KD EDUCATION ACADEMY [9582701166]

Time : 5 Hour | STD 11 Science Physics | Total Marks : 300

kd 90+ question ch-5 work, energy and power

*** Choose The Right Answer From The Given Options.[1 Marks Each]** **[53]**

1. The K.E. of a body becomes 4 times its initial value. The new linear momentum will be:

(A) Same as initial value.
(B) Four times the initial value.
(C) Twice the initial value.
(D) Eight times the initial value.

Ans. :

c. Twice the initial value.

Explanation:

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

When K.E. becomes 4 times, p^2 is 4 times.

Therefore, p becomes 2 times.

2. Two bodies P and Q of equal masses are kept at heights x and 4x respectively. What will be the ratio of their potential energies?

(A) 1 : 8
(B) 4 : 1
(C) 1 : 4
(D) 8 : 1

Ans. :

c. 1 : 4

Explanation:

Potential energy P = mgh

Given, $h_1 = x$; $h_2 = 4x$

Since, the masses are same,

then $\frac{P_1}{P_2} = \frac{h_1}{h_2} = \frac{x}{4x} = 1 : 4$

3. A long spring is stretched by 2cm. Its potential energy is V. If the spring is stretched by 10cm, its potential energy would be:

(A) $\frac{v}{25}$
(B) $\frac{v}{5}$
(C) 5V
(D) 25V

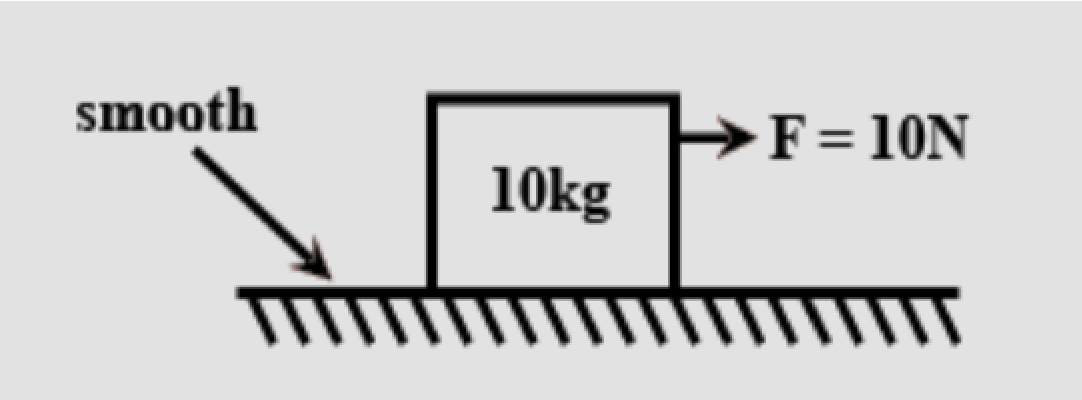
Ans. :

d. 25V

Explanation:

Potential energy $\propto x^2$ When × becomes 5 times, P.E. becomes 25 times.

4. Force shown acts for 2 seconds. Find out work done by force F on 10kg in 3 seconds.



(A) 30J (B) 20J (C) 50J (D) 60J

Ans. :

b. 20J

Explanation:

Work done,

In = Fd

Displacement d is given by,

$\mathrm{d}=\frac{1}{2}\mathrm{at}^2$

F = ma

10 = 10a, a = 1m/ s^2

$\mathrm{d}=\frac{1}{2}(1)(2)^2=2\mathrm{m}$

In = 10 × 2 = 20D

5. A ball of mass 3kg collides with a wall with velocity 10m/ sec at an angle of 30° with the wall and after collision reflects at the same angle with the same speed. The change in momentum of ball in MKS unit is:

(A) 20 (B) 30 (C) 15 (D) 45

Ans. :

b. 30

Explanation:

$\triangle\mathrm{p}{=}2\mathrm{mvcos}60^\circ=\mathrm{min}=2\times3\times10\times21=30\frac{\mathrm{kgm}}{\mathrm{s}}$

6. Two weights of 5kg and 10kg are placed on a horizontal table of height 1.5m. Which will have more potential energy?

(A) 5kg (B) 10kg (C) Both will have equal energy (D) None of the above

Ans. :

b. 10kg

Explanation:

We know that, P.E = mgh

So, It is directly proportional to height and mass.

Since both the weights are at the same height, so the weight with a larger mass will have more potential energy.

Since 10kg object has a larger mass than a 5 medical history

So, the potential energy of a 10kg mass will be greater.

7. Two bodies of masses m and 4m are moving with equal linear momentum. The ratio of their kinetic energies is:

(A) 1 : 4 (B) 4 : 1 (C) 1 : 1 (D) 1 : 2

Ans. :

b. 4 : 1

8. Two bodies of masses m and 4m are moving with equal kinetic energy. The ratio of their linear momenta is:

(A) 1 : 4 (B) 4 : 1 (C) 1 : 2 (D) 1 : 1

Ans. :

c. 1 : 2

9. A ball of mass m moving with a velocity v collides with an identical ball at rest. After collision, the first ball comes to rest. The speed of the other ball is:

(A) $\frac{v}{2}$ (B) 2v (C) v (D) zero

Ans. :

c. v

Explanation:

As the masses of two balls are equal, their velocities are exchanged. As first ball comes to rest, speed of other ball = v.

10. A man does a given amount of work in 10s. Another man does the same amount of work in 20s. The ratio of the output power of the first man to that of second man is

(A) 1 (B) 1 : 2 (C) 2 : 1 (D) 3 : 1

Ans. :

c. 2 : 1

Explanation:

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

So, if W is constant, than $P \propto \frac{1}{t}$

i.e. $\frac{P_1}{P_2} = \frac{t_2}{t_1} = \frac{20}{10}$

$\Rightarrow \frac{P_1}{P_2} = \frac{2}{1}$

$P_1 : P_2$

= 2 : 1

11. A force of 16N is distributed uniformly on one surface of a cube of edge 8cm. The pressure on this surface is:

(A) 3500Pa (B) 2500Pa (C) 4500Pa (D) 5500Pa

Ans. :

b. 2500Pa

Explanation:

F = 16N

A = 8 × 8 × $10^{-4}m^2$

$$P = \frac{F}{A} = \frac{16}{64 \times 10^{-4}} = \frac{1000}{4} = 2500Pa$$

12. What is the ratio of kinetic energy of a particle at the bottom to the kinetic energy at the top when it just loops a vertical loop of radius r?

(A) 5 : 1 (B) 2 : 3 (C) 5 : 2 (D) 7 : 2

Ans. :

a. 5 : 1

13. In a hydroelectric power station, the water is flowing at $2ms^{-1}$ in the river which is 100m wide and 5m deep. The maximum power output from the river is:

(A) 1.5MW. (B) 2MW. (C) 2.5MW. (D) 3MW.

Ans. :

b. 2MW.

14. A stationary particle explodes into two particles of masses m_1 and m_2, which move in opposite directions with velocities v_1 and v_2. The ratio of their kinetic energies $\frac{E_1}{E_2}$ is:

(A) $\frac{m_2}{m_1}$ (B) $\frac{m_1}{m_2}$ (C) 1 (D) $\frac{m_1 v_2}{m_2 v_1}$

Ans. :

a. $\frac{m_2}{m_1}$

Explanation:

According to the principle of conservation of linear momentum,

$$m_1 v_1 - m_2 v_2 = 0$$

$$\therefore \frac{m_1}{m_2} = \frac{v_2}{v_1}$$

$$\frac{E_1}{E_2} = \frac{\frac{1}{2} m_1 v_1^2}{\frac{1}{2} m_2 v_2^2}$$

$$= \frac{m_1}{m_1}\left(\frac{v_1}{v_2}\right)^2 = \frac{m_1}{m_2}\left(\frac{m_2}{m_1}\right)^2$$

$$= \frac{E_1}{E_2} = \frac{m_2}{m_1}$$

15. A body of mass m is rotating in a vertical circle of radius 'r' with critical speed. The difference in its K.E. at the top and the bottom is _____.

(A) 2mgr (B) 4mgr (C) 6mgr (D) 3mgr

Ans. :

a. 2mgr

Explanation:

The change of kinetic energy will be equet to the change in potential energy.

$$\triangle KE = \triangle PE = mg(h_1 - h_2)$$

Since radious r,

h_1 - h_2 = r

16. If g is acceleration due to gravity on earth's surface, the gain in potential energy of an object of mass m raised from surface of earth to a height equal to radius R of the earth is:

(A) $\frac{1}{2}\mathrm{mgR}$ (B) $2\mathrm{mgR}$ (C) mgR (D) $\frac{1}{4}\mathrm{mgR}$

Ans. :

a. $\frac{1}{2}\mathrm{mgR}$

17. The ratio of spring constants of two springs is 2 : 3. What is the ratio of their potential energy if they are stretched by the same force?

(A) 2 : 3 (B) 3 : 2 (C) 4 : 9 (D) 9 : 4

Ans. :

b. 3 : 2

18. In a head on elastic collision of a very heavy body moving with velocity v with a light body at rest. Then, the velocity of heavy body after collision is:

(A) v. (B) 2. (C) Zero. (D) $\frac{\mathrm{v}}{2}$.

Ans. :

a. v.

19. A cricket ball of mass 150g moving with a speed of 126km/ h hits at the middle of the bat, held firmly at its position by the batsman. The ball moves straight back to the bowler after hitting the bat. Assuming that collision between ball and bat is completely elastic and the two remain in contact for 0.001s, the force that the batsman had to apply to hold the bat firmly at its place would be:

(A) 10.5N (B) 21N (C) 1.05×10^4 (D) N

Ans. :

c. $1.05 \times 10^4\mathrm{N}$

Explanation:

We know that force $\mathrm{F} = \frac{\Delta \mathrm{p}}{\Delta \mathrm{t}}$ and $\frac{\Delta \mathrm{p}}{\Delta \mathrm{t}} = \frac{\mathrm{m}[(-\mathrm{v})-\mathrm{u}]}{\mathrm{t}} = \frac{-2\mathrm{mv}}{\mathrm{t}}$

And the magnitude of force will be, $\mathrm{F} = \frac{2\mathrm{mv}}{\mathrm{t}}$

According to the problem, $\mathrm{m} = 150\mathrm{g} = \frac{150}{1000}\mathrm{kg} = \frac{3}{20}\mathrm{kg}$

$\Delta \mathrm{t} = \text{time of contact} = 0.001\mathrm{s}$

$\mathrm{u} = 126\mathrm{km/\ h} = \frac{126\times1000}{60\times60}\mathrm{m/\ s} = 35\mathrm{m\ s}$

$\mathrm{v} = -126\mathrm{km/\ h} = -35\mathrm{m/\ s}$

Change in momentum of the ball

$\Delta \mathrm{P} = \mathrm{m}(\mathrm{v}-\mathrm{u})$

$= \frac{3}{20}(-70) = -\frac{21}{2}$

We know that force $\mathrm{F} = \frac{\Delta \mathrm{P}}{\Delta \mathrm{t}}$

$= \frac{\frac{-21}{2}}{0.001}\mathrm{N} = -1.05 \times 10^4\mathrm{N}$

Here, -ve sign shows that force will be opposite to the direction of movement of the ball before hitting. So the force that the batsman had to apply to hold the bat firmly at its place would be F = 1.05×10^4N K

20. A boy of mass 40kg runs up a flight of 50 steps, each 10cm high in 14s. So, work done by the boy is:

(A) 1960J (B) 19.6J (C) 980J (D) 9.8J

Ans. :

a. 1960J

Explanation:

Mass of the boy, m = 40kg

Number of steps = 50

Height of each step = 10cm

Force on the boy due to gravity, F = mg = 40 × 9. 8 N = 392N

While climbing up the steps, the boy does work against gravity.

Displacement in the vertical direction, s = (50 × 10)cm = 500cm = 5m

Displacement is in the direction of force applied by the boy against gravity.

So, work done, In = F × s = 392 × 5J = 1960J

21. A bomb of mass 1kg is thrown vertically upwards with a speed of 100m/s. After 5 seconds, it explodes into two fragments. One fragment of mass 400 gm is found to go down with a speed of 25m/s. What will happen to second fragment just after explosion? (g = 10m/s^2).

(A) It will go upwards with speed 100m/s. (B) It will go upwards with speed 40m/s. (C) It will go upwards with speed 60m/s. (D) It will go downwards with speed 40m/s.

Ans. :

a. It will go upwards with speed 100m/s.

Explanation:

From v = u + at = 100 – 10 × 5 = 50m/s

This is the velocity at the time of explosion. According to principle of conservation of linear momentum,

$$1 \times 50 = \frac{400}{1000} \times (-25) + \frac{600}{1000} \times \mathrm{v}$$

$$(50 + 10) = 0.6\mathrm{v}$$

$$\mathrm{v} = \frac{60}{0.6} = 100\mathrm{m/s}$$

The second fragment will go upwards with a speed of 100 m/s.

22. A body of mass 2Kg moving (initially) with 10m/ s is acting upon by a resultant constar which is opposite to its initial velocity. Its speed decreases to 4m/ s in 1s. Then the force:

(A) 12N (B) 28N (C) 8N (D) None

Ans. :

a. 12N

23. Two bodies of masses m, and m, have same momentum. The ratio of their KE is:

(A) $\sqrt{\frac{\mathrm{m_2}}{\mathrm{m_1}}}$ (B) $\sqrt{\frac{\mathrm{m_1}}{\mathrm{m_2}}}$ (C) $\frac{\mathrm{m_1}}{\mathrm{m_2}}$ (D) $\frac{\mathrm{m_2}}{\mathrm{m_1}}$

Ans. :

d. $\frac{m_2}{m_1}$

24. A heavy steel ball of mass greater than 1kg moving with a speed of 2m/ s collides head on with a stationary ping pong ball of mass less than 0.1 g. The collision is elastic. After the collision the ping pong ball moves approximately with a speed.

(A) 2m/ s (B) 4m/ s (C) 2 × 104m/ s (D) 2 × 103m/ s

Ans. :

a. 4m/ s

Explanation:

Since the body is much heavy these won't be much change in velocity & e = 1

$\text{i.e.,} \frac{\text{v-2}}{\text{0-2}} = -1$

⇒ v = 4m/ s

25. A pump is used to lift 500kg of water from a depth of 80m in 10s . (Take g = 10m s^{-2}). Calculate the work done by the pump.

(A) 16×10^5J (B) 4×10^5J (C) 4×10^8J (D) 2×10^5J

Ans. :

b. 4×10^5J

Explanation:

Mass of water lifted, m = 500kg

Displacement, d = 80m

Time taken, t = 10s

Force, F = m × g

F = 500 × 10

F = 5000N

Work done, In = F × d

In = 5000 × 80

In = 4 × 105 J.

26. What will be the potential energy of a body of mass 5kg kept at a height of 10m ?

(A) 50J (B) 0.5J (C) 500J (D) 25J

Ans. :

c. 500J

Explanation:

Potential energy is energy stored in an object. This energy has the potential to do work. Gravity gives potential energy to an object. This potential energy is a result of gravity pulling downwards. The gravitational constant, g, is the acceleration of an object due to gravity. This acceleration is about 10 meters per second on earth. The formula for potential energy due to gravity is PE = mgh. As the object gets closer to the ground, its potential energy decreases while its kinetic energy increases.

27. Two masses of 1gm and of 4gm are moving with equal linear momenta. The ratio of their kinetic energies is:

(A) 4 : 1 (B) $\sqrt{2} : 1$ (C) 1 : 2 (D) 1 : 16

Ans. :

a. 4 : 1

28. A certain force acting on a body of mass 2kg increase its velocity from 6m/ s to 15m/ s in 2s. The work done by the force during this interval is ?

(A) 27J (B) 3J (C) 94.5J (D) 189J

Ans. :

d. 189J

Explanation:

v = u + at

15 = 6 + a(2)

a = 4.5m/ s^2

s = ut + 0.5at^2 = 6(2) + 0.5(4.5)(4) = 21m

W = mas = 2(4.5)(21) = 189J

29. In daily life, intake of a human adult is 10^7J, then average human consumption in a day is:

(A) 2400kcal. (B) 1000kcal. (C) 1200kcal. (D) 700kcal.

Ans. :

a. 2400 kcal.

30. A girl weighing 50kg makes a high jump of 1.2m. What is her kinetic energy at the highest point? (g = $10ms^{-2}$)

(A) 6000J (B) 600J (C) 60J (D) Zero

Ans. :

d. Zero

Explanation:

mass of girl M = 50kg

h = 1. 2m

A girl is jumping vertically upward, when it will reach at maximum Hight its velocity will become zero ie in_f = 0

K. And $= \frac{1}{2}\mathrm{min}^2 = \frac{1}{2}\mathrm{m} \times 0 = 0$

31. A force of 10N is applied on an object of mass 2kg placed on a rough surface having coefficient of friction equal to 0.2. Work done by applied force in 4s is:

(A) 120J. (B) 240J. (C) 250J. (D) 100J.

Ans. :

b. 240J.

32. A force $\mathrm{F} = 5\hat{\mathrm{i}} + 6\hat{\mathrm{j}} - 4\hat{\mathrm{k}}$ acting on a body produces a displacement $\mathrm{s} = 6\hat{\mathrm{i}} + 5\hat{\mathrm{k}}$ The work done by the force is:

(A) 18 units. (B) 15 units. (C) 12 units. (D) 10 units.

Ans. :

d. 10 units.

33. A body of mass 2kg makes an elastic collision with another body at rest and comes to rest. The mass of the second body which collides with the first body is:

(A) 2kg (B) 1. 2kg (C) 3kg (D) 1kg

Ans. :

a. 2kg

34. A particle is pushed by forces $2\hat{i} + 3\hat{j} - 2\hat{k}$ and $5\hat{i} + \hat{j} - 2\hat{k}$ simultaneously and it is displaced from point $\hat{i} + \hat{j} + \hat{k}$ to point $2\hat{i} - \hat{j} - 2\hat{k}$. The work done is:

(A) 7 units. (B) -7 units. (C) 10 units. (D) -10 units.

Ans. :

b. -7 units.

Explanation:

Net force, $= 2\hat{i} + 3\hat{j} - 2\hat{k} + 5\hat{i} - \hat{j} - 3\hat{k}$

$= 7\hat{i} + 2\hat{j} - 5\hat{k}$

Diolacement, $d = 2\hat{i} - \hat{j} + 3\hat{k} - \hat{i} - \hat{j} - \hat{k}$

$= \hat{i} - 2\hat{j} + 2\hat{k}$

Work done $= F.d = (7\hat{i} + 2\hat{j} - 5\hat{k}).(\hat{i} - 2\hat{j} + 2\hat{k})$

$= 7 - 4 - 10 = -7$ units.

35. A man raises a box of mass 50kg to a height of 2m in 2minthes, while another man raises the same box to the same height in 5minthes. What is the ratio of work done by them?

(A) 1 : 1 (B) 2 : 1 (C) 1 : 2 (D) 4 : 1

Ans. :

a. 1 : 1

Explanation:

Work = Fs $\cos\theta$

Where, F is the force applied, s is the displacement, and I is the angle between the force applied and displacement.

Hence, work done is independent of time taken.

In the given cases, I = 0° as the force applied are in the same direction. Also, F = mg

So In = Fs = mgs

In both the cases, mass and displacement are the same.

In = 50 × 10 × 2 = 1000 D

36. A force $F = -kx^2 (x \neq 0)$ acts on a particle in X-direction. Find the work done by the force in displacing the particle from x = -a to x = 2a.

(A) $\frac{3k}{2a}$ (B) $\frac{4k}{a^2}$ (C) $\frac{-3k}{2a^2}$ (D) $\frac{-9k}{a^2}$

Ans. :

a. $\frac{3k}{2a}$

37. A car is accelerated on a levelled road and 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 of initial. (C) Becomes 4 times of initial. (D) Becomes 16 times of initial.

Ans. :

a. Does not change.

Explanation:

The potential energy is the energy that an object has due to its position in a force field or that a system has due to the configuration of its parts. The potential energy of the car remains the same and will not change as the road is leveled and the height of the body remains the same, although its speed increases.

38. A body of mass 5kg is thrown vertically up with a kinetic energy of 490J. The height at which the kinetic energy of the body becomes half of the original value is:

(A) 12.5m (B) 10m (C) 2.5m (D) 5m

Ans. :

d. 5m

Explanation:

According to the law of conservation of energy,

$$\frac{1}{2}\mathrm{Mv}^2 = \frac{1}{2}\left(\frac{1}{2}\mathrm{mv}^2\right) + \mathrm{mgh}$$

$$\Rightarrow 490 + 245 + 5 \times 9.8 \times \mathrm{h}$$

$$\mathrm{h} = \frac{245}{49} = 5\mathrm{m}$$

39. What is the dimensions of power:

(A) $[MLT^{-2}]$ (B) $[ML^2T]$ (C) $[ML^2T^2]$ (D) $[MLT^{-3}]$

Ans. :

d. $[MLT^{-3}]$

40. (i) What is the work done by the porter when he climbs up a height of 10m ($g = 10\ ms^{-2}$)?

(A) $5kJ^2$ (B) 50kJ (C) $100kJ^2$ (D) 5kJ

Ans. :

d. 5kJ

Explanation:

The work done by the potter is defined as the product of the force and the displacement.

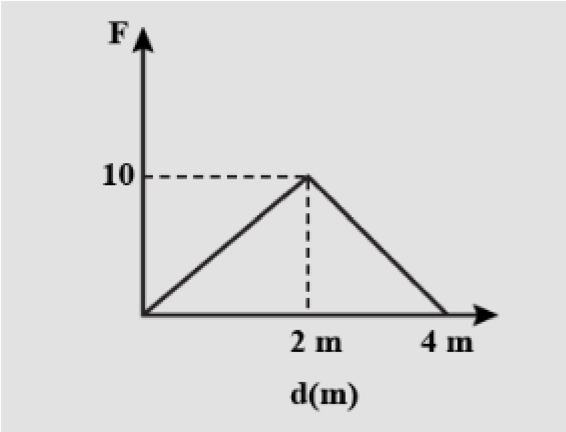
Work done = force × displacement

= m × g × 10 (Since force = mass × gravity)

= 50 × 10 × 10

= 5KJ

41. Work done from d = 0m to d = 4m



(A) 12.5J (B) 15D (C) 17.5J (D) 20D

Ans. :

d. 20D

42. The K.E. of a body can be increased maximum by doubling its:

(A) Mass (B) Weight (C) Speed (D) Density

Ans. :

c. Speed

Explanation:

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

$\mathrm{K.E} \propto \mathrm{m}\ \&\ \mathrm{K.E} \propto \mathrm{v}^2$

So doubling mass will double the kinetic energy and doubling speed will make kinetic energy 4 times.

43. If the linear momentum is increased by 50%, then kinetic energy will be increased by:

(A) 50% (B) 100% (C) 125% (D) 25%

Ans. :

c. 125%

44. The velocity of a bus, moving on a smooth road, is increased from 8m/ s to 32m/ s in 120s. During this process, the potential energy of the bus:

(A) Does not change. (B) Becomes twice that of initial potential energy. (C) Becomes four times that of initial potential energy. (D) Becomes sixteen times that of initial potential energy.

Ans. :

a. Does not change.

Explanation:

As potential energy, P = mgh

Since, there is no vertical displacement so, h = 0.

Hence, potential energy changeP = mgh = 0

The moving bus has only change in its Kinetic energy.

45. A crane pulls up a car of mass 500kg to a vertical height of 4m. So, work done by the crane is:

(A) 19.6J (B) 19.6kJ (C) 19600kJ (D) 4900J

Ans. :

b. 19.6kJ

Explanation:

To raise the car, the crane has to do work against the force of gravity.

Therefore, the force required to lift the car, F = mg = 500 × 9. 8N = 4900N

Displacement, S = vertical height raised = 4m.

∴ Work done, In = F. S = 4900 × 4J = 19600J = 19.6kJ

46. Two masses of 1g and 4g are moving with equal kinetic energy. The ratio of the magnitudes of their momentum is:

(A) 4 : 1 (B) 2 : 1 (C) 1 : 2 (D) 1 : 1

Ans. :

c. 1 : 2

Expalnation:

As we know that linear momentum

$= \sqrt{2\mathrm{mk}}$

$\left(\therefore \mathrm{K} = \frac{\mathrm{P}^2}{2\mathrm{m}}\right)$

For same Kinetic energy, $\mathrm{P} \propto \sqrt{\mathrm{m}}$

$\frac{\mathrm{P}_1}{\mathrm{P}_2} = \sqrt{\frac{\mathrm{m}_1}{\mathrm{m}_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2} = 1 : 2$

47. A molecule in a gas container hits a horizontal wall with speed 200ms^{-2} and angle 30° with the normal and rebounds with the same speed. Which statement is true?

(A) Momentum is conserved. (B) Elastic collision. (C) Inelastic collision. (D) Both (a) and (b).

Ans. :

d. Both (a) and (b).

48. A body of mass 1kg is rotating in a vertical circle of radius 1m. What will be the difference in its kinetic energy at the top and bottom of the circle?
Take g = 10m/ s2

(A) 50D (B) 30J (C) 20D (D) 10D

Ans. :

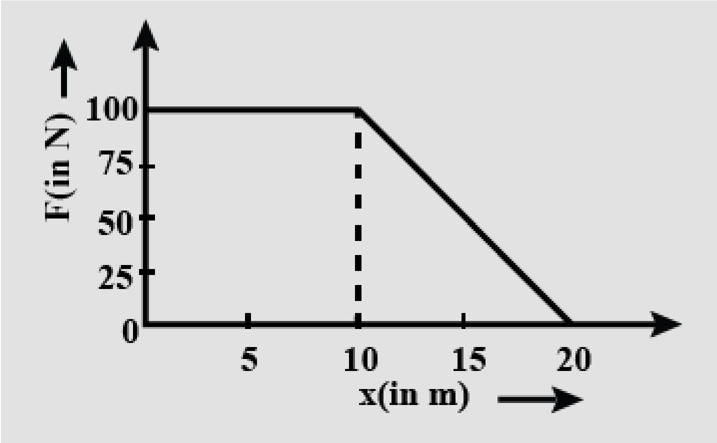
c. 20D

Explanation:

According to work energy theorem, ΔK. And, uh.= In and here work is done by the gravitational force.

⇒ΔK. And, uh. = In = mg(2r) = 1 × 10 × 2(1) = 20D

49. A force F acting on an object varies with distance x as shown in the figure. The work done by the force in moving the object from x = 0 and x = 20m is:



(A) 500J (B) 1000D (C) 1500J (D) 2000D

Ans. :

c. 1500J

Explanation:

Area under force displacement curve is the work done in that interval

Area under the given figure Area of surface Area of triangle. = +

Work done $= 10 \times 100 + \frac{1}{2} \times 10 \times 100$

= 1000 + 500

= 1500J

50. In a shotput event an athlete throws the shotput of mass 10kg with an initial speed of 1m s^{-1} at 45° from a height 1.5m above ground. Assuming air resistance to be negligible and acceleration due to gravity to be 10m s^{-2}, the kinetic energy of the shotput when it just reaches the ground will be:

(A) 20.5J (B) 5.0J (C) 52.5J (D) 155.0J

Ans. :

d. 155.0J

Explanation:

If air resistance is negligible, total mechanical energy of the system will remain constant. And let us take ground as a reference where potential energy will be zero.

According to the problem, h = 1.5 m, v = 1m/ s, m = 10 kg, g = 10m s^{-2}

Initial energy of the shotput $= (\mathrm{PE})_\mathrm{i} + (\mathrm{KE})_\mathrm{i}$

$= \mathrm{mgh} + \frac{1}{2}\mathrm{mv}^2$

$= 10 \times 10 \times 1.5 + \frac{1}{2} \times 10 \times (1)^2$

$= 150 + 5 = 155.0\mathrm{J}$

From conservation of mechanical energy,

$(\mathrm{PE})_\mathrm{i} + (\mathrm{KE})_\mathrm{i} = (\mathrm{PE})_\mathrm{f} + (\mathrm{KE})_\mathrm{f}$

So, final kinetic energy of the shotput is 155J

51. A mass of 5kg is moving along a circular path of radius 1m. If the mass moves with 300 revolutions per minute, its kinetic energy would be:

(A) $250\pi^2$ (B) $100\pi^2$ (C) $5\pi^2$ (D) 0

Ans. :

a. $250\pi^2$

Explanation:

According to the problem, Radius = 1m, mass = m = 5kg

$\mathrm{f} = \frac{300}{60}$

Angular velocity will be

$= 2\pi\mathrm{f} = (300 \times 2\pi)\mathrm{rad/\ min}$

$= (300 \times 3.14)\mathrm{rad/\ 60s}$

$= \frac{300 \times 2 \times 3.14}{60}\mathrm{rad/\ s} = 10\pi\mathrm{rad/\ s}$

And relation between linear velocity and angular velocity is $\mathrm{v} = \omega\mathrm{R}$

$= \left(\frac{300 \times 2\pi}{60}\right)(1\mathrm{m})$

$= 10\pi\mathrm{m/\ s}$

And kinetic energy $= \frac{1}{2}\mathrm{mv}^2$

$= \frac{1}{2} \times 5 \times (10\pi^2)$

$= 100\pi^2 \times 5 \times \frac{1}{2}$

$= 250\pi^2\mathrm{J}$

52. A body of mass 'M' collides against a wall with a velocity v and retraces its path with the same speed. the change in momentum is .... (take initial direction of velocity as positive)

(A) Zero (B) 2Mv (C) Mv (D) -2 Mv

Ans. :

b. 2Mv

Explanation:

Taking + x direction to be positive, and assuming ball was travelling in + x direction initially.

Pi = Mv

After collision ball will move in - x direction

Pf = − Mv

Change in momentum:

ΔP = Pi − Pf

ΔP = Mv + Mv = 2Mv

53. If the linear momentum is increased by 50%, then K.E. will be increased by:

(A) 50% (B) 100% (C) 125% (D) 25%

Ans. :

c. 125%

* Answer The Following Questions In One Sentence.[1 Marks Each] [10]

54. A body of mass 2kg initially at rest moves under the action of an applied horizontal force of 7N on a table with coefficient of kinetic friction = 0.1. Compute the: Change in kinetic energy of the body in 10s.

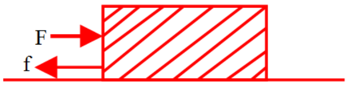
Ans. : M = 2kg

Applied force F = 7N

Coefficient of kinetic friction $\mu = 0.1$

Normal reaction is N = mg = 2 × 9.8 = 19.6N

Hence, force or friction is $\mathrm{f} = \mu\mathrm{N} = 1.96\mathrm{N}$



Total force = F - f = 7 - 1.96 = 5.04N

Acceleration of body is,

$\mathrm{a} = \left(\frac{\mathrm{F}-\mathrm{f}}{\mathrm{m}}\right)$

$= \frac{5.04}{2} \simeq 2.5\mathrm{ms}^{-2}$

Displacement of body in time t is,

$\mathrm{x} = \frac{1}{2}\mathrm{at}^2$

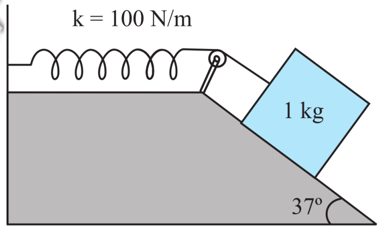
Int = 10s

$\mathrm{x} = \frac{1}{2} \times 2.5 \times 10^2$

$= 125\mathrm{m}$

Change in kinetic energy = Net work done = 630J

55. A 1kg block situated on a rough incline is connected to a spring of spring constant $100\mathrm{Nm}^{-1}$ as shown in. The block is released from rest with the spring in the unstretched position. The block moves 10cm down the incline before coming to rest. Find the coefficient of friction between the block and the incline. Assume that the spring has a negligible mass and the pulley is frictionless.



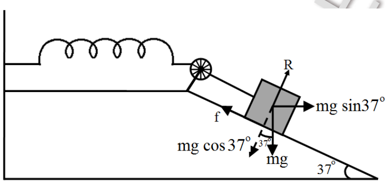
Ans. : Mass of the block, m = 1kg

Spring constant, $k = 100\mathrm{Nm}^{-1}$

Displacement in the block, X = 10cm = 0.1m

The given situation can be shown as in the following figure.

At equilibrium:



Normal reaction, $\mathrm{R} = \mathrm{mg}\cos 37^\circ$

Frictional force, $\mathrm{f} = \mu\mathrm{R} = \mathrm{mg}\sin 37^\circ$

Where, μ is the coefficient of friction

Net force acting on the block $= \mathrm{mg}\sin 37^\circ - \mathrm{f}$

$= \mathrm{mg}\sin 37^\circ - \mu\mathrm{m}\cos 37^\circ$

$= \mathrm{mg}(\sin 37^\circ - \mu \cos 37^\circ)$

At equilibrium, the work done by the block is equal to the potential energy of the spring, i.e.,

$= \mathrm{mg}(\sin 37^\circ - \mu \cos 37^\circ)\mathrm{x} = \left(\frac{1}{2}\right)\mathrm{kx}^2$

$1 \times 9.8(\sin 37^\circ - \mu \cos 37^\circ) = \left(\frac{1}{2}\right) \times 100 \times (0.1)$

$0.602 - \mu \times 0.799 = 0.510$

$\therefore \mu = \frac{0.092}{0.799} = 0.115$

56. A body of mass 2kg initially at rest moves under the action of an applied horizontal force of 7N on a table with coefficient of kinetic friction = 0.1. Compute the: Work done by the applied force in 10s.

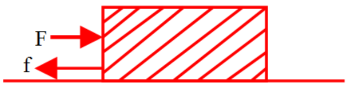
Ans. : M = 2kg

Applied force F = 7N

Coefficient of kinetic friction $\mu = 0.1$

Normal reaction is N = mg = 2 × 9.8 = 19.6N

Hence, force or friction is $\mathrm{f} = \mu \mathrm{N} = 1.96\mathrm{N}$



Total force = F - f = 7 - 1.96 = 5.04N

Acceleration of body is,

$\mathrm{a} = \left(\frac{\mathrm{F}-\mathrm{f}}{\mathrm{m}}\right)$

$= \frac{5.04}{2} \simeq 2.5\mathrm{ms}^{-2}$

Displacement of body in time t is,

$\mathrm{x} = \frac{1}{2}\mathrm{at}^2$

Int = 10s

$\mathrm{x} = \frac{1}{2} \times 2.5 \times 10^2$

$= 125\mathrm{m}$

Work done by F is

W = Fx = 7 × 125 J = 875J

57. How many ergs make one joule?

Ans. : One joule = 10= erg.

58. A body of mass 2kg initially at rest moves under the action of an applied horizontal force of 7N on a table with coefficient of kinetic friction = 0.1. Compute the: Change in kinetic energy of the body in 10s.

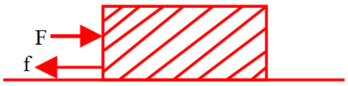
Ans. : M = 2kg

Applied force F = 7N

Coefficient of kinetic friction $\mu = 0.1$

Normal reaction is N = mg = 2 × 9.8 = 19.6N

Hence, force or friction is $\mathrm{f} = \mu \mathrm{N} = 1.96\mathrm{N}$



Total force = F - f = 7 - 1.96 = 5.04N

Acceleration of body is,

$$a = \left(\frac{F - f}{m}\right)$$

$$= \frac{5.04}{2} \simeq 2.5ms^{-2}$$

Displacement of body in time t is,

$$x = \frac{1}{2}at^2$$

Int = 10s

$$x = \frac{1}{2} \times 2.5 \times 10^2$$

$$= 125m$$

Change in kinetic energy = Net work done = 630J

59. Two blocks of masses 10kg and 20kg moving at speeds of $10ms^{-1}$ and $20ms^{-1}$ respectively in opposite directions, approach each other and collide. If the collision is completely inelastic, find the thermal energy developed in the process.

Ans. : Given,

Mass of the first block, m_1 = 10kg

Mass of the second block, m_2 = 20kg

Initial velocity of the first block, u_1 = 10m/s

Initial velocity of the second block, u_2 = 20m/s

Let the velocity of the blocks after collision be v.

Applying conservation of momentum, we get

$m_2u_2 - m_1u_1 = (m_1 + m_2)v$

⇒ 20 × 20 - 10 × 10 = (10 + 20)v

⇒ 400 - 100 = 30v

⇒ 300 = 30v

⇒ v = 10m/s

Initial kinetic energy is given by,

$$K_i = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$$

$$K_i = \frac{1}{2} \times 10 \times (10)^2 + \frac{1}{2} \times 20 \times (20)^2$$

$$K_i = 500 + 4000 = 4500$$

Final kinetic energy is given by,

$$K_f = \frac{1}{2}(m_1 + m_2)v^2$$

$$K_f = \frac{1}{2}(10 + 20)(10)^2$$

$$K_f = \left(\frac{30}{2}\right) \times 100 = 1500$$

∴ Total change in KE = 4500J - 1500J = 3000J

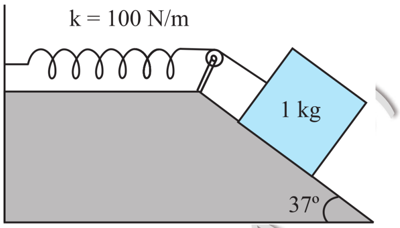
Thermal energy developed in the process = 3000J

60. A body falling from a height of 10m rebounds from a hard floor. It loses 20% of its energy in impact. What is the height to which it would rise after the impact?

Ans. : $\frac{80}{100}\mathrm{mgh} = \mathrm{mgh}'$

$\mathrm{h}' = \frac{4}{5}\mathrm{h} = \frac{4}{5} \times 10\mathrm{m} = 8\mathrm{cm}$

61. A 1kg block situated on a rough incline is connected to a spring of spring constant $100\mathrm{Nm}^{-1}$ as shown in. The block is released from rest with the spring in the unstretched position. The block moves 10cm down the incline before coming to rest. Find the coefficient of friction between the block and the incline. Assume that the spring has a negligible mass and the pulley is frictionless.



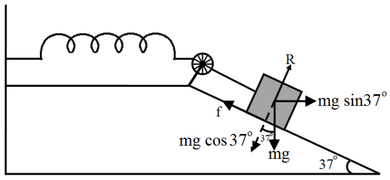
Ans. : Mass of the block, m = 1kg

Spring constant, k = $100\mathrm{Nm}^{-1}$

Displacement in the block, X = 10cm = 0.1m

The given situation can be shown as in the following figure.

At equilibrium:



Normal reaction, $\mathrm{R} = \mathrm{mg}\cos 37^\circ$

Frictional force, $\mathrm{f} = \mu\mathrm{R} = \mathrm{mg}\sin 37^\circ$

Where, μ is the coefficient of friction

Net force acting on the block $= \mathrm{mg}\sin 37^\circ - \mathrm{f}$

$= \mathrm{mg}\sin 37^\circ - \mu\mathrm{m}\cos 37^\circ$

$= \mathrm{mg}(\sin 37^\circ - \mu\cos 37^\circ)$

At equilibrium, the work done by the block is equal to the potential energy of the spring, i.e.,

$= \mathrm{mg}(\sin 37^\circ - \mu\cos 37^\circ)\mathrm{x} = \left(\frac{1}{2}\right)\mathrm{kx}^2$

$1 \times 9.8(\sin 37^\circ - \mu\cos 37^\circ) = \left(\frac{1}{2}\right) \times 100 \times (0.1)$

$0.602 - \mu \times 0.799 = 0.510$

$\therefore \mu = \frac{0.092}{0.799} = 0.115$

62. A bolt of mass 0.3kg falls from the ceiling of an elevator moving down with an uniform speed of $7\mathrm{ms}^{-1}$. It hits the floor of the elevator (length of the elevator = 3m) and does not rebound. What is the heat produced by the impact? Would your answer be different if the elevator were stationary?

Ans. : Mass of the bolt, m= 0.3kg

Speed of the elevator = 7m/s

Height, h = 3m

Since the relative velocity of the bolt with respect to the lift is zero, at the time of impact, potential energy gets converted into heat energy.

Heat produced = Loss of potential energy

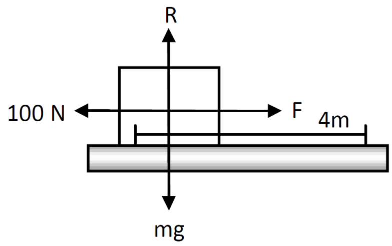
= mgh = 0.3 × 9.8 × 3

= 8.82J

The heat produced will remain the same even if the lift is stationary. This is because of the fact that the relative velocity of the bolt with respect to the lift will remain zero.

63. A box is pushed through 4.0m across a floor offering 100N resistance. How much work is done by the resisting force?

Ans. :



$\mathrm{F} = 100\mathrm{N}$

$\mathrm{S} = 4\mathrm{m}, \theta = 0^{\circ}$

$\omega = \vec{\mathrm{F}}.\vec{\mathrm{S}}$

$= 100 \times 4 = 400\mathrm{J}$

*** Given Section consists of questions of 2 marks each.** **[38]**

64. Find the angle between force $F = (3\hat{i} + 4\hat{j} - 5\hat{k})$ unit and displacement $d = (5\hat{i} + 4\hat{j} + 3\hat{k})$ unit. Also find the projection of F on d.

$$\text{Answer } F \cdot d = F_x d_x + F_y d_y + F_z d_z$$
$$= 3(5) + 4(4) + (-5)(3)$$
$$= 16 \text{ unit}$$
$$\text{Hence } F \cdot d = Fd\cos\theta = 16 \text{ unit}$$
$$\text{Now } F \cdot F \quad F^2 = F_x^2 + F_y^2 + F_z^2$$
$$= 9 + 16 + 25$$

Ans. :

$$= 50 \text{ unit}$$
$$\text{and } d \cdot d = d^2 = d_x^2 + d_y^2 + d_z^2$$
$$= 25 + 16 + 9$$
$$= 50 \text{ unit}$$
$$\therefore \cos\theta = \frac{16}{\sqrt{50}\sqrt{50}} = \frac{16}{50} = 0.32,$$
$$\theta = \cos^{-1} 0.32$$

65. A cyclist comes to a skidding stop in 10 m. During this process, the force on the cycle due to the road is 200 N and is directly opposed to the motion. (a) How

much work does the road do on the cycle ? (b) How much work does the cycle do on the road ?

Ans. : Work done on the cycle by the road is the work done by the stopping (frictional) force on the cycle due to the road.

(a) The stopping force and the displacement make an angle of $180^{\circ}(\pi\, rad)$ with each other. Thus, work done by the road,

$$
\begin{aligned}
W_r &= Fd\cos\theta \\
&= 200\times 10\times \cos\pi \\
&= -2000J
\end{aligned}
$$

It is this negative work that brings the cycle to a halt in accordance with WE theorem.

(b) From Newton's Third Law an equal and opposite force acts on the road due to the cycle. Its magnitude is 200 N. However, the road undergoes no displacement. Thus, work done by cycle on the road is zero.

66. Example 5.4 In a ballistics demonstration a police officer fires a bullet of mass $50.0g$ with speed $200ms^{-1}$ (see Table 5.2) on soft plywood of thickness $2.00cm$. The bullet emerges with only 10% of its initial kinetic energy. What is the emergent speed of the bullet?

Ans. : The initial kinetic energy of the bullet is $mv^2/2 = 1000J$. It has a final kinetic energy of $0.1\times 1000 = 100J$. If v_f is the emergent speed of the bullet,

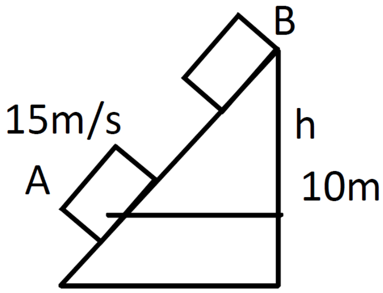
$$\frac{1}{2}mv_f^2 = 100J$$

$$
\begin{aligned}
v_f &= \sqrt{\frac{2\times 100J}{0.05kg}} \\
&= 63.2ms^{-1}
\end{aligned}
$$

The speed is reduced by approximately 68% (not 90\%).

67. A car weighing 1400kg is moving at a speed of 54km/h up a hill when the motor stops. If it is just able to reach the destination which is at a height of 10m above the point, calculate the work done against friction (negative of the work done by the friction).

Ans. :



m = 1400kg, v = 54km/h = 15m/sec, h = 10m

Work done = Total K.E. - Total P.E.

$$= 0 + \frac{1}{2}\mathrm{mv}^2 - \mathrm{mgh}$$

$= \frac{1}{2} \times 1400 \times (15)^2 - 1400 \times 9.8 \times 10$
$= 157500 - 137200$
$= 20300$

So, work done against friction, W_t = 20300J

68. The displacement (in metre) of a particle moving along X-axis is given by x(m) = 18t + $5t^2$. Calculate:

   a. The instantaneous velocity.
   b. Instantaneous acceleration.

   At = 2 second.

Ans. : x(m)= 18t + $5t^2$

a. Instantaneous velocity (v) $= \frac{dx}{dt}$

$= (18 + 10t)ms^{-1}$

$\text{at } t = 2 \text{ sec,} v = 18 + 20 = 38m/\ s$

b. Instanraneous acceleration $a = \frac{dx}{dt} = 10m/\ s^2$

69. An unruly demonstrator lifts a stone of mass 200g from the ground and throws it at his opponent. At the time of projection, the stone is 150cm above the ground and has a speed of 3.00m/s. Calculate the work done by the demonstrator during the process. If it takes one second for the demonstrator to lift the stone and throw, what horsepower does he use?

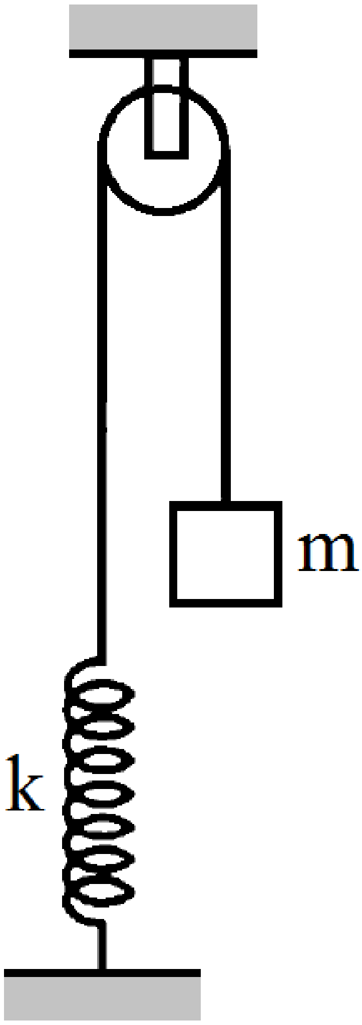
Ans. : m = 200g = 0.2kg, h = 150cm = 1.5m, v = 3m/sec, t = 1sec

Total work done $= \frac{1}{2}mv^2 + mgh$

$= \left(\frac{1}{2}\right) \times (0.2) \times 9 + (0.2) \times (9.8) \times (1.5) = 3.84J$

h.p. used $= \frac{3.84}{746} = 5.14 \times 10^{-3}$

70. Consider the situation shown in figure. Initially the spring is unstretched when the system is released from rest. Assuming no friction in the pulley, find the maximum



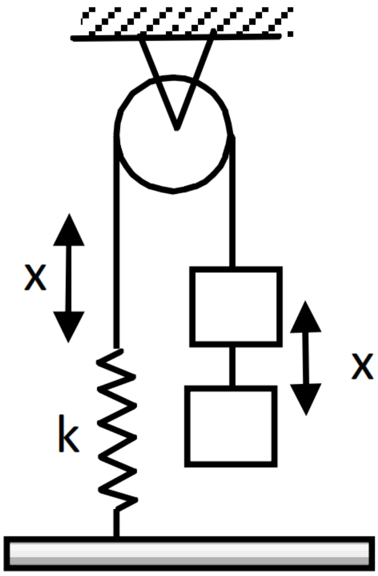
elongation of the spring.

Ans. : Mass of the body = m

Let the elongation be x

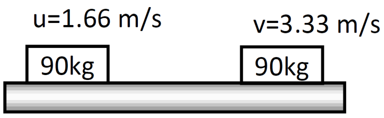
So, $\frac{1}{2}\mathrm{kx}^2 = \mathrm{mgx}$

$\Rightarrow \mathrm{x} = 2\mathrm{mg}/\mathrm{k}$



71. The mass of cyclist together with the bike is 90kg. Calculate the increase in kinetic energy if the speed increases from 6.0km/h to 12km/h.

Ans. :



M = m_c + m_b = 90kg

u = 6.0km/h = 1.666 m/sec

ν = 12 km/h = 3.333 m/sec

Increase in K.E.

$$= \frac{1}{2}\mathrm{Mv}^2 - \frac{1}{2}\mathrm{mu}^2$$
$$= \frac{1}{2}90 \times (3.333)^2 - \frac{1}{2}90 \times (1.66)^2$$
$$= 499.4 - 124.6$$
$$= 374.8 \approx 375\mathrm{J}$$

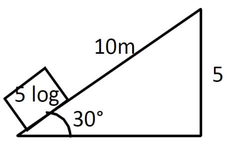
72. An aeroplane's velocity is doubled. What happens to its momentum and kinetic energy?

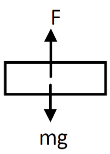
Ans. :

- When the velocity (v) of an aeroplane is doubled its momentum is also doubled. When the velocity of the aeroplane is increased in forward direction, the velocity of exhaust gases also increases but in backward direction due to action of its engines. Taking forward direction as positive and backward direction as negative, thus total momentum remains same.
- The kinetic energy of aeroplane $\frac{1}{2}\mathrm{mv}^2$ becomes four times its previous value, when its value is doubled. The additional kinetic energy comes from chemical energy of the fuel of engine.

73. A block of mass 5.0kg slides down an incline of inclination 30° and length 10m. Find the work done by the force of gravity.

Ans. :





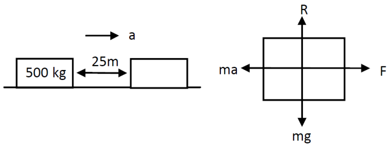
$$\mathrm{m} = 5\mathrm{kg}$$
$$\theta = 30^\circ$$
$$\mathrm{S} = 10\mathrm{m}$$
$$\mathrm{F} = \mathrm{mg}$$

So, work done by the force of gravity

$$\omega = \mathrm{mgh}$$
$$= 5 \times 9.8 \times 5 = 245\mathrm{J}$$

74. Find the average force needed to accelerate a car weighing 500kg from rest to 72km/h in a distance of 25m.

Ans. :



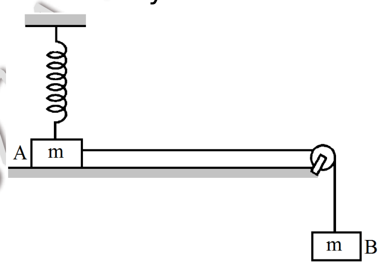
m = 500kg, u = 0, v = 72km/h = 20m/s

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

$\Rightarrow \frac{400}{50} = 8 m/sec^2$

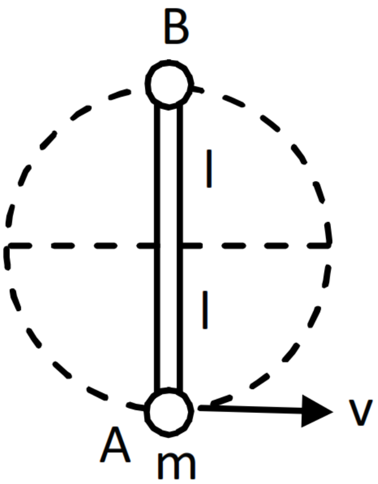
force needed to accelerate the car F = ma = 500 × 8 = 4000N

75. A small heavy block is attached to the lower end of a light rod of length l which can be rotated about its clamped upper end. What minimum horizontal velocity should the



block be given so that it moves in a complete vertical circle?

Ans. :



Let the velocity of the body at A is 'V' for minimum velocity given at A velocity of the body at point B is zero.

Applying law of conservation of energy at A & B.

$\frac{1}{2}mv^2 = mg(2\ell)$

$\Rightarrow v = \sqrt{(4g\ell)} = 2\sqrt{g\ell}$

76. The average work done by a human heart while it beats once is 0.5J. Calculate the power used by heart if it beats 72 times in a minute.

Ans. : According to the problem, average work done by a human heart per beat = 0.5J

Total work done during 72 beats in 1 minute

= 72 × 0.5J = 36J

Power = Work done = 36J/60s = 0.6w

77. Calculate the work done by a car against gravity in moving along a straight horizontal road. The mass of the car is 400kg and the distance moved is 2m.

Ans. : $\because \ \mathrm{WD} = \mathrm{Fs}\cos\theta$

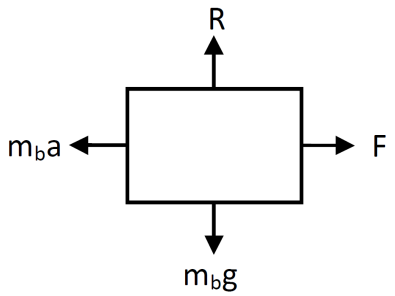
As rhe angle between horicontal distance 2m and gravity vertically downward is 90º So WD.

$$\mathrm{WD} = \mathrm{Fs}\cos 90^\circ = 0$$

So work done by car aginst the gravity is zero.

78. A man moves on a straight horizontal road with a block of mass 2kg in his hand. If he covers a distance of 40m with an acceleration of 0.5m/s^2, find the work done by the man on the block during the motion.

Ans. :



m_b = 2kg, s = 40m, a = 0.5m/sec^2

So, force applied by the man on the box

F = m_ba = 2 × (0.5) = 1N

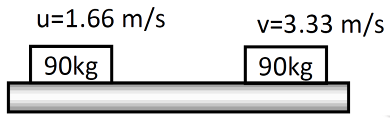
$$\omega = \mathrm{FS} = 1 \times 40 = 40\mathrm{J}$$

79. One person says that the potential energy of a particular book kept in an almirah is 20J and the other says it is 30J. Is one of them necessarily wrong?

Ans. : No, both are correct. We measure potential energy from a reference level chosen by the observer. Therefore, in this case, both observers are measuring the potential energy from different reference levels.

80. The mass of cyclist together with the bike is 90kg. Calculate the increase in kinetic energy if the speed increases from 6.0km/h to 12km/h.

Ans. :



M = m_c + m_b = 90kg

u = 6.0km/h = 1.666 m/sec

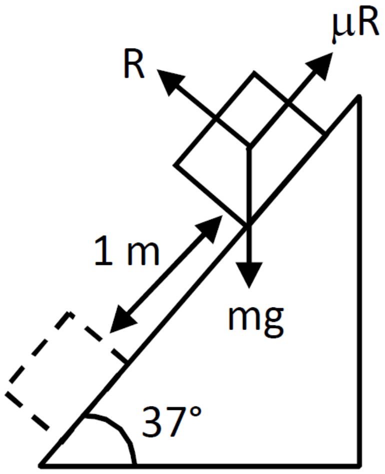
ν = 12 km/h = 3.333 m/sec

Increase in K.E.

$$= \frac{1}{2}\mathrm{Mv}^2 - \frac{1}{2}\mathrm{mu}^2$$
$$= \frac{1}{2}90 \times (3.333)^2 - \frac{1}{2}90 \times (1.66)^2$$
$$= 499.4 - 124.6$$
$$= 374.8 \approx 375\mathrm{J}$$

81. A block of mass 250g slides down an incline of inclination 37° with a uniform speed. Find the work done against the friction as the block slides through 1.0m.

Ans. :



$m_b = 250g = .250kg$

$\theta = 37^\circ, S = 1m.$

Frictional force $f = \mu R$

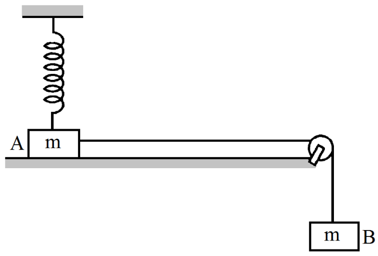
$mg \sin \theta = \mu R \ \ldots (1)$

$mg \cos \theta \ldots (2)$

so, work done against $\mu R = \mu RS \cos 0^\circ = mg \sin \theta$

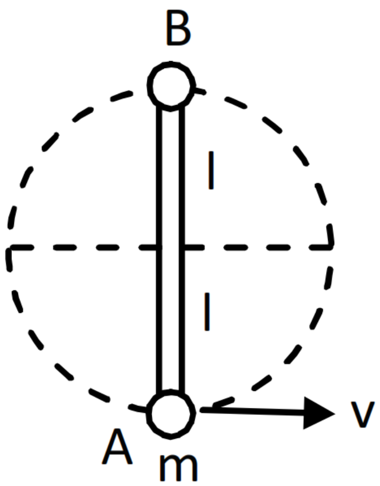
$S = 0.250 \times 9.8 \times 0.60 \times 1 = 1.5J$

82. A small heavy block is attached to the lower end of a light rod of length l which can be rotated about its clamped upper end. What minimum horizontal velocity should the



block be given so that it moves in a complete vertical circle?

Ans. :



Let the velocity of the body at A is 'V' for minimum velocity given at A velocity of the body at point B is zero.

Applying law of conservation of energy at A & B.

$\frac{1}{2}mv^2 = mg(2\ell)$

$$\Rightarrow v = \sqrt{(4g\ell)} = 2\sqrt{g\ell}$$

*** Given Section consists of questions of 3 marks each. [69]**

83. A trolley of mass 300kg carrying a sandbag of 25kg is moving uniformly with a speed of 27km/h on a frictionless track. After a while, sand starts leaking out of a hole on the floor of the trolley at the rate of 0.05 kgs^{-1}. What is the speed of the trolley after the entire sand bag is empty?

Ans. : As the trolley carrying the sand bag is moving uniformly, therefore, external force on the system = 0. When the sand leaks out, it does not lead to the application of any external force on the trolley. Hence, the speed of the trolley shall not change.

84. A body of mass 2kg is initially at rest. A constant force of 5 N acts on it for 10s. Calculate the average power of the force.

Ans. : Here, m = 2kg, u = 0, F = 5N, t = 10s,