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Chapter – 11 Work and Energy

Multiple Choice Questions

Q1. When a body falls freely towards the earth, then its total energy

a) **Increases**
b) **Decreases**
c) **Remains constant**
d) **First increases and then decreases**

Answer: Option c) Remains constant

The energy of a system is conserved, so body falls freely towards the earth and its total energy remain constant i.e., the sum of the kinetic and potential energy of the body is same at all points.

Q2. A car is accelerated on a levelled road attains a velocity 4 times of its initial velocity. In this process, the potential energy of the car

a) **Does not change**
b) **Becomes twice to that of initial**
c) **Becomes 4 times that of initial**
d) **Becomes 16 times that of initial**

Answer: Option a) Does not change

P.E of the car do not change but K.E changes

initial velocity $= u$

$$Kinetic\ energy, K_1 = \frac{1}{2}mu^2$$

velocity become 4 times of its initial velocity,

$$final\ velocity, v = 4\,u$$

substitute $v = 4\,u$ in Kinetic energy equation,

$$Kinetic\ energy = \frac{1}{2}m(4u)^2$$

$$= \frac{1}{2}m\ 16\ u^2$$

$$K_2 = 16\frac{1}{2}mu^2$$

by kinetic equation,

$$K_2 = 16K_1$$

the kinetic energy of car is16 times of initial energy.

Q3. In case of negative work, the angle between the force and displacement is

a) 0
b) 45^o
c) 90^o
d) 180^o

Answer: Option d) 180^0

a) Work done, $W = F.d\ cos\theta$

W.D at $\theta = 0^o$, $W = F.d\cos 0^o$

$\cos 0^o = 1$

$$W = F.d$$

for angle $\theta = 0^o$
W,D is positive, so it's not true.

b) Work done, $W = F.d\cos\theta$

W.D at $\theta = 45^o$

$$\cos 45^o = \frac{1}{\sqrt{2}}$$

$$W = \frac{F.d}{\sqrt{2}}$$

for angle $\theta = 45^o$
Work done is positive, so it's not true.

c) Work done, $W = F.d\cos\theta$

W.D at $\theta = 90^o$

$$W = F.d\cos 90^o$$
$$\cos 90^o = 0$$
$$W = 0$$

for angle $\theta = 90^o$
Work done is positive, so it's not true.

d) Work done, $W = F.d\cos\theta$

W.D at $\theta = 180^o$

$$W = F.d\cos 180^o$$

$$\cos 180^o = -1$$

$$W = -F.d$$

For negative work, the angle is 180^o between the force and displacement. So, it is true.

Q4. An iron sphere of mass 10 kg has the same diameter as an aluminium sphere of mass 3.5 kg. both spheres are dropped simultaneously from a tower. When they are 10 m above the ground, they have the same

a) Acceleration
b) Momenta
c) Potential energy
d) Kinetic energy

Answer: Option a) Acceleration

The acceleration is same when both the spheres are dropped, as free fall acceleration of body is equals to $g = 9.8\, m/s^2$.

Q5. A girl is carrying a school bag of 3 kg mass on her back and moves 200 m on a levelled road. The work done against the gravitational force will be $(\boldsymbol{g = 10\, ms^{-2}})$

a) $\boldsymbol{6 \times 10^3\, J}$
b) $\boldsymbol{6\, J}$
c) $\boldsymbol{0.6\, J}$
d) Zero

Answer: Option d) Zero

The work done, $W = F.d\cos\theta$

Force on the school bag is at 90^o from the road,

$$\theta = 90^o$$

$$W = F.d\cos 90^o$$

$$\cos 90^o = 0^o$$

$$W = 0$$

So, W.D against the gravitational force is zero.

Q6. Which one of the following is not the nit of energy?

a) **Joule**
b) **Newton metre**
c) **Kilowatt**
d) **Kilowatt hour**

Answer: Option c) Kilowatt

The joule, newton metre and kilowatt hour are the units of energy and the kilowatt is the unit of power.

Q7. The work done on an object does not depend upon the

a) **Displacement**
b) **Force applied**
c) **Angle between force and displacement**
d) **Initial velocity of the object**

Answer: Option d) Initial velocity of the object

work done, $W = F.d\cos\theta$

The force $= F$ applied on the object,

$d = displacement$

$\theta = angle$ between force and displacement.

W.D on an object do not depend on the initial velocity of the object.

Q8. Water stored in a dam possesses

a) **No energy**
b) **Electrical energy**
c) **Kinetic energy**
d) **Potential energy**

Answer: Option d) Potential energy

Potential energy is stored energy, so water stored in a dam has potential energy.

Q9. A body is falling from a height h, after it has fallen a height $h/2$, it will possess

a) **Only potential energy**
b) **Only kinetic energy**
c) **Half potential and half kinetic energy**
d) **More kinetic and less potential energy**

Answer: Option c) Half potential and half kinetic energy

Body at height, h,

$$Total\ energy = Kinetic\ Energy + Potential\ energy$$

at height 'h', velocity of body is zero.

$$Kinetic\ Energy = 0$$

$$Potential\ Energy = mgh$$

$$Total\ energy = mgh + 0 = mgh$$

At height, $\frac{h}{2}$

$$Potential\ energy = mg\frac{h}{2} = \frac{mgh}{2} \qquad .....i)$$

$$Kinetic\ energy = \frac{1}{2}\ mv^2$$

by the equation of motion

$$v^2 = u^2 + 2gh$$

$$v^2 = \frac{2gh}{2}$$

$$v = \sqrt{gh}$$

$$Kinetic\ energy = \frac{1}{2}m \times \left(\sqrt{gh}^2\right) = \frac{mgh}{2} \qquad ....ii)$$

So, body at height $\frac{h}{2}$ has half potential and kinetic energy.

Short Answer Type Questions

Q10. A rocket is moving up with a velocity v. If the velocity of this rocket is suddenly tripled, what will be the ratio of two kinetic energies?

Answer:

$$v_1 = v$$

$$v_2 = 3v$$

Kinetic energy of rocket (K) $= \frac{1}{2}mv^2$

The ratio of two kinetic energies,

$$\frac{K_1}{K_2} = \frac{\frac{1}{2}mv_1^2}{\frac{1}{2}mv_2^2}$$

$$\frac{K_1}{K_2} = \frac{v_1^2}{v_2^2}$$

$v_2 = 3v$ and $v_1 = v$

$$= \frac{v^2}{(3v)^2}$$

$$= \frac{v^2}{9v^2}$$

$$\frac{K_1}{K_2} = \frac{1}{9}$$

So, the ratio of two kinetic energies,

$$K_1 : K_2 = 1 : 9$$

Q11. Avinash can run with a speed of 8 ms^{-1} against the frictional force of 10 N and Kapil can move with a speed of 3 ms^{-1} against the frictional force of 25 N. Who is more powerful and why?

Answer:

force by Avinash $= 10\ N$

Speed of Avinash $= 8\ ms^{-1}$

Power of Avinash $= F.v = 10 \times 8 = 80\ W$

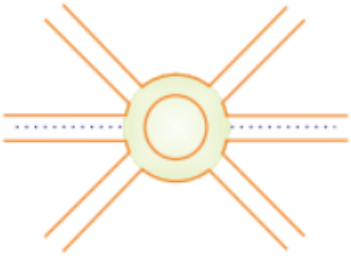
Force by Kapil $= 25\ N$

Speed of Kapil $= 3\ ms^{-1}$

Power of Kapil $= F.v = 25 \times 3 = 75\ W$

So, Avinash has more power than Kapil $(80 - 75) = 5\ W$. Avinash is more powerful.

Q12. A boy is moving on a straight road against a frictional force of 5 N. After travelling a distance of 1.5 km, he forgot the correct path at a round about of radius 100 m as shown in figure. However, he moves on the circular path for one and half cycle and then he moves forward up to 2.0 km. Calculate the work done by him.



Answer:

force by boy against friction $= 5\ N$

Displacement on the circular path = One cycle + Half cycle = 0 + Half cycle

$$= 0 + Diameter\ of\ circular\ path$$

$$= 0 + 2\,r = 0 + 2 \times 100$$

$$= 0 + 200 = 200\ m$$

Total displacement $= 1.5\ km + 200\ m + 2.0\ km$

$$= 1.5 \times 1000 + 200 + 2 \times 1000\ km$$

$$= 3700\ m$$

Work done by boy $= F.s\cos\theta$

Since, $\theta = 0^o$

$$\cos 0^o = 1$$

$$= 5 \times 3700 \times \cos 0 = 18500\ J$$

Q13. Can any object have mechanical energy even if its momentum is zero?

Answer:

Mechanical energy is sum of kinetic and potential energy.

Momentum of the body is zero as velocity and kinetic energy of body is also zero, but it has potential energy.

Mechanical energy = potential energy + kinetic energy

if mechanical energy is zero.

$$Potential\ energy + Kinetic\ energy = 0$$

$$Potential\ energy = -Kinetic\ energy$$

So, body has momentum, if mechanical energy is zero.

Q14. The power of a motor pump is 2 kW. How much water per minute, the pump can raise to a height of 10 cm? [given, $g = 10\ ms^{-2}$]

Answer:

power of a motor= $2kW = 2 \times 1000\ W = 2000\ W$

$$Power, p = \frac{Energy}{Time}$$

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

$$2000 = \frac{m \times 10 \times 10}{60}$$

$$m = \frac{2000 \times 60}{10 \times 10}$$

$$m = 1200\ kg$$

Q15. The weight of a person on a planet A is about half that on the earth. He can jump up to 0.4 m height on the surface of the earth. How high he can jump on the planet A?

Answer:

weight of a person on the earth = w

The height he can jump $h_1 = 0.4\ m$

The potential energy $= mgh = mg \times 0.4$

weight of the person on the other planet $= \frac{w}{2}$

He can jump to a height h_2 and its potential energy is $\frac{w}{2} h_2 = \frac{mg}{2} h_2$

The potential energy is same, as the person applied same amount of effort .

$$0.4 = \frac{mg}{2} h_2$$

$$h_2 = 0.4 \times 2 = 0.8\ m$$

Q16. The velocity of a body moving in a straight line is increased by applying a constant force F, for some distance in the distance in the direction of the motion. Prove that the increase in the kinetic energy of the body is equal to the work done by the force on the body.

Answer:

an object of mass m moving with a uniform velocity u.

it is displaced through a distance s, when force F acts on it in the direction of its displacement.

by the third equation of motion,

$$v^2 = u^2 + 2as$$

$$v^2 - u^2 = 2as$$

$$s = \frac{v^2 - u^2}{2a}$$

Work done is, $W = F\, s \cos\theta$

So, $\theta = 0^o$ also F = ma.

$$= ma.s$$

$$= ma \times (\frac{v^2 - u^2}{2a})$$

$$W = \frac{1}{2}m(v^2 - u^2)$$

If the object is starting from rest, $u = 0$,

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

So, the work done is the change in the kinetic energy of an object.

Q17. Is it possible that an object is in the state of accelerated motion due to external force acting on it, but no work is being done by the force? Explain it with an example.

Answer

Yes, force is perpendicular to the direction of displacement.

Example: earth revolves around the sun under gravitational force, no work is done by the sun, though earth has centripetal acceleration.

Q18. A ball is dropped from a height of 10 m. if the energy of the ball reduce by 40% after striking the ground, how much high can the ball bounce back? [$g = 10\ ms^{-2}$]

Answer:

if the energy of the ball reduces by 40% after striking the ground, then remaining energy of the ball is 60% of initial energy.

initial energy of the body of mass, m at height h is mgh.

$$mgh' = 60\%\ of\ mgh$$

$$h' = 60\% \times h$$

$$h' = \frac{60}{100} \times 10 = 6\,m$$

Q19. If an electric iron of 1200 W is used for 30 min everyday, find electric energy consumed in the month of April.

Answer:

Power of electric iron $= 1200\ W$

$$Time\ (t) = 30\ \text{min} = 30 \times 60\ s = 1800\ s$$

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

$$1200 = \frac{Energy}{30 \times 60}$$

$$E = 1200 \times 30 \times 60$$

$$E = 21.6 \times 10^5\ J$$

Energy consumed in one day $= 21.6 \times 10^5\ J$

Energy used in 30 days $= 21.6 \times 10^5 \times 30$

$$= 6.4 \times 10^7\ J$$

Long Answer Type Questions

Q20. A light and a heavy object have the same have the same momentum. Find out the ratio of their kinetic energies. Which one has a larger kinetic energy?

Answer:

m_1 and m_2 are masses of a light and a heavy object,

$$Kinetic\ energy\ (K) = \frac{1}{2}mv^2$$

$$momentum\ (p) = mv$$

Multiply and dividing with m in,

$$K = \frac{1}{2}\ \frac{mv^2 \times m}{m}$$

$$K = \frac{1}{2}\frac{(mv)^2}{m}$$

As $\rho = mv$

$$K = \frac{p^2}{2m}$$

$$kinetic\ energy, K = \frac{p^2}{2m}$$

the momentum is same for light and heavy body

$$kinetic\ energy, K \propto \frac{1}{m}$$

kinetic energy is inversely proportional to the mass and lighter body has larger kinetic energy.

Q21. An automobile engine propels a 1000 kg car A along a levelled road at a speed of $36\ kmh^{-1}$. Find the power if the opposing frictional force is 100 N. Now, suppose after travelling a distance of 200 m, this car collides with another stationary car B of same mass and comes to rest. Let its engine also stop at the same time. Now car B starts moving on the same level road without getting its engine started. Find the speed of the car B just after the collision.

Answer:

mass of car (A) $= 1000\ kg$

Mass of car B $= 1000\ kg$

Force by car A = $100\ N$

The speed (v_A) of car $36\ kmh^{-1}$

$$= 36 \times \frac{5}{18} = 10\ ms^{-1}$$

the power of the car (A),

$$P_A = F.v_A = 100 \times 10 = 1000\ W$$

For car A, Newton's law,

$$F = ma$$

$$100 = 1000 \times a$$

$$a = \frac{100}{1000}$$

$$a = \frac{1}{10} ms^{-2}$$

Velocity of car A after 200 m is,

by third equation of motion,

$$v^2 = u^2 + 2as$$

$$v^2 = (10)^2 + 2 \times \frac{1}{10} \times 200$$

$$v^2 = 100 + 40 = 140$$

$$v = \sqrt{140} = 11.8 ms^{-1}$$

After 200 m, the speed of car A, $u_1 = 11.8 ms^{-1}$

After the collision, initial speed of car B, $u_2 = 0$

By conservation of mass momentum,

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

$$m_1 \times 11.8 + m_2 \times 0 = m_1 \times 0 + m_2 \times v_2$$

$$11.8\, m_1 = m_2 v_2$$

$$11.8\, m_1 = m_1 v_2$$

$$v_2 = 11.8\, ms^{-1}$$

Q22. A girl having mass of 35 kg sits on a trolley of mass 5 kg. the trolley is given an initial velocity of $4\ ms^{-1}$ by applying a force. The trolley comes to rest after traversing a distance of 16 m. (a) how much work is done on the trolley? (b) How much work is done by the girl?

Answer:

$$Ju = 4\, m/s$$

$$v = 0$$

$$s = 16\, m$$

by third equation of motion, for retardation, the acceleration is negative.

$$v^2 = u^2 - 2as$$

$$(0)^2 = (4)^2 - 2a \times 16$$

$$0 = 16 - 32\, a$$

$$a = \frac{16}{32} = 0.5\, ms^{-2}$$

$u = initial\ velocity$

$v = final\ velocity$

$a = acceleration$

$s = displacement$

a) Total mass $= 35 + 5 = 40\ kg$
Work done on the trolley,

$$W = F.d = ma.s$$
$$W = 40 \times 0.5 \times 16 = 320\ J$$

b) Mass of girl, $m = 35\ kg$
Work done by girl,

$$W = F.d = ma.s$$
$$W = 35 \times 0.5 \times 16 = 280$$

Q23. Four men lifted a 250 kg box to a height of 1 m and hold it without raising or lowering it. (a) How much work is done by the men in lifting the box? (b) How much work do they do in just holding it? (c) Why so they get tired while holding it? [given $=$ $\mathbf{10\ ms^{-2}}$].

Answer:

$m = 250\ kg$

$h = 1\ m$

$acceleration\ due\ to\ gravity\ g = 10\ ms^{-2}$

a) Work done by the man,

$$W = Potential\ energt\ of\ box$$
$$W = mgh$$
$$W = 250 \times 1 \times 10 = 2500\ J$$

b) Work done is zero in holding a box, because displacement is zero.

c) While holding a box, the energy of man loses and he feel tired.

Q24. What is power? How do you differentiate kilowatt from kilowatt hour? The Jog Falls in Karnataka state are nearly 20 m high. 2000 tonnes of water falls from it in a minute. Calculate the equivalent power if all this energy can be utilised? [$g =$ $\mathbf{10\ ms^{-2}}$].

Answer:

i) Power is the rate of transfer of energy or work done.
ii) Kilowatt is the unit of power and the kilowatt hour is unit of energy.

$$1kWh = 1000 \times 3600\ \Rightarrow 1\ kilowatt\ hour = 3.6 \times 10^6\ J$$

iii) Mass of water $= 2000\ tonnes$

mass of water $= 2000 \times 1000 = 2 \times 10^6\ kg$

$$Power = \frac{Energy}{Time}$$

$$p = \frac{mgh}{t}$$

$$P = \frac{2 \times 10^6 \times 10 \times 20}{60}$$

$$P = 6.67 \times 10^6\ W$$

So, all the power can be utilised.

Q25. How is the power related to the speed at which a body can be lifted? How many kilograms will a man working at the power of 100 W, be able to lift at constant speed of $1\ ms^{-1}$ vertically? [$g = 10\ ms^{-2}$]

Answer:

i) The power of a body is the force applied to the body and the velocity v of the body

$$Power\ (P) = \frac{work}{time}$$

$$P = \frac{F.s}{t}$$

F = force
S = displacement
T = time

$$P = F.v$$

$$W = F.s$$

$$v = \frac{s}{t}$$

$Power\ (P) 100\ W$

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

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

$$P = F.v \; and \; F = mg$$

$$\Rightarrow P = mg.v$$

$$100 = m \times 10 \times 1$$

$$m = \frac{100}{10}$$

$$m = 10 \; kg$$

A man working with power of 100 W can lift 10 kg.

Q26. Define watt. Express kilowatt in terms of joule per second. A 150 kg car engine develops 500 W for each kg. What force does it exert in moving the car at speed of $20 \; ms^{-1}$?

Answer:

i) One watt is the power of a body which work at the rate of 1 J/s.

$$1 \; watt = 1 \frac{joule}{second}$$

ii) 1 kilowatt = 1000 watt = 1000 J/s

iii) $m = 150 \; kg$

$$P = 500 \; W \; and \; v = 20 \; ms^{-1}$$

A car engine 150 kg has 500 watts for each kg.

Total power = $150 \times 500 = 75000 \; W$

$$Power = Force \times speed$$

$$75000 = Force \times 20$$

$$Force = \frac{75000}{20} = 3750 \; N$$

Q27. Compare the power at which each of the following is moving upwards against the force of gravity? [given, $g = 10 \; ms^{-2}$].

Answer:

i) Mass of butterfly $= 1.0 \; g = \frac{1}{1000} \; kg$

$$g = 10 \; ms^{-2}$$
$$speed = 0.5 \; ms^{-1}$$

$$Power = Force \times Speed$$

$$P = mgv$$

$$P = \frac{1}{1000} \times 10 \times 0.5$$

$$P = \frac{1}{200}\ W$$

ii) Mass of squirrel $= 250\ g = \frac{250}{1000}\ kg$

Speed $= 0.5\ ms^{-1}$

$$Power = Force \times Speed$$

$$P = mg \times v$$

$$P = \frac{250}{1000} \times 10 \times 0.5$$

$$P = \frac{250}{200}\ W$$

So, squirrel has more power than butterfly.