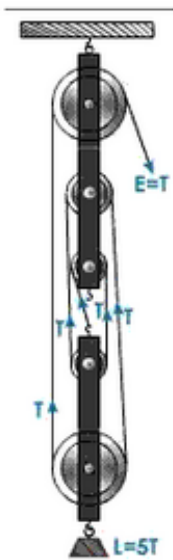
Solution 16

Two uses of pulley:

- (i) To change the direction of application of force to a convenient direction.
- (ii) To multiply force. Yes, a pulley is a force multiplier

Solution 17

Correct winding of rope around pulleys, load and effort is as shown:



- (i) Since there are five strings in the block and tackle system, therefore, the velocity ratio of the system is $V.R. = n = 5$

$$\text{Now, } V.R. = \frac{d_E}{d_L}$$

$$\text{or, } d_E = 5 \times d_L = 5 \times 1 = 5m$$

- (ii) 5 strands of tackle are supporting the load.

$$(iii) M.A. = L/E$$

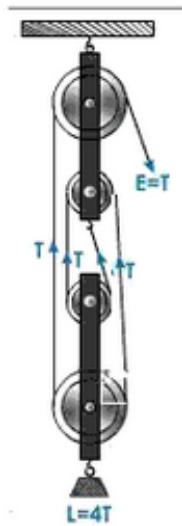
$$\text{Here, } L = 5T, E = T$$

$$\therefore M.A. = \frac{5T}{T} = 5$$

Solution 18

(i) 4 strands of tackle are supporting the load.

(ii) Correct winding of rope around pulleys, load and effort is as shown:



(iii) $M.A. = L/E$

Here, $L = 4T$, $E = T$

$$\therefore M.A. = \frac{4T}{T} = 4$$

(iv) Since there are four strings in the block and tackle system, therefore, the velocity ratio of the system is $V.R. = n = 4$

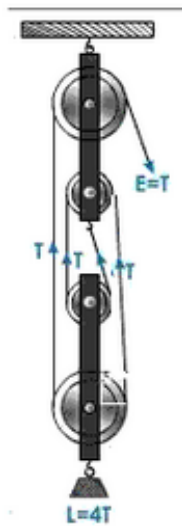
$$\begin{aligned} \text{Now, } V.R. &= \frac{d_g}{d_e} \\ \text{or, } d_g &= 4 \times d_e = 4 \times 1 = 4m \end{aligned}$$

Solution 19

A block and tackle system of pulleys consists of two blocks of pulleys, each block having one or more than one pulley. The upper block of pulleys is fixed to a rigid support and the lower block of pulleys is movable. The number of pulleys in the movable block is either equal to or one less than the number of pulleys in the fixed block.

Solution 20

(i) Correct winding of rope around pulleys, load and effort is as shown:



(ii) Since there are four strings in the block and tackle system, therefore, the velocity ratio of the system is $V.R. = n = 4$.

(iii) $M.A. = L/E$

Here, $L = 4T$, $E = T$

$$\therefore M.A. = \frac{4T}{T} = 4$$

(iv) The assumptions made are movable pulleys are weightless and efficiency of the system is 100%.

Solution 21

(i) 'Gear ratio' is defined as the ratio between the number of teeth in the driven gear and those on the driving gear.

(ii) A vehicle moving uphill uses a lower gear to increase the torque and to raise velocity ratio i.e., speed decreased.

(iii) Gear ratio, in bicycle is less than one, thus, one rotation of 'penion' causes a number of rotations of 'idler'.

PAGE NO-47:

Solution 1

Force

Solution 2

Yes

Solution 3

Joule

Solution 4

Work

Solution 5

1N, 1m in its own direction

Solution 6

When no net force is applied, the work done which is the dot product of force and displacement is zero.

PAGE NO-48:

Solution 7

The work done is zero because the displacement is zero.

Solution 8

The work done is zero because:

Work done = force \times displacement $\times \cos \theta$

Now, since $\theta = 90^\circ$; $\cos \theta = 0$ and hence work done is equal to zero.

Solution 9

Work is a scalar quantity because it is a measure of transfer of energy without indicating any direction.

Solution 10

When the displacement of the body is in the direction opposite to that of the applied force, the work done is negative.

$$W = Fd \cos \theta = Fd \cos 180^\circ = -Fd$$

Solution 11

The work done by the gravitational force of the earth on a satellite revolving around the earth is zero because the motion of the satellite is perpendicular to the force at every point.

Solution 12

Given, load $m = 500 \text{ kg}$; height $h = 5\text{m}$; $g = 10\text{ms}^{-2}$

$$W = mgh = 500 \times 10 \times 5 = 25000 \text{ J} = 25 \text{ kJ}$$

Solution 13

Given, mass $m = 10 \text{ kg}$; height $h = 4\text{m}$; $g = 10\text{ms}^{-2}$

$$W = mgh = 10 \times 10 \times 4 = 400 \text{ J}$$

Solution 14

The work done against gravity is zero when a body is moved horizontally along a frictionless surface because the force of gravity is perpendicular to the displacement in this case.

Solution 15

'Work' is said to be done when the applied force makes the body move i.e., there is a displacement of body. It is equal to the product of force and the displacement of the point of application of the force in the direction of force.

Solution 16

Work done depends upon:

- (i) the magnitude and direction of the applied force, and
- (ii) the displacement it produces.

Solution 17

Yes, we perform work against gravity.

Solution 18

The angle should be 90° .

Solution 19

This is because at each point of the circular path, the displacement is perpendicular to the force, which is directed towards the centre, along the radius.

Solution 20

When the angle between the direction of motion and that of the force is 90° ; $W = Fd \cos 90^\circ = 0$
When the angle between the direction of motion and that of the force is 0° ; $W = Fd \cos 0^\circ = Fd$
Hence in the second case, when the angle is 0° ; the work done is more.

Solution 21

The displacement of the man and suitcase is along the horizontal direction. Thus, the angle between the displacement and the force of gravity is 90° ; Thus, $W = Fd \cos 90^\circ = 0$
Hence, no work is done against gravity in this case.

Solution 22

When a body moves along a circular path, work done by the gravitational force towards the centre of the path is zero, because the displacement in this case is normal to the gravitational force.

Solution 23

The work done by the gravitational force of the sun on earth during its motion around the sun is zero because at every point, the displacement of earth is perpendicular to the gravitational force of sun i.e., $W = Fd \cos 90^\circ = 0$

Solution 24

A kilojoule of work is said to be done when a force of 1 newton displaces a body through 1000 metres in its own direction. $1 \text{ kJ} = 10^3 \text{ joules}$

Solution 25

$1 \text{ MJ} = 10^6 \text{ joules}$

Solution 26

The SI unit of work is joule. 1 joule of work is said to be done when a force of 1 newton displaces a body through 1 metre in its own direction.

Solution 27

The SI unit of work is 'joules' and the CGS unit is 'erg'. $1 \text{ joule} = 10^7 \text{ erg}$
Thus the ratio is $10^7:1$

Solution 28

Given, work done = 54,000J, force = 6000 N, $\theta = 0^\circ$

Now, work done = force \times displacement $\times \cos 0^\circ$

$$\text{or, displacement} = \frac{54,000}{6000} = 9\text{m}$$

Solution 29

Given, work done = 150J, displacement = 10 m, $\theta = 0^\circ$

Now, work done = force \times displacement $\times \cos 0^\circ$

$$\text{or, force} = \frac{150}{10} = 15 \text{ N}$$

Solution 30

Applied force, displacement in the direction of the applied force.

Solution 31

Examples of work done:

- (i) In free fall of a body of mass m , under gravity from a height h , the force of gravity ($F=mg$) is in the direction of displacement ($=h$) and the work done by the gravity is mgh .
- (ii) A coolie lifting a load does work against gravity.

Solution 32

Work done depends upon:

- (i) the magnitude and direction of the applied force, and
- (ii) the displacement it produces.

Solution 33

Work done = force \times displacement $\times \cos \theta$

$$\text{Or, } W = Fd \cos \theta$$

Solution 34

Work done against gravity = mass \times acceleration due to gravity \times height Or, $W = mgh$

Solution 35

The displacement of the man and box is along the horizontal direction. Thus, the angle

between the displacement and the force of gravity is 90° ; Thus, $W = Fd \cos 90^\circ = 0$ Hence, no work is done against gravity in this case; however some work is done against friction.

Solution 36

Yes, power is a scalar quantity.

Solution 37

No, every force cannot produce work. Force can produce work if the applied force cause displacement in the direction of the force.

Solution 38

Work is said to be done only when the applied force on a body makes the body move but power is the rate of doing work. The SI unit of work is 'joules' and that of power is 'watt'.

Solution 39

- (a) joule, watt
- (b) power, energy
- (c) work
- (d) 10^7
- (e) 746

Solution 40

Given, load $m = 200 \text{ kgf}$, displacement $h = 25 \text{ m}$, time $= 5 \text{ s}$, $g = 10 \text{ N kg}^{-1}$

Now, work done $= 200 \text{ kgf} \times 25 = 5000 \text{ J}$

$$\text{or, power} = \frac{\text{work done}}{\text{time taken}} = \frac{5000}{5} = 1000 \text{ watt}$$

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Solution 41

Given, load $m = 750 \text{ N}$, displacement $h = 16 \text{ m}$, time $= 5 \text{ s}$, $g = 10 \text{ N kg}^{-1}$

Now, work done $= mgh = 750 \times 16 = 12000 \text{ J}$

$$\text{or, power} = \frac{\text{work done}}{\text{time taken}} = \frac{12000}{5} = 2400 \text{ watt}$$

Solution 42

Power

Solution 43

Work done depends upon the vertical height and not the path taken, hence if the boy uses a lift to reach the same vertical height, work done will be mgh .

Solution 44

Yes, for e.g. if you push a wall, you apply force on it but no work is done since the displacement is zero.

Solution 45

1 H.P. = 0.746 kW

Solution 46

(i) Work done depends on the displacement, now, vertical distance travelled by A and B is same, hence ratio of work done by them is 1:1

$$(ii) \quad \text{Power} = \frac{\text{work done}}{\text{time taken}}$$

$$\therefore \frac{P_A}{P_B} = \frac{1}{1} \times \frac{15}{20} = \frac{3}{4}$$

The required ratio is 3:4.

Solution 47

The SI unit of power is 'watt'.

If 1 joule of work is done in 1 second, the power is said to be 1 watt.

Solution 48

SI unit of power = watt

CGS unit of power = erg per second

$$1 \text{ W} = 1 \text{ J s}^{-1} = 10^7 \text{ erg s}^{-1}$$

PAGE NO-72:

Solution 1

When the resultant of a group of forces acting on the same object is zero, the forces are said to be balanced. Balanced forces do not change the speed of stationary objects. They may deform objects.

Solution 2

Yes, force is a vector quantity.

Solution 3

$1 \text{ kgf} = \text{force due to gravity on } 1 \text{ kg mass} = 1 \text{ kg mass} \times \text{acceleration due to gravity } g \text{ in } \text{ms}^{-2}$
 $= g \text{ newton}$
 $1 \text{ kgf} = 9.8 \text{ newton}$

Solution 4

The SI unit of force is 'newton'. In CGS system, the unit of force is 'dyne'. $1 \text{ newton} = 10^5 \text{ dyne}$
Therefore, ratio of SI to CGS unit of force is $10^5 : 1$.

Solution 5

Yes, weight is a force.

Solution 6

When we kick a football at rest, it starts moving.

Solution 7

When a balloon is inflated the force of air inside changes its shape or size.

Solution 8

Effects a force can produce and examples:

1. Change the state of rest; e.g. pushing a door to open it or close it.
2. Change the state of motion; e.g. applying a force to stop the cricket ball.
3. Change the direction of motion and not speed; e.g. when a force is applied to move a body in a circular path with uniform speed there is only a change in direction of motion but speed remains constant.
4. Change both speed and direction of motion; e.g. when a body is swirled in the vertical circle its direction of motion and speed changes at every point.
5. Change the dimension; when a balloon is inflated the force of air inside changes its shape or size.

Solution 9

No

Solution 10

No

Solution 11

The turning effect produced by a force on a rigid body about a point, pivot or fulcrum is called the moment of force or torque. It is measured by the product of force and the perpendicular distance of the pivot from the line of action of force. $\text{Moment of a force} = \text{Force} \times \text{perpendicular distance of the pivot from the force}$. Its SI unit is newton-metre (Nm).

Solution 12

The physical quantity is 'torque'.

Solution 13

The turning effect produced by a force on a rigid body about a point, pivot or fulcrum is called the moment of force or torque. It is measured by the product of force and the perpendicular distance of the pivot from the line of action of force.

Solution 14

$$\begin{aligned}\text{Moment of force} &= \text{applied force} \times \text{perpendicular distance from the pivot} \\ &= 10 \times 30 \times 10^{-2} = 3 \text{ Nm}\end{aligned}$$

Solution 15

SI unit of couple = newton
CGS unit of couple = dyne

Solution 16

No, the moment of force is a vector quantity.

Solution 17

A larger diameter provides a greater torque ($= \text{force} \times \text{perpendicular distance}$); hence, it is easier to turn a steering wheel of a large diameter than that of a small diameter.

Solution 18

The point through which the resultant of the weights of all the particles of the body acts is called its centre of gravity



Solution 19

A body is said to be in equilibrium under the action of a number of forces, if the forces are not able to produce any change in the state of rest or of uniform motion or uniform rotation.

Solution 20

Principle of moments: If a body is in equilibrium under the action of number of force, then the sum of clockwise moments is equal to the sum of anticlockwise moments.

Solution 21

Mass	Weight
1. It is the measure of quantity of matter contained in the body, at rest.	1. It is the force with which the earth attracts a body.
2. It is a scalar quantity.	2. It is a vector quantity.
3. Its SI unit is kg.	3. Its SI unit is newton (N).
4. It is measured by a physical or beam balance.	4. It is measured by a spring balance which is calibrated to read in newton.
5. It is constant for a body and does not change by changing the place of a body.	5. It is not constant for a body, but varies from place to place on the earth's surface and also with altitude and depth from the earth's surface.

Solution 22

Moment of force = applied force \times perpendicular distance from the line of action

$\therefore 10 = 20 \times \text{perpendicular distance from the line of action}$

or, Perpendicular distance from the line of action = 0.5 m

Solution 23

The point through which the resultant of the weights of all the particles of the body acts is called its centre of gravity

Solution 24

The centre of gravity of a uniform ring is situated at the centre of the ring.

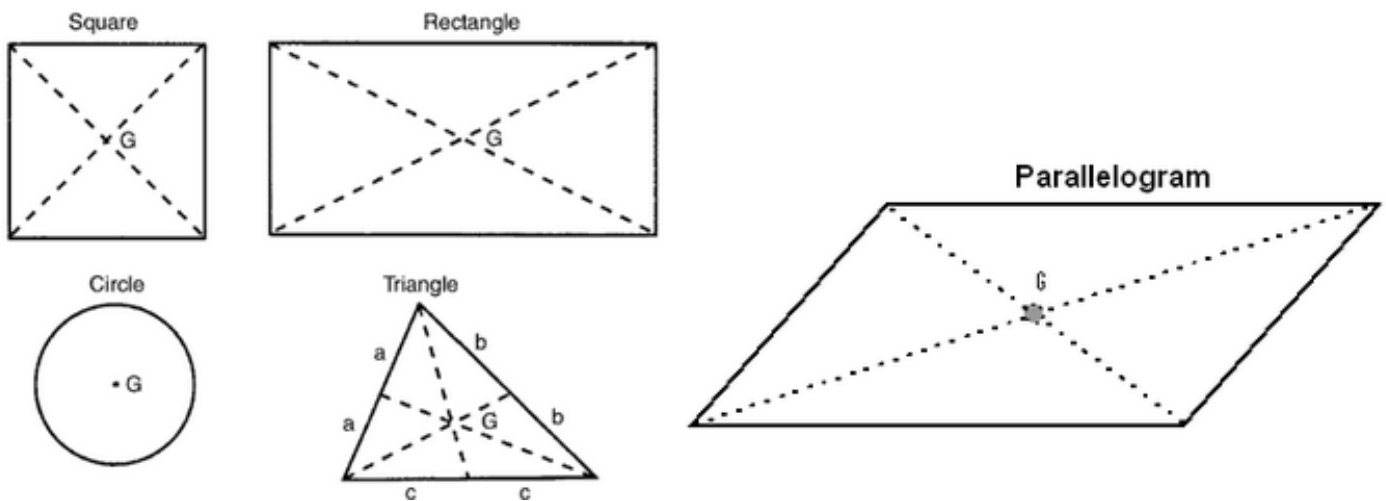
Solution 25

The centre of gravity of a body depends upon: (i) Body's weight (ii) Body's shape

Solution 26

Yes, the centre of gravity of a body can be outside it. The CG of a uniform ring is at its centre, a point which is not on the body.

Solution 27



Solution 28

Centripetal force: Whenever a body is moving in a circular path with a uniform speed, its velocity is continuously changing due to change in its direction. The body thus possesses acceleration and this acceleration is called centripetal acceleration. The force which produces this acceleration is called centripetal force. It acts along the radius towards the centre of the circular path. It is not the same as the centrifugal force.

Solution 29

Yes, force can be used to change the size and shape of the body. Example: On squeezing toothpaste tube, its size as well as shape changes.

Solution 30

Characteristics of non-contact forces:

- (i) Forces at distance are equal and opposite.
- (ii) Depend upon the distance between the two objects.
- (iii) Depend upon the medium between the two objects for electrical and magnetic forces but not gravitational forces.

Solution 31

Examples where force can start the motion of a body:

- (i) The pulling of a cart by a rope.
- (ii) Pushing a door to open it.

Examples where force can stop the motion of a body:

- (i) Applying a force to stop a cricket ball.
- (ii) Applying the brakes of car to stop it.

Solution 32

The physical quantity is 'torque'. Torque may be defined as the turning effect produced by a force on a rigid body about a point, pivot or fulcrum. It is measured by the product of force and the perpendicular distance of the pivot from the line of action of force.

Solution 33

Two equal and opposite parallel forces acting along different lines on a body constitute a couple. Its SI unit is 'newton'.

Solution 34

The turning effect produced by a force on a rigid body about a point, pivot or fulcrum is called the moment of force or torque. It is measured by the product of force and the perpendicular distance of the pivot from the line of action of force. Examples of turning effect of force:

- (i) Turning a steering wheel
- (ii) Tightening a cap

Solution 35

A body is said to be in equilibrium under the action of a number of forces, if the forces are not able to produce any change in the state of rest or of uniform motion or uniform rotation.

Solution 36

Equilibrium in any case requires the \sum forces acting on an object = 0, i.e. that there is $F_{\text{net}} = 0$. Static equilibrium is the situation where the object upon which the forces act is not moving. The object is "static" hence the state of equilibrium gets its name. Dynamic equilibrium is the situation where an object is in constant velocity motion. {This object can't experience an acceleration which means $F_{\text{net}} > 0$ }

Solution 37

When the centre of gravity is nearer to the base of a body, the body is in stable equilibrium. Conditions for stable equilibrium:

- (a) The body should have a broad base.
- (b) Centre of gravity of the body should be as low as possible.
- (c) Vertical line drawn from the centre of gravity should fall within the base of the support.

Solution 38

- (a) If both the forces act at the same point of the body, they have the same line of action, and then the moment becomes zero.
- (b) If both the forces act at two different points of the body at a separation d then they constitute a torque whose value is given $F \times d$.

Solution 39

(i) Moment of force = applied force \times perpendicular distance from the line of action

$$\therefore \text{Moment of force at O} = 8 \times 1.5 = 12 \text{ Nm}$$

(ii) Moment of force = applied force \times perpendicular distance from the line of action

$$\therefore \text{Moment of force at P} = 8 \times 3 = 24 \text{ Nm}$$

Solution 40

(i) Pulling of a cart.

(ii) A ball falls down when it is dropped from a height

Solution 41

In the given figure, forces 10 N and 100 N act clockwise and the forces 15 N and 4 N act anticlockwise.

Moment of force = sum of clockwise moments - sum of anticlockwise moments

$$\therefore \text{Moment of force} = (10 \times 5 + 100 \times 0 + 4 \times 6) - (15 \times 4) = 74 - 60 = 14 \text{ Nm}$$

Or, 14 Nm in clockwise direction.

Solution 42

Principle of moments: If a body is in equilibrium under the action of number of force, then the sum of clockwise moments is equal to the sum of anticlockwise moments.

\therefore Sum of clockwise moments = sum of anticlockwise moments

$$40 \times 20 \text{ cm} = \text{mass of scale} \times 30 \text{ cm}$$

$$\text{or, Mass of scale} = \frac{800}{30} = 26.7 \text{ g}$$

Solution 43

Let the mass of 50 g be situated at distance 'd' from the mid-point on the right hand side.

Taking moments about the mid-point i.e. at 50 cm,

$$80 \times 30 = (40 \times 10) + (50 \times d)$$

$$\therefore 2400 = 400 + 50d$$

$$\text{or, } 50d = 2000$$

$$\text{or, } d = 40 \text{ cm to the right of the mid-point.}$$

Solution 44

Resultant torque = sum of clockwise moments - sum of anticlockwise moments

Taking, moments about the mid-point,

$$\text{Resultant torque} = (300 \times 40) - (500 \times 20)$$

$$\text{Or, Resultant torque} = 12000 - 10000 = 2000 \text{ gf-cm}$$

Let a mass of 100 gf be suspended at a distance 'd' from the mid-point towards the right side, so as to balance the metre scale.

Then, in balanced condition:

sum of clockwise moments = sum of anticlockwise moments

$$(300 \times 40) = (500 \times 20) + (100 \times d)$$

$$\text{or, } 12000 = 10000 + 100 d$$

$$\text{or, } 100 d = 2000$$

$$\text{or, } d = 20 \text{ cm to the right of the mid-point.}$$

Solution 45

Let mass 'm' be suspended from 65 cm mark so as to balance the meter scale.

In balanced condition:

sum of clockwise moments = sum of anticlockwise moments

$$50 \times (50 - 20) = m \times (65 - 50)$$

$$\text{or, } 50 \times 30 = m \times 15$$

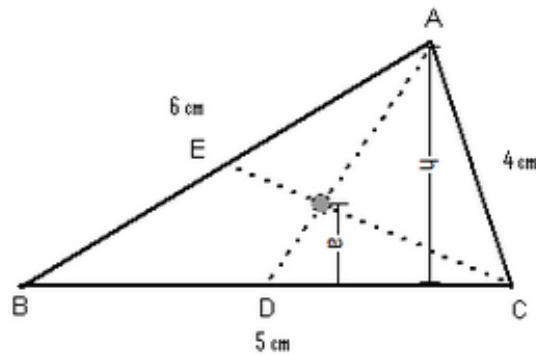
$$\text{or, } m = \frac{1500}{15} = 100 \text{ g}$$

Solution 46

A body is said to be in equilibrium under the action of a number of forces, if the forces are not able to produce any change in the state of rest or of uniform motion or uniform rotation. Conditions for stable equilibrium:

- (a) The body should have a broad base.
- (b) Centre of gravity of the body should be as low as possible.
- (c) Vertical line drawn from the centre of gravity should fall within the base of the support.

Solution 47

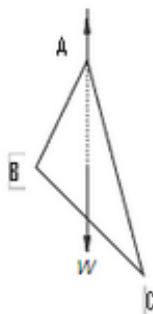


The center of gravity is at the intersection of lines BE and AD. The distance a can be calculated as

$$a = h / 3$$

Solution 48

Diagram showing the relative position of vertices of the triangle when it is suspended by a pin from the hole A:



The position of vertices changes because the triangle is in equilibrium and the centre of gravity lies on the vertical line through the point of suspension as the weight acts along this same line.

Solution 49

- (i) We keep our body balanced on two feet by keeping the center of gravity of our body between our feet. It acts normal to the sea level vertically downwards. If COG goes out we fall or we get unbalanced. A boy standing on both legs has his COG in balanced position and is thus in stable equilibrium but a boy standing on one leg has his COG in unbalanced position which makes him quite unstable and hence it is easier to push him.
- (ii) A man bends forward in order to keep himself in a stable equilibrium while climbing up a slope. By bending forward he increases the base of the support, so that the vertical line passing through his centre of gravity may still fall within the base.
- (iii) When a truck is not fully loaded, its COG is at a high point and hence the turning moment of the weight is much greater, thus, the truck will be quite unstable and there are chances of toppling, when a truck takes a sharp turn.
- (iv) When a man gets down from a moving train, his feet come to rest immediately, while the upper part of his body due to inertia of motion still remains in motion and consequently he



leans in forward direction. The person while getting down of a train should run forward in the direction of the moving train to avoid fall.

(v) This is due to the fact that the body of the passenger is in the state of rest as long as the bus is at rest. When the bus starts, his feet acquire the velocity of the bus and come to motion with the moving bus, while the upper portion of his body due to inertia of rest tends to remain in the state of rest, resulting in his tendency to fall backwards.

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Solution 50

To increase the stability of a body, its base should be made broad and heavy, and the centre of gravity of the body should be lowered.

Solution 51

- (i) Two equal and opposite parallel forces acting along different lines on a body constitute a couple.
(ii)

(ii) Two equal and opposite parallel forces acting along different lines on a body constitute a couple.(ii)

$$\begin{aligned}\text{Moment of couple} &= \text{either force} \times \text{perpendicular distance} \\ &= 4 \times 10 = 40 \text{ Nm}\end{aligned}$$

Solution 52

(i) Leaning tower of Pisa is stable because a line through the centre of gravity falls within the structure's base. If the line falls outside the structure's base then there is a possibility that overturning will occur. This structure could be classified as unstable.

(ii) We bend forward in order to keep ourselves in a stable equilibrium while climbing up a hill. By bending forward we increase the base of the support, so that the vertical line passing through our centre of gravity still falls within the base.

(iii) By keeping the legs apart, the base of the body broadens, thus the C.G. lowers and the body attains a more stable equilibrium.

(iv) Passengers are usually advised not to stand in the upper deck of the double deck bus. When the passengers are standing, the C.G. rises. This decreases the stability of the bus. When the passengers are sitting, the C.G. gets lowered and stability of the bus increases.

Solution 53

The body will move in the direction of net torque.

Net torque = Sum of clockwise moments - sum of anticlockwise moments

In the given figure, force 40 N is acting clockwise and forces 20 N and 60 N are acting anticlockwise.

$$\begin{aligned}\therefore \text{Net torque} &= (40 \times 3) - [(20 \times 2) + (60 \times 1)] \\ &= 120 - 100 = 20 \text{ Nm}\end{aligned}$$

Hence, the body will move in clockwise direction about 'O'.

Solution 54

Let the weight 500N be hung from the 40 cm mark and the weight 300 N be hung from the 80 cm mark.

(i) Then, total clockwise moment = $500 \times (50-40) = 500 \times 10 = 5000 \text{ Nm}$

Total anticlockwise moment = $300 \times (80 - 50) = 300 \times 30 = 9000 \text{ Nm}$

(ii) Difference in clockwise and anticlockwise moment = $9000 - 5000 = 4000 \text{ Nm}$

(iii) Let the 100 N weight be hung at a distance 'd' from the point 'O' to its left.

Then, total clockwise moment = $5000 + 100 d$

In balanced condition, sum of clockwise moments = sum of anticlockwise moments

$$\therefore 5000 + 100 d = 9000$$

$$\text{or, } 100 d = 4000$$

$$\text{or, } d = 40 \text{ cm}$$

\therefore the weight 100 N should be hung from the 40 cm mark so as to balance the scale.

Solution 55

Let m be the mass of the metre scale

In balanced condition, sum of clockwise moments = sum of anticlockwise moments

$$\therefore 400 \times 10 = m \times 90$$

$$\text{or, } 4000 = 90 m$$

$$\text{or, } m = 44.4 \text{ g}$$

\therefore the mass of the scale is 44.4 g.

Solution 56

'Work' is said to be done when the applied force makes the body move i.e., there is a displacement of body. It is equal to the product of force and the displacement of the point of application of the force in the direction of force. The SI unit of work is 'joules' and the CGS unit is 'erg'.

Solution 57

(i) [C]

(ii) [A]

(iii) [D]

(iv) [E]

(v) [B]

Solution 58

Given, force = $5 \text{ kgf} = 5 \text{ kgf} \times 10 \text{ ms}^{-2} = 50 \text{ N}$

displacement = 10 m

Work done = force \times displacement = $50 \times 10 = 500 \text{ J}$

Solution 59

Given, mass = 20 kg

displacement = 40 m

(a) In vertical direction work is done against gravity

$$\text{Work done} = mgh = 20 \times 9.8 \times 40 = 7840 \text{ J}$$

(b) In horizontal direction,

$$\text{Work done} = Fs \cos \theta = (mg)s \cos 0^\circ = 20 \times 9.8 \times 40 = 7840 \text{ J}$$

Solution 60

(a) The rate of doing work is called power.

SI unit of power = watt

CGS unit of power = erg per second

(b) Given, mass = 50 kg

$$\text{Total height traveled} = 60 \times 20 \text{ cm} = 1200 \text{ cm} = 12 \text{ m}$$

$$g = 10 \text{ ms}^{-2}$$

$$\text{time taken} = 5 \text{ min} = 5 \times 60 \text{ s} = 300 \text{ s}$$

$$\text{Work done} = mgh = 50 \times 10 \times 12 = 6000 \text{ J}$$

$$\text{Power} = \frac{\text{Work done}}{\text{time taken}} = \frac{6000}{300} = 20 \text{ watt}$$

Solution 61

The energy of a body is its capacity to do work. The SI unit of work is 'joules' and the CGS unit is 'erg'.

Solution 62

When an elevator begins to move downwards in an accelerated mode, the forces acting on the body are the following:

- Weight of the body acting downwards
- Normal reaction of the floor acting upwards
- The centrifugal force acting on the body, acting upwards

Weight of the body is due to gravitational force on the body acting downwards. Normal reaction is the force that is exerted by the elevator floor in response to the force with which the body presses itself against the floor. The centrifugal force here is fictitious force that acts on the body in the direction opposite to the acceleration of the reference frame, here it is, the elevator floor. It is given by ma , where m is the mass of the body & a is the acceleration of the elevator floor. Centrifugal force is directed opposite to the acceleration of the elevator floor. Weightlessness is the condition of the zero apparent weight. When the acceleration of the elevator is such that the upward centrifugal force F_c completely balances the downward weight W_t of the body, the resultant normal reaction ($N = F_c - W_t$) of the body is reduced to zero. That's when the body on the elevator floor will experience the state of weightlessness.



Solution 63

(a) given, force = 500 N,

Vertical displacement = Final position - initial position = BC = 4m

∴ work done = force × displacement = $500 \times 4 = 2000 \text{ J}$

(b) P.E. gained = $mgh = (mg)h = 500 \times 4 = 2000 \text{ J}$

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Solution 64

We know that, K.E. = $\frac{1}{2}mv^2$

$$\therefore 375 = \frac{1}{2} \times 30 \times v^2$$

$$\text{or, } v^2 = \frac{375 \times 2}{30} = 25 \text{ m/s}$$

$$\text{or, } v = 5 \text{ m/s}$$

Solution 65

Given, mass = 50 kg

Total height traveled = $40 \times 20 \text{ cm} = 800 \text{ cm} = 8 \text{ m}$

$g = 10 \text{ m/s}^2$

time taken = 20s

Work done = $mgh = 50 \times 10 \times 8 = 4000 \text{ J}$

$$\text{Power} = \frac{\text{Work done}}{\text{time taken}} = \frac{4000}{20} = 200 \text{ watt}$$

Solution 66

Given, mass of water = 80 kg

Height = 20 m

$g = 10 \text{ m/s}^2$

time taken = 10s

Work done = $mgh = 80 \times 10 \times 20 = 16000 \text{ J}$

$$\text{Power} = \frac{\text{Work done}}{\text{time taken}} = \frac{16000}{10} = 1600 \text{ watt}$$

Solution 67

We know that, $\text{power} = \text{force} \times \text{velocity}$

Here, $\text{force} = 3000 \text{ N}$,

$\text{velocity} = 36 \text{ kmhr}^{-1} = 10 \text{ m/s}$

$\therefore \text{power} = 3000 \times 10 = 30000 \text{ watt}$

Solution 68

The energy of a body is its capacity to do work. The SI unit of work is 'joules' and the CGS unit is 'erg'. According to the law of conservation of energy, energy can neither be created nor be destroyed but can be transformed from one form to another. In other words, energy can be transformed from one form to another but the total amount of all the energies remain the same.

Solution 69

Six forms of energy:

1. Solar energy: The energy radiated by the sun is called the solar energy. Inside the sun, energy is produced by nuclear fusion reaction. Solar energy cannot be used to do work directly, because it is too diffused and is not always uniformly available. However, a number of devices such as solar panels, solar cells etc. have been invented to make use of solar energy.
2. Heat energy: The energy released on burning coal, oil, wood or gas is the heat energy. The stem possesses heat energy it has capacity to do work.
3. Light energy: It is the form of energy in presence of which other objects are seen. The natural source of light energy is sun. Many other sources of heat energy also give light energy.
4. Chemical or fuel energy: The energy possessed by fossil fuels such as coal, petroleum and natural gas is called chemical energy or fuel energy. These fuels are formed from the decayed remains of dead plants and animals that lived millions of years ago. In the interior of earth, due to high pressure and temperature the remains slowly changed into fossil fuels.
5. Hydro energy: The energy possessed by fast moving water is called the hydro energy. This energy is used to generate electricity in hydroelectric power stations. For this, dams are built across the rivers high up in the hills to store water. Water is allowed to run down the pipes and the energy of running water is used to turn a turbine. The turbine drives generators to produce electrical energy.
6. Nuclear energy: The energy released during the processes of nuclear fission and fusion is called nuclear (or atomic) energy. In both these processes, there is loss in mass which converts into energy in accordance with Einstein's mass-energy relation, $E = mc^2$.

Solution 70

The energy possessed by a body by virtue of its position, shape or change of configuration is called potential energy. Examples of potential energy:

- (i) Water stored at a height in a reservoir.
- (ii) A stretched spring.
- (iii) A bent bow. The energy possessed by a body by virtue of its motion is called kinetic energy.

Examples of kinetic energy:

- (i) Air in motion has kinetic energy.



- (ii) A swinging pendulum.
- (iii) Moving hands of a clock.

Solution 71

$$\text{K.E. of the bullet} = \frac{1}{2}mv^2$$

(a) If the mass is doubled,

$$\text{K.E.'} = \frac{1}{2}(2m)v^2 = 2 \times \frac{1}{2}mv^2 = 2\text{K.E.}$$

$$\therefore \frac{\text{K.E.'}}{\text{K.E.}} = \frac{2}{1}$$

(b) If the velocity is tripled,

$$\text{K.E.'} = \frac{1}{2}m(3v)^2 = 9 \times \frac{1}{2}mv^2$$

$$\therefore \frac{\text{K.E.'}}{\text{K.E.}} = \frac{9}{1}$$

Solution 72

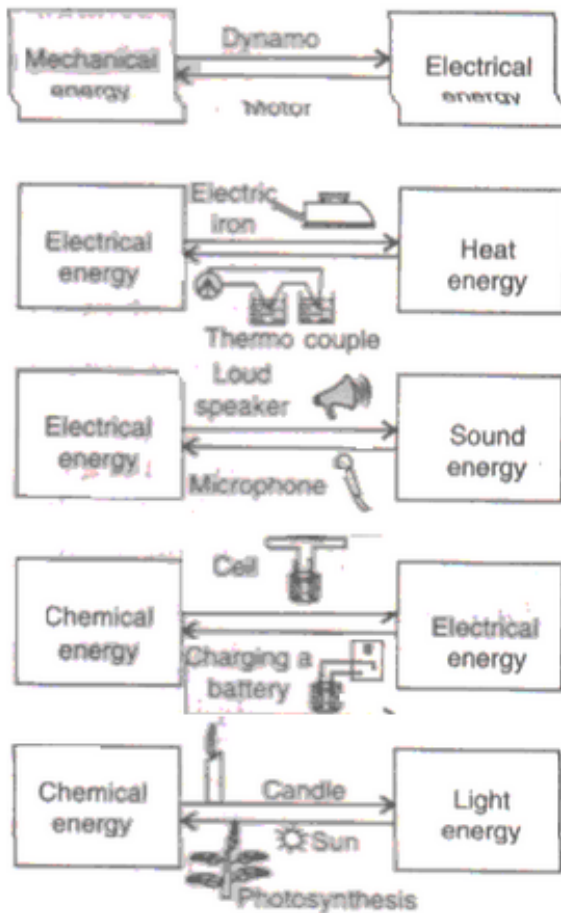
Given, mass $m = 400 \text{ kg}$, height $= 20 \text{ m}$, $g = 10 \text{ ms}^{-2}$

$$\text{P.E.} = mgh = (400) (10) (20) = 80000 \text{ J}$$

Solution 73

- (a) Potential energy
- (b) Potential energy
- (c) Kinetic energy
- (d) Potential energy
- (e) Kinetic energy

Solution 74



Solution 75

- (a) P.E. (Water stored in the dam) → K.E. (falling water) → Electrical energy (Generators of turbine form electrical energy).
- (b) Electrical energy (Electric current) → Light energy + heat energy (bulb).
- (c) Chemical energy (chemical reaction) → Heat energy (burning).
- (d) P.E. (Stone at the top of cliff) → K.E. (Falling stone) → P.E. (Stone at ground).
- (e) P.E (Wound spring) to K.E. (motion)
- (e) P.E (Wound spring) to K.E. (motion)

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Solution 76

- (a) Electric bell
(b) Candle flame
(c) Dry cell

- (d) Solar cell
- (e) Electric iron

Solution 77

Given, mass $m = 1000 \text{ kg}$,

velocity $v = 72 \text{ km/hr} = 20 \text{ m/s}$

$$\text{Now, K.E.} = \frac{1}{2}mv^2 = \frac{1}{2}(1000)(20)^2$$

$$\text{or, K.E.} = 2 \times 10^5 \text{ J}$$

Solution 78

$$\text{Given, mass } m = 25\text{g} = \frac{25}{1000} \text{ kg} = \frac{1}{40} \text{ kg}$$

initial velocity $u = 600 \text{ m/s}$

final velocity $v = 0 \text{ m/s}$

Distance traveled, $s = 50 \text{ cm} = 0.5\text{m}$

$$\text{Now, K.E. of the bullet} = \frac{1}{2}mu^2 = \frac{1}{2}\left(\frac{1}{40}\right)(600)^2$$

$$\text{or, K.E.} = 4500 \text{ J}$$

Let F' be the resistive force.

According to work-energy theorem,

work done = change in K.E.

$$\text{or, work done} = \frac{1}{2}m(v-u)^2 = \frac{1}{2}\left(\frac{1}{40}\right)(0 - 600)^2 = -4500 \text{ J}$$

Also, we know that : work done = force \times displacement

$$\therefore -4500 = F \times 0.5$$

$$\text{or, } F = \frac{-4500}{0.5} = -9000 \text{ N}$$

Hence, the resistive force is 9000 N.

Solution 79

Given, initial velocity, $u = 70 \text{ m/s}$

final velocity, $v = 0 \text{ m/s}$

sp. heat capacity of lead, $s = 140 \text{ J/kgK}$

Let Δt be the change in temperature.

$$\text{K.E. possessed by the bullet} = \frac{1}{2} m (70)^2 = 2450m \text{ joules}$$

$$\text{Heat energy} = 80\% \text{ of K.E.} = \frac{80}{100} \times 2450 m = 1960m \text{ joules}$$

We know that, $H = m s \Delta t$

$$\text{or, } 1960m = m \times 140 \times \Delta t$$

$$\text{or, } \Delta t = \frac{1960}{140} = 14^\circ\text{C}$$

Solution 80

Given, Sp. heat capacity of water, $s = 4200 \text{ J/kgK}$

Temperature difference, $\Delta t = 0.21^\circ\text{C}$

Let 'h' be the height of the waterfall and 'm' be the mass of water.

Then, P.E. of the water = mgh

Given that, heat energy, $H = 60\% \text{ of P.E.}$

$$\text{or, } ms\Delta t = \frac{60}{100} \times mgh$$

$$\text{or, } 4200 \times 0.21 = 0.6 \times 10 \times h$$

$$\text{or, } h = \frac{4200 \times 0.21}{0.6 \times 10} = \frac{882}{6} = 147m$$

Solution 81

(a) Simple machine: A machine is a device by which we can either overcome a large resistive force at some point by applying a small force at a convenient point and in a desired direction or by which we can obtain a gain in speed.

(b) Lever: A lever is a rigid, straight or bent bar which is capable of turning about a fixed axis.

(c) Mechanical advantage (M.A.): The ratio of the load to the effort is called the mechanical advantage of the machine.

(d) Velocity ratio (V.R.): The ratio of the velocity of effort to the velocity of load is called the velocity ratio of the machine. It is also defined as the ratio of the displacement of effort to the displacement of load.

(e) Efficiency: Efficiency of a machine is the ratio of the useful work done by the machine to the work put into the machine by the effort. In other words, it is the ratio of the work output to the work input.

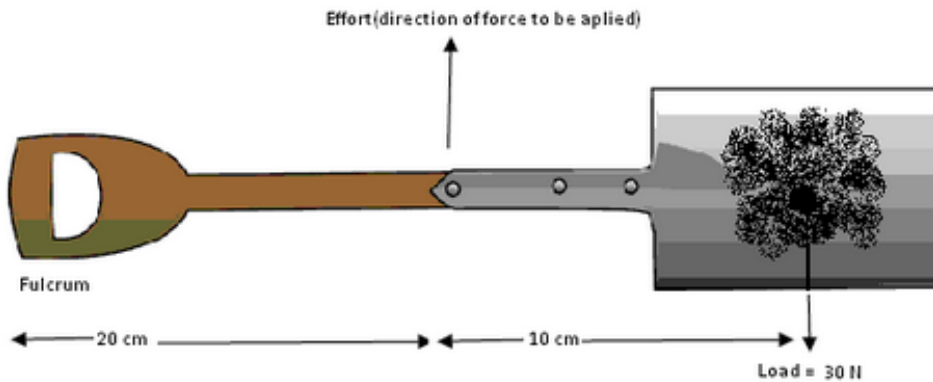
Solution 82

E.g. of class I lever with M.A. = 1: A physical balance has both arms equal (i.e. effort arm =

load arm), thus its M.A. = 1 E.g. of class I lever with M.A. = 1: A pair of scissors used to cut a piece of cloth has blades longer than the handle (i.e. effort arm is shorter than the load arm), thus its M.A. = 1. E.g. of class I lever with M.A. = 1: Shears used for cutting thin metal sheets have much longer handles as compared to the blades (i.e. effort arm is longer than the load arm), thus its M.A. = 1 and it serves as a force multiplier.

Solution 83

(a) Diagram showing the direction of application of least force on the handle:



(b)

Given, Load, $L = 30\text{ N}$

Let, effort = E

effort - arm = 20 cm

load - arm = $20 + 10 = 30\text{ cm}$

Now, load \times load - arm = effort \times effort - arm

$$\therefore \text{effort} = \frac{30 \times 30}{20} = 45\text{ N}$$

(c) On moving the left hand towards the soil on the spade, the length of effort arm will increase and effort being inversely proportional to the length of effort arm, the force or effort necessary to keep the soil balanced would be less.

(d) A spade belongs to Class III lever.

Solution 84

A crowbar is a class I lever, thus, its fulcrum lies in between the load and effort.

Given, load, $L = 500 \text{ kgf}$

Length of crowbar $= 4 \text{ m} = 400 \text{ cm}$

Therefore, load arm $= 50 \text{ cm}$

Effort arm $= 400 - 50 \text{ cm} = 350 \text{ cm}$

Let effort $= E$

$$\text{Now, M.A.} = \frac{\text{Effort arm}}{\text{Load arm}} = \frac{350}{50} = 7$$

$$\text{Also, M.A.} = \frac{L}{E}$$

$$\therefore 7 = \frac{500}{E}$$

$$\text{Or, } E = 71.4 \text{ kgf}$$

$$\text{Or, } E = 71.4 \text{ kgf}$$

Solution 85

Let L be the load.

Given, load arm $= 3 \text{ cm}$

effort arm $= 12 \text{ cm}$

Effort, $E = 10 \text{ gf}$

$$\text{Now, M.A.} = \frac{\text{Effort arm}}{\text{Load arm}} = \frac{12}{3} = 4$$

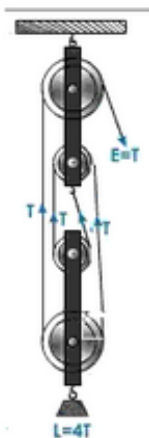
$$\text{Also, M.A.} = \frac{L}{E}$$

$$\therefore 4 = \frac{L}{10}$$

$$\text{or, } L = 40 \text{ gf}$$

Solution 86

(a) Correct winding of rope around pulleys, load and effort is as shown:



(b) Since there are four strings in the block and tackle system, therefore, the velocity ratio of the system is $V.R. = n = 4$

(c)

(i)

Given, Load, $L = 720\text{ N}$

Let, Effort = E

$$\text{Efficiency} = \frac{M.A.}{V.R.}$$

$$\text{or, } 80\% = \frac{L/E}{4}$$

$$\text{or, } \frac{80}{100} \times 4 = \frac{720}{E}$$

$$\text{or, } E = \frac{720 \times 100}{80 \times 4} = 225\text{ N}$$

(ii)

Given, Load, $L = 720\text{ N}$

Displacement - of - load, $d_L = 2\text{ m}$

$$\text{Efficiency} = \frac{\text{work - output}}{\text{work - input}}$$

$$\text{or, work - input} = \frac{\text{work - output}}{\text{Efficiency}} = \frac{\text{Load} \times d_L}{\eta}$$

$$\text{or, work - input} = \frac{720 \times 2}{0.8} = 1800\text{ J}$$

Solution 87

(a) A balance becomes faulty, if the lengths of its arms are unequal or the weights of both the pans are not same.

(b)



m_O = actual weight

m_L = weight of left pan

m_R = weight of right pan

$$m_L + 8 = m_O + m_R$$



$$m_R + 8.2\text{kg} = m_O + m_2$$

Adding the two equations

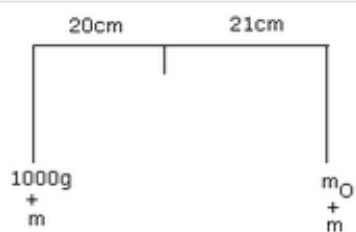
$$m_L + m_R + 16.2\text{kg} = 2m_O + m_2 + m_R$$

$$\Rightarrow 16.2 = 2m_O$$

$$m_O = 8.1\text{kg}$$

(c)

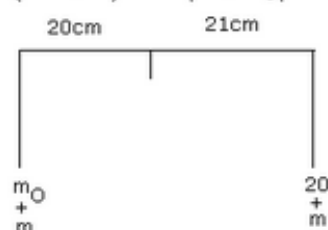
(c)



m = mass of each pan

m_O = actual mass of the body

$$(100 + m)20 = (m + m_O)21$$



Dividing the two equations

$$\frac{21}{20} = \frac{(100 + m)20}{(20 + m)21}$$

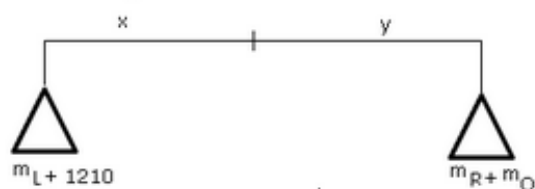
$$1.1(20 + m) = (1000 + m)$$

$$22 + 1.1m = 1000 + m$$

$$0.1m = 978$$

$$m = 9780g$$

(d)



PAGE NO-68:

Solution 1

The energy possessed by a body by virtue of its motion is called kinetic energy.

Solution 2

Examples of kinetic energy:

- (i) Air in motion has kinetic energy.
- (ii) A swinging pendulum

Solution 3

SI unit of energy is 'joule'.

Solution 4

Work

Solution 5

'Energy' is the body's ability to do work.

Solution 6

Energy is a scalar quantity.

Solution 7

$$\text{K.E.}, K = \frac{1}{2}mv^2$$

If speed is doubled;

$$\text{K.E.}, K' = \frac{1}{2}m(2v)^2$$

$$\text{or, } K' = 4 \times \frac{1}{2}mv^2 = 4K$$

Thus, K.E. becomes four times.

Solution 8

Kinetic energy of a body depends upon:

- (i) Mass of the body
- (ii) Speed of the body

Solution 9

Yes, if the body is not in motion; it has zero kinetic energy

Solution 10

A moving bullet possesses kinetic energy

Solution 11

$$\text{K.E.} = \frac{1}{2}mv^2$$

$$\text{K.E.} = \frac{1}{2}(2)(20)^2$$

$$\text{or, K.E.} = 400 \text{ J}$$

Thus, K.E. is 400 J

Solution 12

$$\text{K.E.} = \frac{1}{2}mv^2$$

$$60 = \frac{1}{2}(30)(v)^2$$

$$\text{or, } v^2 = 4 \text{ m/s}$$

$$\text{or, } v = 2 \text{ m/s}$$

Solution 13

Flowing water possesses kinetic energy.

Solution 14

$$\text{K.E.}, K = \frac{1}{2}mv^2$$

If speed is increased four times;

$$\text{K.E.}, K' = \frac{1}{2}m(4v)^2$$

$$\text{or, } K' = 16 \times \frac{1}{2}mv^2 = 16 K$$

Thus, K.E. becomes sixteen times.

Solution 15

The car should be moving faster because the mass of the car is less than that of the bus.

Solution 16

Its kinetic energy changes with the change in velocity. Velocity becomes zero at the highest point.



Solution 17

$$\text{K.E.}, K = \frac{1}{2}mv^2$$

If mass is increased four times;

$$\text{K.E.}, K' = \frac{1}{2}(4m)(v)^2$$

$$\text{or, } K' = 4 \times \frac{1}{2}mv^2$$

To maintain the same kinetic energy, the velocity should be made half.

$$\text{Then, } K'' = 4 \times \frac{1}{2}m \left(\frac{v}{2}\right)^2 = K$$

Solution 18

$$\text{K.E.}, K = \frac{1}{2}mv^2$$

If speed is doubled;

$$\text{K.E.}, K' = \frac{1}{2}m(2v)^2$$

$$\text{or, } K' = 4 \times \frac{1}{2}mv^2 = 4K$$

Thus, K.E. becomes four times.

Thus, if initially the K.E. is 5J, after increasing the speed twice, its K.E. will become $4 \times 5 = 20\text{ J}$.

Solution 19

The parameters that can change the kinetic energy are: (i) Mass (ii) Speed

Solution 20

A ball at lying at rest on the floor possesses zero kinetic energy.

Solution 21

The energy possessed by a body by virtue of its position, shape or change of configuration is called potential energy.

Solution 22

Potential energy of a body depends upon:

(i) Mass of the body

- (ii) Acceleration due to gravity
- (iii) Height of the body

Solution 23

SI unit of energy is 'joules'.

Solution 24

$$\text{P.E.} = mgh = 1 \times 10 \times 1 = 10 \text{ J}$$

Solution 25

Examples of potential energy:

- (i) Water stored at a height in a reservoir.
- (ii) A stretched spring.

Solution 26

P.E of a body lying on a floor is zero.

Solution 27

The energy spent by the heart in pumping blood through the body is 1 J per beat.

Solution 28

Potential energy

Solution 29

The work done in winding a clock spring is stored as P.E. in the spring. This P.E. is then used to run the hands of the clock.

Solution 30

P.E. of a body of mass M and at a height H above the earth's surface is: $\text{P.E.} = MgH$; here, g = acceleration due to gravity.

Solution 31

P.E. is a scalar quantity.

Solution 32

- (i) Potential energy
- (ii) Heat energy
- (iii) Potential energy

Solution 33

- (i) At the height H because the height is maximum.
- (ii) At the ground level because the velocity is maximum.
- (iii) At half distance of the total path i.e. at height $H/2$, the P.E. is equal to the K.E.

Solution 34

- (a) As the height above the ground increases, the potential energy also increases.
- (b) At the highest point, the height of the cricket ball is maximum and hence the potential energy is also maximum.

Solution 35

P.E. is the energy possessed by a body by virtue of its position, shape or configuration but K.E. is the energy possessed by a body by virtue of its velocity or motion. E.g. A ball kept on a cliff possesses P.E. but as soon as it is kicked it possesses K.E.

Solution 36

Whenever one form of energy dissipates or disappears, another form of equivalent amount of energy is produced; this is referred to as transformation of energy. E.g. when a particular switch is pressed electric lamps light up owing to the heat produced in the filament. This is the transformation of electrical energy to heat and light energy.

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Solution 37

No, total energy of a body does not remain constant but the total energy of a closed system remains constant e.g. universe.

Solution 38

Energy is a scalar quantity.

Solution 39

No, we cannot destroy energy associated with a body.

Solution 40

Energy is the capacity or ability of a body to do work or energy is stored work.

Solution 41

The law of conservation of energy states that energy cannot be created or destroyed; the sum total of energy in a closed system remains unchanged. Energy only changes from one form to another.

Solution 42

Potential energy of water stored at a height in dams get converted into the kinetic energy of the flowing water which is used by a turbine.

Solution 43

Two uses of solar cells:

- (i) Solar cells are used as energy sources in calculators.
- (ii) Solar panels made up of solar cells are used for the purpose of street lights.

Solution 44

The renewable sources of energy are those sources of energy which can be used again and again. E.g. sun, hydro-energy.

Solution 45

The non renewable sources of energy are those sources of energy, which once exhausted are not easily available again. E.g. coal, petroleum products.

Solution 46

Sun is the most abundant source of energy on the earth.

Solution 47

Solar energy is obtained from the sun.

Solution 48

A dry cell converts chemical energy into electrical energy.

Solution 49

A D.C. motor converts electrical energy into mechanical energy.

Solution 50

A dynamo converts mechanical energy into electrical energy.

Solution 51

Four different forms of energy:

- (i) Solar energy
- (ii) Mechanical energy
- (iii) Wind energy
- (iv) Nuclear energy

Solution 52

At a thermal power station, nuclear energy is converted into electrical energy.

Solution 53

- (i) Electrical energy to sound energy
- (ii) Mechanical energy into heat energy.
- (iii) Potential energy into kinetic energy and vice-versa.
- (iv) Chemical energy obtained from food is converted into mechanical energy and heat energy in muscles.
- (v) A dynamo converts mechanical energy into electrical energy.

Solution 54

The rate of doing work is called power.

Solution 55

'Watt' is the SI unit of power.

Solution 56

Horse power is the unit of power. The horsepower used for electrical machines is defined as exactly 746 watt. Classically, a horse exerting 1 H.P. can raise 330 pounds of coal 100 feet in a minutes, or 33 pounds of coal 1,000 feet in one minute, or, 1,000 pounds 33 feet in one minute.

Solution 57

If 1 joule of work is done in 1 second, the power is said to be 1 watt. $1 \text{ H.P.} = 746 \text{ watt}$

Solution 58

$$\text{POWER} = \frac{\text{work done}}{\text{time taken}} = \frac{20}{10} = 2 \text{ watt}$$

Solution 59

Power is the physical quantity associated with the 'rate of doing work'.

Solution 60

Given, mass $m = 4 \text{ kg}$, height $h = 10\text{m}$, time $t = 5\text{s}$

(i) work done $= mgh = 4 \times 10 \times 10 = 400 \text{ J}$

(ii) power $= \frac{\text{work done}}{\text{time taken}} = \frac{400}{5} = 80 \text{ W}$

Solution 61

Practical or commercial unit of power is kilowatt-hour.

Solution 62

When we wind a watch, the configuration of its spring is changed. The energy stored in the spring is obviously potential in nature (elastic potential to be more accurate).

Solution 63

This heat energy comes from the mechanical energy.

Solution 64

When we rub our hands, mechanical energy is converted into heat energy.

Solution 65

When the head of a nail is struck with a hammer, the mechanical energy of the hammer pushes the nail into the plank of wood and in this process a part of energy is converted into heat energy.

Solution 66

Given, power of lamp = 100 watt

Rate of dissipation of light = 10 J/s

Therefore, percentage of electrical energy converted into light energy $= \frac{10}{100} \times 100\% = 10\%$

Solution 67

Given, force $F = 300 \text{ N}$, $u = 18 \text{ km/hr}$.

Now, $\text{power} = \frac{W}{t} = \frac{F \cdot s}{t} = F \cdot v$

or, $P = 300 \times \frac{18 \times 10^3}{60 \times 60} = 1500 \text{ watt}$

Now, 1 H.P. = 746 watt

$\therefore 1500 \text{ watt} = 2 \text{ H.P. (approx.)}$

Solution 68

Given, Power = 100 watt, time = 2hrs

Energy consumed = power \times time
 $= 100 \times 2 \times 60 \times 60$
 $= 7.2 \times 10^5 \text{ J}$

Solution 69

Given, mass = 5 kg, height = 10 m, time = 10s

$\text{Power} = \frac{mgh}{t} = \frac{5 \times 10 \times 10}{10} = 50 \text{ watt}$