NCERT solutions for class 11 physics chapter 5 laws of motion exercise

Q5.1 (a) Give the magnitude and direction of the net force acting on

(a) a drop of rain falling down with a constant speed

Answer:

Since the drop is falling with constant speed, so the net acceleration of the drop is zero. This means net force on the drop is zero.

Q5.1 (b) Give the magnitude and direction of the net force acting on (b) a cork of mass 10 g floating on water,

Answer:

Since the cork is floating on the water, that implies the gravitational force of cork is balanced by the buoyant force. Thus net force acting on cork is zero.

Q5.1 (c) Give the magnitude and direction of the net force acting on (c) a kite skillfully held stationary in the sky,

Answer:

Since the kite is stationary in the sky, thus according to Newton's law, the net force on the kite is zero.

Q5.1 (d) Give the magnitude and direction of the net force acting on (d) a car moving with a constant velocity of 30 km/h on a rough road,

Answer:

Since the car is moving with constant velocity thus the net acceleration of the car is zero. Thus net force acting on the car is zero.

Q5.1 (e) Give the magnitude and direction of the net force acting on

(e) a high-speed electron in space far from all material objects, and free of electric and magnetic fields.

Answer:

Since the electron is free from the electric and magnetic field so net force acting on the electron is zero.

Q5.2 (a) A pebble of mass 0.05 kg is thrown vertically upwards. Give the direction and magnitude of the net force on the pebble,

(a) during its upward motion

Answer:

During upward motion, the force acting on the pebble is only the gravitational force which is **acting in a downward direction** .

The gravitational force :

$= mg$

or $= 0.05(10)\ N$

or $= 0.5\ N$

Q5.2 (b) A pebble of mass 0.05 kg is thrown vertically upwards. Give the direction and magnitude of the net force on the pebble,

(b) during its downward motion,

Answer:

Since the pebble is moving in the downward direction the net force acting is also in the **downward direction** .

The net force is the gravitational force.

Gravitational force:-

$= \ mg$

or $= \ (0.05)10$

$= \ 0.5 \ N$

Q5.2 (c) A pebble of mass 0.05 kg is thrown vertically upwards. Give the direction and magnitude of the net force on the pebble,

(c) at the highest point where it is momentarily at rest. Do your answers change if the pebble was thrown at an angle of 45° with the horizontal direction? Ignore air resistance.

Answer:

At the highest point velocity becomes zero for a moment. At this point also, the net force acting is the gravitational force which acts in the **downward direction** .

Gravitational force:-

$= mg$

or $= (0.05)10$

$= 0.5\ N$

When a pebble is thrown at 45^0 with the horizontal direction then also net force will be the same gravitational force.

Q5.3 (a) Give the magnitude and direction of the net force acting on a stone of mass 0.1 kg,

(a) just after it is dropped from the window of a stationary train, Neglect air resistance throughout.

Answer:

Since the train is stationary so the net force acting on the stone is the gravitational force which acts in the **downward direction** .

Gravitational force :

$F = ma = mg$

or $= (0.1)10$

or $= 1\ N$

Q5.3 (b) Give the magnitude and direction of the net force acting on a stone of mass 0.1 kg

(b) just after it is dropped from the window of a train running at a constant velocity of 36 km/h, Neglect air resistance throughout.

Answer:

Since the train is travelling with the constant speed so the acceleration of the train is zero. Thus there is no force on stone due to train.

The net force acting on the stone will be the gravitational force which acts in a downward direction.

Gravitational force:-

$F \ = \ mg$

or = $(0.1)10 \ N$

or = $1 \ N$

Q5.3 (c) Give the magnitude and direction of the net force acting on a stone of mass 0.1 kg, (c) just after it is dropped from the window of a train accelerating with $1ms^{-2}$, Neglect air resistance throughout.

Answer:

Just after the stone is dropped, the stone is free from the acceleration of the train. Thus the force acting on the stone will be just the gravitational force which acts in the downward direction.

The gravitational force is given by:-

$F \ = \ mg$

or = $(0.1)10$

or = $1 \ N$

Q5.3 (d) Give the magnitude and direction of the net force acting on a stone of mass 0.1 kg,

(d) lying on the floor of a train which is accelerating with 1 m s -2 , the stone being at rest relative to the train. Neglect air resistance throughout.

Answer:

As the stone is in contact with the train thus the acceleration of stone is the same as that of train i.e. 1 m/s ^{2}.

Thus force acting on the stone is given by :

$F \ = \ ma$

or = $0.1 \times 1 \ = \ 0.1 \ N$

This force is acting in the horizontal direction.

Q5.4 One end of a string of length l is connected to a particle of mass m and the other to a small peg on a smooth horizontal table. If the particle moves in a circle with speed v the net force on the particle (directed towards the centre) is :

(i) T

(ii) $T - \frac{mv^2}{l}$

(iii) $T + \frac{mv^2}{l}$

(iv) 0

T is the tension in the string. [Choose the correct alternative].

Answer:

When the particle is moving in a circular path, the centripetal force will be :

$$F_c = \frac{mv^2}{r}$$

This centripetal force will be balanced by the tension in the string.

So, the net force acting is :

$$F = T = \frac{mv^2}{r}$$

Q5.5 A constant retarding force of 50 N is applied to a body of mass 20 kg moving initially with a speed of $15ms^{-1}$. How long does the body take to stop?

Answer:

We are given the retarding force. So we can find the deacceleration this force is causing.

By Newton's second law of motion, we get :

$$F = ma$$

or $-50 = (20)a$

or $a = \frac{50}{20} = -2.5\ m/s^2$

Now we will use the first equation of motion,

$$v = u + at$$

The final velocity, in this case, will be zero (Since the vehicle stops).

$0 = 15 + (-2.5)t$

Thus $t = \frac{15}{2.5} = 6\ s$

Thus the time taken to stop the vehicle is 6 sec.

Q5.6 A constant force acting on a body of mass 3.0 kg changes its speed from $2.0ms^{-1}$ to $3.5ms^{-1}$ in 25 s. The direction of the motion of the body remains unchanged. What is the magnitude and direction of the force?

Answer:

Since the velocity of the body is increased by applying the force. This is possible only when the force is applied in the direction of the motion.

For finding the magnitude of the force, we need to calculate acceleration.

By using first equation of the motion,

$v = u + at$

or $3.5 = 2 + a(25)$

or $a = \frac{3.5 - 2}{25} = 0.06\ m/s^2$

Thus force can be written as :

$F = ma$

$= 3 \times 0.06$

$= 0.18\ N$

Q5.7 A body of mass 5 kg is acted upon by two perpendicular forces 8 N and 6 N. Give the magnitude and direction of the acceleration of the body.

Answer:

The magnitude of the resulting force can be found by :

$R = \sqrt{F_1^2 + F_2^2}$

or = $\sqrt{8^2 + 6^2}$

or = $10 \ N$

Now force direction,

$\tan \Theta = \frac{6}{8}$

or $\Theta = 37°$

The acceleration of the body is given by :

$a = \frac{F}{m}$

or $a = \frac{10}{5} = 2 \ m/s^2$

Hence acceleration of the body is $2 \ m/s^2$ and its direction is the same as of the resultant force.

Q5.8 The driver of a three-wheeler moving with a speed of 36 km/h sees a child standing in the middle of the road and brings his vehicle to rest in 4.0 s just in time to save the child. What is the average retarding force on the vehicle? The mass of the three-wheeler is 400 kg and the mass of the driver is 65 kg.

Answer:

Total mass of the system = 400 + 65 = 425 kg

Using first law of motion, we get

$$v = u + at$$

Since the car comes to rest, thus final velocity will be zero.

$$0 = 10 + a(4)$$

or

$$a = \frac{-10}{4} = -2.5\ m/s^2$$

So the force required :

$$F = ma$$

or $= 465 \times (-2.5)$

or $F = -1162.5\ N$

So the magnitude of the force is 1162.5 N and it is retarding force.

Q5.9 A rocket with a lift-off mass 20,000 kg is blasted upwards with an initial acceleration of $5.0ms^{-2}$. Calculate the initial thrust (force) of the blast.

Answer:

Let the initial thrust be F Newton.

Using Newton's second law of motion, we get

$$F - mg = ma$$

or $F = ma + mg$

$$F = m(a+g)\ N$$

Substituting values in this equation, we get :

$$F = 20000(5+10)$$

or $F = 3 \times 10^5\ N$

Q5.10 A body of mass 0.40 kg moving initially with a constant speed of $10ms^{-1}$ to the north is subject to a constant force of 8.0 N directed towards the south for 30 s. Take the instant the force is applied to be $t = 0$, the position of the body at that time to be $x = 0$, and predict its position at $t = -5s, 25s, 100s$.

Answer:

The acceleration of force is given by :

$$a = \frac{F}{m}$$

$$a = \frac{-8}{0.4} = -20\ m/s^2$$

At t = - 5 s :

There is no force acting so accleration is zero and u = 10 m/s

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

or $= \ 10(-5) \ + \ \frac{1}{2}.0.t^2$

or $= \ -50 \ m$

At t = 25 s :

Acceleration is - 20 m/s ^{2} and u = 10 m/s

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

or $= \ 10(25) \ + \ \frac{1}{2}(-20)25^2$

or $= \ -6000 \ m$

At t = 100 s

We have acceleration for first 30 sec, and then it will move with constant speed.

So for $0 < t < 30$:

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

or $= \ 10(30) \ + \ \frac{1}{2}(-20)30^2$

or $= \ -8700 \ m$

Now for t > 30 s :

We need to calculate velocity at t = 30 sec which will be used as the initial velocity for 30 < t < 100.

$v \ = \ u \ + \ at$

or $= \ 10 \ + \ (-20)30 \ = \ -\ 590 \ m/s$

Now $s \ = \ vt \ + \ \frac{1}{2}at^2$

or $= \ (-590)70 \ + \ \frac{1}{2}.0.t^2$

or $= \ -\ 41300 \ m$

Hence total displacement is : - 8700 + (- 41300) = - 50000 m.

Q5.11 (a) A truck starts from rest and accelerates uniformly at $2.0ms^{-2}$. At $t = 10s$, a stone is dropped by a person standing on the top of the truck (6 m high from the ground). What are the (a) velocity of the stone at $t = 11s$? (Neglect air resistance.)

Answer:

The initial velocity of the truck is given as zero.

We need to find the final velocity (at t = 10 s), so we will use the equation of motion :

$v \ = \ u \ + \ at$

or $= \ 0 \ + \ (2)10 \ = \ 20 \ m/s$

This is the velocity imparted to stone by the truck that's why it is a horizontal component of velocity.

The stone is dropped at t = 10 sec. so it has travelled 1 sec in the air (11 - 10 = 1 s). We need to find the final vertical velocity.

$$v = u + at$$

$$= 0 + 10(1) = 10\ m/s$$

Thus resultant of both the component is the required velocity.

$$R = \sqrt{v_h^2 + v_v^2}$$

or $= \sqrt{20^2 + 10^2}$

or $= 22.36\ m/s$

Direction :

$$\tan\Theta = \frac{v_v}{v_h} = \frac{10}{20}$$

or $\Theta = 26.57^\circ$

Q5.11 (b) A truck starts from rest and accelerates uniformly at $2.0ms^{-2}$. At $t = 10s$, a stone is dropped by a person standing on the top of the truck (6 m high from the ground). What are the (b) acceleration of the stone at $t = 11s$? (Neglect air resistance.)

Answer:

When the stone is dropped, the stone comes only in effect of gravity.

So the acceleration of stone is 10 m/s ^{2} and it acts in the downward direction.

Q5.12 (a) A bob of mass 0.1 kg hung from the ceiling of a room by a string 2 m long is set into oscillation. The speed of the bob at its mean position is $1ms^{-1}$. What is the trajectory of the bob if the string is cut when the bob is (a) at one of its extreme positions

Answer:

At the extreme positions, the velocity of the bob will become zero for a moment. So if we cut the string at this time, then Bob will fall vertically downward due to gravity.

Q5.12 (b) A bob of mass 0.1 kg hung from the ceiling of a room by a string 2 m long is set into oscillation. The speed of the bob at its mean position is $1ms^{-1}$. What is the trajectory of the bob if the string is cut when the bob is (b) at its mean position.

Answer:

At the mean position, the bob will have velocity tangential to the circular path (it will be completely horizontal). If the bob is cut at this place then it will follow a parabolic path having only horizontal velocity.

Q5.13 (a) A man of mass 70 kg stands on a weighing scale in a lift which is moving

(a) upwards with a uniform speed of 10 m s^{-1}

What would be the readings on the scale in each case?

Answer:

Since lift is moving with a constant speed or in this case constant velocity so the acceleration provided to man by lift is zero.

The net force on the man will be zero. So a = 0.

Using Newton's law of motion, we can write :

$R - mg = ma$

or $R - mg = 0$

Thus $R = mg$

$= 70 \times 10 = 700\ N$

So, reading on weighing scale will be :

$$= \frac{R}{g} = \frac{700}{10} = 70\ Kg$$

Q5.13 (b) A man of mass 70 kg stands on a weighing scale in a lift which is moving

(b) downwards with a uniform acceleration of $5ms^{-2}$.

What would be the readings on the scale in each case?

Answer:

(b) Using Newton&##39;s law of motion, we have :

$R + mg = ma$

or $R - 70(10) = 70(-5)$ (Since we took downward direction as negative and upward as positive).

or $R = 700 - 350 = 350\ N$

Thus the reading on the weighing scale will be :

$$= \frac{R}{g} = \frac{350}{10} = 35\ Kg$$

Q5.13 (c) A man of mass 70 kg stands on a weighing scale in a lift which is moving

(c) upwards with a uniform acceleration of $5ms^{-2}$. What would be the readings on the scale in each case?

Answer:

(c) The acceleration of lift is given to be 5 m/s ^{2} . Let us assume the upward direction to be positive.

Using Newton's law of motion, we can write :

$$R - mg = ma$$

or $R - 70(10) = 70(5)$

or $R = 350 + 700 = 1050\ N$

Thus the reading of the weighing scale will be :

$$= \frac{R}{g} = \frac{1050}{10} = 105\ Kg$$

Q5.13 (d) A man of mass 70 kg stands on a weighing scale in a lift which is moving

(d) What would be the reading if the lift mechanism failed and it hurtled down freely under gravity?

Answer:

(d) If the lift falls freely then the acceleration of lift will be acceleration due to gravity.

Using Newton's law of motion we can write :

$R - mg = ma$

or $R - mg = m(-g)$

or $R = m(-g) + mg = 0\ N$

Thus the reading of weighing scale will also be zero since there is no normal force.

This state is called the state of weightlessness.

Q5.14 (a) Figure 5.16 shows the position-time graph of a particle of mass 4 kg. What is the (a) force on the particle for $t < 0, t > 4s, 0 < t < 4s$?

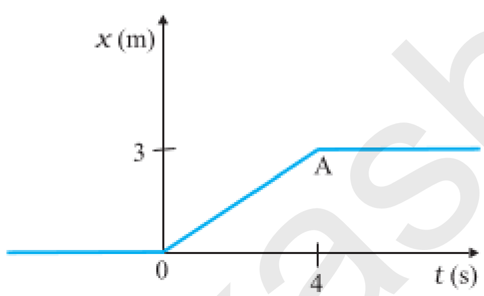


Fig. 5.16

Answer:

(i) **For t < 0 :**

In this range the position of particle coincides with time, that implies no motion takes place. Hence net force on the particle is zero.

(ii) **For t > 4 :**

In this range displacement of the particle is not changed so the net force is zero.

(iii) **For 0 < t < 4 :**

In this range the slope of the position-time graph is constant that means the particle is moving with constant speed. And hence net force, in this case, is zero.

Q5.14 (b) Figure 5.16 shows the position-time graph of a particle of mass 4 kg. What is the

(b) impulse at t = 0 and t = 4 s ? (Consider one-dimensional motion only).

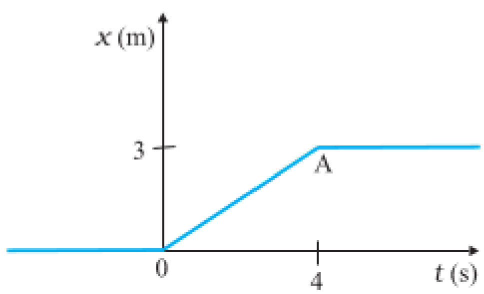


Fig. 5.16

Answer:

Impulse is defined by :

$I = mv - mu$ (Change in momentum).

At t = 0 s :

$u = 0 \; and \; v = \frac{3}{4} \; m/s$

or $I = 4(\frac{3}{4}) - 0$

or $I = 3 \; Kg \; m/s$

At t = 4 s :

$u \ = \ \frac{3}{4} \ m/s$ and $v \ = \ 0$

Thus $I \ = \ 0 \ - \ 4\left(\frac{3}{4}\right)$

or $I \ = \ -3 \ Kg \ m/s$

Q5.15 (i) Two bodies of masses 10 kg and 20 kg respectively kept on a smooth, horizontal surface are tied to the ends of a light string. A horizontal force F = 600 N is applied to (i) A along the direction of the string. What is the tension in the string in each case?

Answer:

We will consider A and B in a system. So total mass in the system is = 10 + 20 = 30 Kg.

Thus acceleration of the system is given by :

$a \ = \ \frac{F}{m}$

or $= \ \frac{600}{30} \ = \ 20 \ m/s^2$

When force is applied at block A :

Using Newton's law of motion :

$F \ - \ T \ = \ m_1 a$

or $600 \ - \ T \ = \ 10 \times 20$

Thus $T \ = \ 400 \ N$

Q5.15 (ii) Two bodies of masses 10 kg and 20 kg respectively kept on a smooth, horizontal surface are tied to the ends of a light string. A horizontal force F = 600 N is applied to (ii) B along the direction of the string. What is the tension in the string in each case?

Answer:

We will consider A and B in a system. So total mass in the system is = 10 + 20 = 30 Kg.

Thus acceleration of the system is given by :

$$a = \frac{F}{m}$$

or $= \frac{600}{30} = 20\ m/s^2$

When force is applied at block B :

Using Newton's law of motion, we can write

$$F - T = m_2 a$$

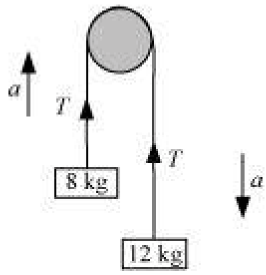
or $600 - T = 20(20)$

Thus $T = 200\ N$

Q5.16 Two masses 8 kg and 12 kg are connected at the two ends of a light inextensible string that goes over a frictionless pulley. Find the acceleration of the masses, and the tension in the string when the masses are released.

Answer:

Since both the masses are connected with string so they will have the same acceleration, let say 'a'.



We will apply Newton's law for each block individually.

For smaller block (8 Kg) :

$T - m_s g = m_s a$ ....(i)

For larger block (12 Kg) :

The equation of motion is given by :

$m_l g - T = m_l a$ ....(ii)

Adding both the equations we get :

The acceleration is given by :

$$a = \left(\frac{m_l - m_s}{m_l + m_s}\right) g$$

or $= \left(\frac{12 - 8}{12 + 8}\right) 10$

or $= 2\ m/s^2$

Now put the value of acceleration in any of the equations to get the value of T.

$$T = \left(m_l - \frac{m_l^2 - m_s m_l}{m_s + m_l}\right) g$$

or $$= \left(\frac{2 m_s m_l}{m_s + m_l}\right) g$$

or $$= \left(\frac{2 \times 12 \times 8}{12 + 8}\right) 10$$

$$= 96\ N$$

Thus the tension in the string is 96 N.

Q5.17 A nucleus is at rest in the laboratory frame of reference. Show that if it disintegrates into two smaller nuclei the products must move in opposite directions.

Answer:

Let the mass of parent nuclei be m.

And the mass of daughter nuclei be m_1 and m_2.

Initial momentum is zero since the nuclei is at rest.

But after dissociation, the momentum becomes :

$$M = m_1 v_1 + m_2 v_2$$

Using conservation of momentum,

$$0 = m_1 v_1 + m_2 v_2$$

or $v_1 = \frac{-m_2 v_2}{m_1}$

Thus both velocities have opposite direction.

Q5.18 Two billiard balls each of mass 0.05 kg moving in opposite directions with speed $6ms^{-1}$ collide and rebound with the same speed. What is the impulse imparted to each ball due to the other?

Answer:

Impulse imparted can be calculated by knowing the change in momentum.

The initial momentum of each ball is :

$p_i = mu = (0.05)6 = 0.3\ Kg\ m/s$

The final momentum is given by :

$p_f = mv = (0.05)(-6) = -0.3\ Kg\ m/s$

So the impulse is :

$I = p_f - p_i$

or $= -0.3 - 0.3$

or $= -0.6\ Kg\ m/s$

Q5.19 A shell of mass 0.020 kg is fired by a gun of mass 100 kg. If the muzzle speed of the shell is $80ms^{-1}$, what is the recoil speed of the gun?

Answer:

In this question, we will use the conservation of momentum.

Final momentum = Initial momentum

For initial momentum :

Both gun and shell are at rest initially so momentum is zero.

For final momentum :

The direction of the velocity of the shell is opposite to that of the gun.

So, $p_f = m_s v_s - m_g V_g$

The recoil speed of the gun :

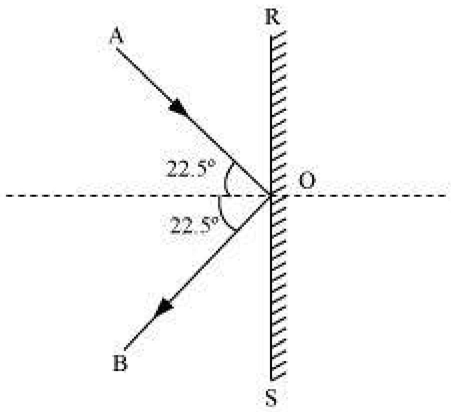
$$V_g = \frac{m_s v_s}{m_g}$$

or $V_g = \dfrac{0.020 \times 80}{100 \times 1000} = 0.016\ m/s$

Q5.20 A batsman deflects a ball by an angle of 45° without changing its initial speed which is equal to 54 km/h. What is the impulse imparted to the ball? (Mass of the ball is 0.15 kg.)

Answer:

The situation is shown below :



The horizontal components of velocity are to be considered for imparting impulse as vertical components are in the same direction thus impulse in the vertical direction is zero.

The impulse is given by a change in momentum.

Initial momentum = $-mv\cos\Theta$

Final momentum = $mv\cos\Theta$

Thus impulse is $= \ mv\cos\Theta \ - \ (-\ mv\cos\Theta) \ = \ 2mv\cos\Theta$

or $= \ 2\times 0.15\times 15\ \cos 22.5^{\circ}$

or $= \ 4.16\ Kg\ m/s$

Q5.21 A stone of mass 0.25 kg tied to the end of a string is whirled round in a circle of radius 1.5 m with a speed of 40 rev./min in a horizontal plane. What is the tension in the string? What is the maximum speed with which the stone can be whirled around if the string can withstand a maximum tension of 200 N?

Answer:

We are given, frequency :

$$n = \frac{40}{60} = \frac{2}{3}$$

So, the angular velocity becomes :

$$\omega = 2\Pi n$$

By Newton's law of motion, we can write :

$$T = F_{centripetal}$$

or $= \dfrac{mv^2}{r} = mw^2 r$

or $= (0.25)\left(2 \times \Pi \times \dfrac{2}{3}\right)^2 (1.5)$

or $= 6.57\ N$

Now, we are given maximum tension and we need to find maximum velocity for that :

$$T_{max} = \frac{mv_{max}^2}{r}$$

Thus, $v_{max} = \sqrt{\dfrac{T_{max}.r}{m}}$

or $= \sqrt{\dfrac{200 \times 1.5}{0.25}}$

or $= 34.64\ m/s$

Q5.22 (a) If, in Exercise 5.21, the speed of the stone is increased beyond the maximum permissible value, and the string breaks suddenly, which of the following correctly describes the trajectory of the stone after the string breaks :

(a) the stone moves radially outwards,

Answer:

The stone should move in the direction of velocity at that instant. Since velocity is tangential at that moment so the stone will **not** move radially outward.

Q5.22 (b) If, in Exercise 5.21, the speed of the stone is increased beyond the maximum permissible value, and the string breaks suddenly, which of the following correctly describes the trajectory of the stone after the string breaks :

(b) the stone flies off tangentially from the instant the string breaks,

Answer:

(b) This statement is correct as the direction of velocity at the instant of the breaking of the string is tangential thus stone will move tangentially.

Q5.22 (c) If, in Exercise 5.21, the speed of the stone is increased beyond the maximum permissible value, and the string breaks suddenly, which of the following correctly describes the trajectory of the stone after the string breaks :

(c) the stone flies off at an angle with the tangent whose magnitude depends on the speed of the particle?

Answer:

The direction of velocity at the instant of breakage of the string is tangential so the stone will fly tangentially. Hence given statement is false.

Q5.23 (a) Explain why

(a) a horse cannot pull a cart and run in empty space,

Answer:

The horse moves forward by pushing ground backwards. The ground will then give the normal force to the horse (action-reaction pair), which is responsible for the movement of the horse. In an empty space, no such force is present so the horse cannot get the push to run forward. Thus, a horse cannot pull a cart and run in empty space.

Q5.23 (b) Explain why

(b) passengers are thrown forward from their seats when a speeding bus stops suddenly,

Answer:

This is because of inertia. When the bus is moving our body has the same speed. But when the bus comes to rest, the inertia of our body opposes to stop and continues its motion. That's why passengers are thrown forward from their seats when a speeding bus stops suddenly.

Q5.23 (c) Explain why

(c) it is easier to pull a lawnmower than to push it,

Answer:

Because when you pull the lawnmower at some angle, one component of force is in the upward direction and one in horizontal (to move). The vertical force reduces the effective weight of the motor which makes it easier. But in case of a push, the vertical force is directed downward which makes its effective weight even greater than before. That's why it is said 'pull is easier than push'.

Q5.23 (d) Explain why

(d) a cricketer moves his hands backwards while holding a catch.

Answer:

According to Newton's law, we can write :

$F = ma$

or $F = m\frac{dv}{dt}$

Thus $F \propto \frac{dv}{dt}$

It can be seen from the equation that if we increase the impact time then the experienced force will be lesser.

So a cricketer increases the impact time by taking his hands backwards while holding a catch, resulting in less force on their hand.

NCERT solutions for class 11 physics chapter 5 laws of motion additional exercise

Q5.24. Figure 5.17 shows the position-time graph of a body of mass 0.04 kg. Suggest a suitable physical context for this motion. What is the time between two consecutive impulses received by the body? What is the magnitude of each impulse?

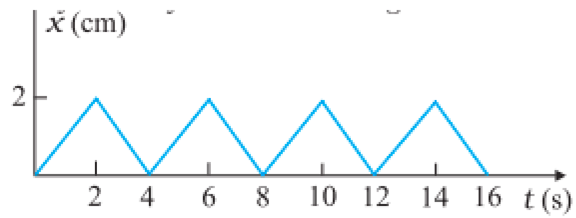


Fig. 5.17

Answer:

From the graph, it is clear that the direction of motion is changing after every 2 seconds. And has the same magnitude after 2 seconds.

This can be understood from a situation that a ball collides with wall elastically in seconds and returns to the original mean position after 4 seconds.

Since the slope of the graph is changing after every 2 s, so impulse is given after 2 sec. of duration.

Velocity can be known by calculating the slope of the position-time curve.

$$u = \frac{(2-0)}{2-0} \times 10^{-2} = 10^{-2}\ m/s$$

or $v = -\ 10^{-2}\ m/s$

Therefore, the magnitude of impulse is given by = | Change in momentum |

$$I = |mv - mu|$$

or $= 0.04(-\ 10^{-2} - 10^{-2})$

or $= 0.08 \times 10^{-2}\ Kg\ m/s$

Q5.25 Figure 5.18 shows a man standing stationary with respect to a horizontal conveyor belt that is accelerating with $1 m s^{-2}$. What is the net force on the man? If the coefficient of static friction between the man's shoes and the belt is 0.2, up to what acceleration of the belt can the man continue to be stationary relative to the belt? (Mass of the man = 65 kg.)

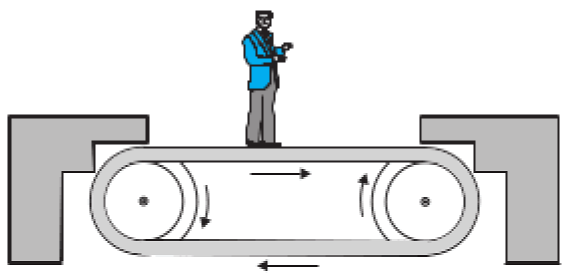


Fig. 5.18

Answer:

The net force on the man is given by :

$F \;=\; ma$

or $= \;65 \times 1 \;=\; 65\ N$

The maximum force can be exerted is given by :

$F_r \;=\; \mu mg$

or $= \;0.20(650) \;=\; 130\ N$

So the maximum acceleration is :

$ma_{max} \;=\; \mu mg$

or $a_{max} \;=\; \mu g$

or $a_{max} \;=\; 0.2 \times 10 \;=\; 2\ m/s^2$

Q5.26 A stone of mass m tied to the end of a string revolves in a vertical circle of radius R. The net forces at the lowest and highest points of the circle directed vertically downwards are : [Choose the correct alternative]

Lowest Point Highest Point

(a) $mg - T_1 \; mg + T_2$

(b) $mg + T_1 \; mg - T_2$

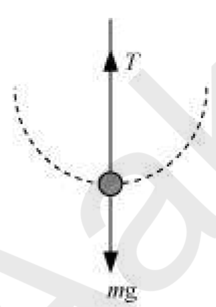
(c) $mg + T_1 - (mv_1^2))/R \; mg - T_2 + (mv_1^2))/R$

(d) $mg - T_1 - (mv_1^2))/R \; mg + T_2 + (mv_1^2))/R$

T_1 and v_1 denote the tension and speed at the lowest point. T_2 and v_2 denote corresponding values at the highest point.

Answer:

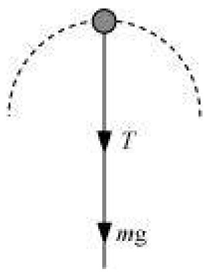
The FBD of stone at the lowest point is shown below :



Using Newton's law of motion,

$$T - mg = \frac{mv^2}{r}$$

The FBD of stone at the highest point is given below :



Using Newton's law of motion we have :

$$T + mg = \frac{mv^2}{r}$$

Thus option **(a)** is correct.

Q5.27 (a) A helicopter of mass 1000 kg rises with a vertical acceleration of $15ms^{-2}$. The crew and the passengers weigh 300 kg. Give the magnitude and direction of the

(a) force on the floor by the crew and passengers,

Answer:

(a) The normal force on the floor will be the reaction force due to crew and passengers.

Using Newton's laws of motion we can write :

$$N - m_c g = m_c a$$

Thus $N = m_c a + m_c g$

or $= 300\,(15 + 10)$

or $= 7500\ N$

The direction of normal force on the floor will be vertically upward.

Q5.27 (b) A helicopter of mass 1000 kg rises with a vertical acceleration of 15 m s $^{-2}$. The crew and the passengers weigh 300 kg. Give the magnitude and direction of the

(b) action of the rotor of the helicopter on the surrounding air,

Answer:

(b) In this case, we need to consider helicopter and passengers in a system because we need to determine the action of the rotor.

So by Newton's laws motion, we have :

$R - mg = ma$

or $R = ma + mg$

or $= 1300\,(15 + 10)$

or $= 32500\ N$

The direction of the force of rotor on the surrounding will be in the downward direction.

Q5.27 (c) A helicopter of mass 1000 kg rises with a vertical acceleration of 15 m s $^{-2}$. The crew and the passengers weigh 300 kg. Give the magnitude and direction of the

(c) force on the helicopter due to the surrounding air.

Answer:

$R - mg = ma$

or $R = ma + mg$

or $= 1300\,(15 + 10)$

or $= 32500\ N$

The direction of the force of the rotor on the surrounding will be in the downward direction.

By action-reaction pair, the force on helicopter due to the surrounding is 32500 N and it is directed vertically upward.

Q5.28 A stream of water flowing horizontally with a speed of 15 m s $^{-1}$ gushes out of a tube of cross-sectional area 10 $^{-2}$ m ^{2}, and hits a vertical wall nearby. What is the force exerted on the wall by the impact of water, assuming it does not rebound?

Answer:

Firstly we will calculate the mass of water passing through per second :

$m = \rho V$

or $= \rho A v$

or $= 10^3 \times 15 \times 10^{-2} = 150\ Kg/s$

Force is defined as the rate of change of momentum.

$F = \dfrac{\Delta P}{\Delta t}$

or $= \dfrac{mv}{t}$

or $= 150 \times 15 = 2250\ N$

Q5.29 (a) Ten one-rupee coins are put on top of each other on a table. Each coin has a mass m. Give the magnitude and direction of

(a) the force on the 7 th coin (counted from the bottom) due to all the coins on its top.

Answer:

The weight on the 7th coin is due to the top 3 coins.

So required force is equal to the weight of 3 coins = **3 mg**

This force is acting vertically downward.

Q5.29 (b) Ten one-rupee coins are put on top of each other on a table. Each coin has a mass m. Give the magnitude and direction of

(b) the force on the 7^{th} coin by the eighth coin,

Answer:

The eighth coin is placed directly above the 7th coin. Thus the net force experienced by 7th coin is due to 8th coin (as the 7th coin is in contact with 8th coin only from the top). Hence the force on the 7^{th} coin by the eighth coin is **3 mg.**

Q5.29 (c) Ten one-rupee coins are put on top of each other on a table. Each coin has a mass m. Give the magnitude and direction of

(c) the reaction of the 6^{th} coin on the 7^{th} coin.

Answer:

Since the 6th coin will experience a force due to 4 coins that are present above i.e., 4 mg. According to Newton's law of action-reaction pair, the 6th coin will have a reaction force on 7th coin of magnitude**4 mg** in the upward direction.

Q5.30 An aircraft executes a horizontal loop at a speed of 720 km/h with its wings banked at 15°. What is the radius of the loop?

Answer:

Convert speed of aircraft in SI units :

$$V \ = \ 720 \ Km/h \ = \ 720 \times \frac{5}{18} \ = \ 200 \ m/s$$

We are familiar with the following relation :

$$\tan \Theta \ = \ \frac{v^2}{rg}$$

or $r \ = \ \dfrac{v^2}{g \tan \Theta}$

or $= \ \dfrac{200^2}{10 \times \tan 15^{\circ}}$

or $= \ 14925.37 \ m \ = \ 14.9 \ Km$

Q5.31 A train runs along an unbanked circular track of radius 30 m at a speed of 54 km/h. The mass of the train is 10^{6} kg. What provides the centripetal force required for this purpose — The engine or the rails? What is the angle of banking required to prevent wearing out of the rail?

Answer:

The required centripetal force is provided by the **rails** , as by Newton's third law of motion, wheels apply force on the rails and thus rails provides a force on the wheels (action-reaction pair).

We know that the angle of banking is given by :

$$\tan \Theta = \frac{v^2}{rg}$$

or $= \dfrac{15^2}{30 \times 10}$

or $= 0.75$

Thus $\Theta = 36.87°$

Q5.32 A block of mass 25 kg is raised by a 50 kg man in two different ways as shown in Fig. 5.19. What is the action on the floor by the man in the two cases? If the floor yields to a normal force of 700 N, which mode should the man adopt to lift the block without the floor yielding?

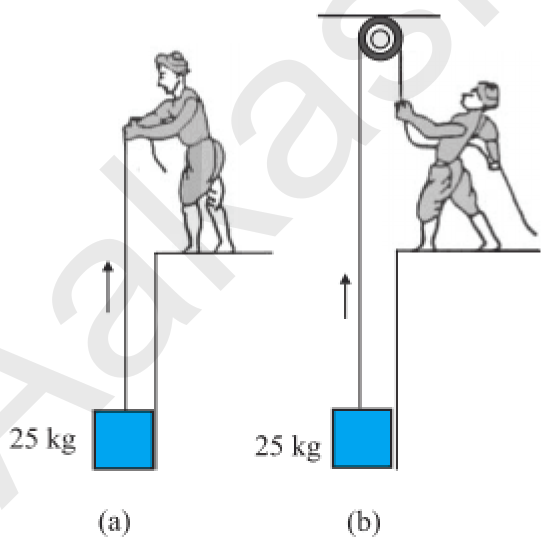


Fig. 5.19

Answer:

Using Newton's law force applied on the block:- $F = ma$

or $F = 25 \times 10 = 250\ N$

Weight of man = 500 N

Case 1:- When a man is lifting block directly, man is applying force in the upward direction directly.

The net force on floor : - 250 + 500 = 750 N

Case 2:- When a man is lifting block through pulley :

The net force on floor :- 500 - 250 = 250 N

Now it is given that the floor can yield 700 N of the normal force. Thus the man should adopt case 2.

Q5.33 A monkey of mass 40 kg climbs on a rope (Fig. 5.20) which can stand a maximum tension of 600 N. In which of the following cases will the rope break: the monkey

(a) climbs up with an acceleration of 6 m s^{-2}

(b) climbs down with an acceleration of 4 m s^{-2}

(c) climbs up with a uniform speed of 5 m s^{-1}

(d) falls down the rope nearly freely under gravity?

(Ignore the mass of the rope).

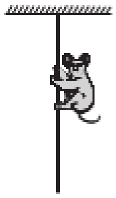


Fig. 5.20

Answer:

Given that $T_{max} = 600$ N.

(a) Acceleration of 6 m s $^{-2}$ in the upward direction:-

Using Newton's law of motion we can write :

$$T - mg = ma$$

or $T = 40(6+10) = 640\ N$

Thus rope will break.

(b) Acceleration of 4 m s $^{-2}$ in a downward direction:-

Using Newton's law of motion we can write :

$$T - mg = ma$$

or $T = 40(10-4) = 240\ N$

Thus the rope will **not** break.

(c) Upward with a constant speed of 5 m/s:-

Since speed is constant thus acceleration is 0.

$$T - mg = ma$$

or $T = 40(0 + 10) = 400\ N$

Thus the rope will **not** break.

(d) Acceleration is due to gravity (in a downward direction):-

Using Newton's law :

$$T - mg = ma$$

or $T = 40(-10 + 10) = 0\ N$

Thus the rope will **not** break.

Q5.34 (a) Two bodies A and B of masses 5 kg and 10 kg in contact with each other rest on a table against a rigid wall (Fig. 5.21). The coefficient of friction between the bodies and the table is 0.15. A force of 200 N is applied horizontally to A. What are (a) the reaction of the partition? What happens when the wall is removed? Ignore the difference between μ_s and μ_k .

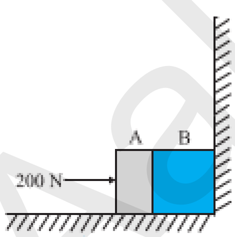


Fig. 5.21

Answer:

The applied force is 200 N.

The maximum friction force on the system is given by :

$$F = \mu(m_A + m_B)g$$

or $= 0.15(5 + 10)g = 22.5\ N$

So the net force on partition is 200 - 22.5 = 177.5 N.

This will be equal to the reaction of the partition (action-reaction pair). The direction will be leftward.

Q5.34 (b) Two bodies A and B of masses 5 kg and 10 kg in contact with each other rest on a table against a rigid wall (Fig. 5.21). The coefficient of friction between the bodies and the table is 0.15. A force of 200 N is applied horizontally to A. What are (b) the action-reaction forces between A and B ? What happens when the wall is removed? Does the answer to (b) change, when the bodies are in motion? Ignore the difference between μ_s and μ_k .

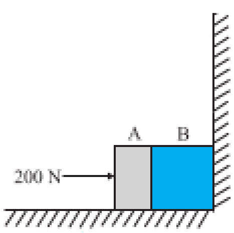


Fig. 5.21

Answer:

Consider block A.

The frictional force on block A will be :

$$f_A = \mu m_A g$$

or $= 0.15 \times 5 \times 10 = 7.5\ N$

Thus net force on B due to block A is = 200 - 7.5 = 192.5 N.

The net force on the partition is 177.5 N.

Using Newton's law of motion we have,

$$a = \frac{Force}{m_A + m_B}$$

or $a = \frac{177.5}{5+10} = 11.83\ m/s^2$

For block A :

$$F_A = m_A a$$

or = $5 \times 11.83 = 59.15\ N$

So the required normal force is = 192.15 - 59.15 = 133.35 N.

Q5.35 (a) A block of mass 15 kg is placed on a long trolley. The coefficient of static friction between the block and the trolley is 0.18. The trolley accelerates from rest with 0.5 m s $^{-2}$ for 20 s and then moves with uniform velocity. Discuss the motion of the block as viewed by (a) a stationary observer on the ground.

Answer:

(a) Using Newton's second law of motion we can write :

$$F = ma$$

or = $15 \times 0.5 = 7.5\ N$ Its direction is in the direction of motion of trolley.

The frictional force is $f = \mu mg$

or = $0.18 \times 15 \times 10 = 27\ N$

Since the frictional force is greater than the applied force so the block will appear to be at rest when seen by any stationary person.

Q5.35(b) A block of mass 15 kg is placed on a long trolley. The coefficient of static friction between the block and the trolley is 0.18. The trolley accelerates from rest with 0.5 m s $^{-2}$ for 20 s and then moves with uniform velocity. Discuss the motion of the block as viewed by (b) an observer moving with the trolley.

Answer:

(b) With reference to the observer moving with trolley, the trolley will be at rest as a pseudo force will act to balance out the frictional force. In relative motion both are moving together, thus are rest with respect to each other.

Q5.36 The rear side of a truck is open and a box of 40 kg mass is placed 5 m away from the open end as shown in Fig. 5.22. The coefficient of friction between the box and the surface below it is 0.15. On a straight road, the truck starts from rest and accelerates with 2 m s $^{-2}$. At what distance from the starting point does the box fall off the truck? (Ignore the size of the box).

Answer:

Using Newton's second law of motion we can write :

$$F = ma$$

$$= 40 \times 2 = 80\ N$$

Also, the frictional force is given by :

$f = \mu mg$

or $= 0.15 \times 40 \times 10 = 60\ N$

Thus net force acting is : 80 - 60 = 20 N.

The backward acceleration is :

$$a_b = \frac{20}{40} = 0.5\ m/s^2$$

Now using the equation of motion we can write :

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

or $5 = 0 + \frac{1}{2}(0.5)t^2$

Thus $t = \sqrt{20}\ s$

And the distance travelled by truck is :

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

or $= 0 + \frac{1}{2} \times 2(\sqrt{20})^2$

or $= 20\ m$

Q5.37 A disc revolves with a speed of $33\frac{1}{3}$ rev/min, and has a radius of 15 cm. Two coins are placed at 4 cm and 14 cm away from the centre of the record. If the coefficient of friction between the coins and the record is 0.15, which of the coins will revolve with the record?

Answer:

Frequency of revolution is :

$$= \frac{100}{3 \times 60} = \frac{5}{9}\, rev/sec$$

(i) Case 1 :- When coin is placed at 4 cm :

Radius = 0.04 m

Angular frequency :

$$\omega = 2\pi v$$

or $= 2\pi \times \frac{5}{9} = 3.49\ s^{-1}$

The frictional force is given by :

$$f = \mu m g$$

or $= 0.15 \times m \times 10 = 1.5m\ N$

Thus the centripetal force will be :

$$F_c = m r \omega^2$$

or $= m \times 0.04(0.39)^2 = 0.49m\ N$

Since frictional force is greater than the centripetal force so coin will revolve around the record.

(ii) Case 2:- When the coin is placed at 14 cm :

Radius = 0.14 m

The centripetal force will be :

$$F_c = mr\omega^2$$

or $= \; m \times 0.14(0.39)^2 \; = \; 1.7m \; N$

Since frictional force is lesser than the centripetal force so the coin will slip from the record.

Q5.38 You may have seen in a circus a motorcyclist driving in vertical loops inside a 'death-well' (a hollow spherical chamber with holes, so the spectators can watch from outside). Explain clearly why the motorcyclist does not drop down when he is at the uppermost point, with no support from below. What is the minimum speed required at the uppermost position to perform a vertical loop if the radius of the chamber is 25 m?

Answer:

The motorcyclist does not drop down when he is at the uppermost point because of their weight and the normal force is **balanced by the centripetal force** .

$$F_N + F_g = ma_{centripetal}$$

or $F_N + mg = \dfrac{mv^2}{r}$

At minimum velocity, the normal reaction is zero.

So the equation becomes :

$$mg = \frac{mv_{min}^2}{r}$$

or $v_{min} = \sqrt{rg}$

or $= \sqrt{25 \times 10} = 15.8\ m/s$

Q5.39 A 70 kg man stands in contact against the inner wall of a hollow cylindrical drum of radius 3 m rotating about its vertical axis with 200 rev/min. The coefficient of friction between the wall and his clothing is 0.15. What is the minimum rotational speed of the cylinder to enable the man to remain stuck to the wall (without falling) when the floor is suddenly removed?

Answer:

Frequency of rotation is :

$$= \frac{200}{60} = \frac{10}{3}\ rev/sec$$

The required condition so that man will not fall :

$$mg < f$$

or $mg < \mu F_N$

or $mg < \mu m r \omega^2$

or $\omega > \sqrt{\frac{g}{\mu r}}$

And thus :

$$\omega_{min} = \sqrt{\frac{10}{0.5 \times 3}} = 4.71\ rad\ s^{-1}$$

Thus the required minimum rotational speed is 4.71 rad/s.