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Question 5. 1. Give the magnitude and direction of the net force acting on
(a) a drop of rain falling down with a constant speed,
(b) a cork of mass 10 g floating on water,
(c) a kite skilfully held stationary in the sky,
(d) a car moving with a constant velocity of 30 km/h on a rough road,
(e) a high-speed electron in space far from all material objects, and free of electric and magnetic fields.
Answer:
(a) As the drop of rain is falling with constant speed, in accordance with first law of motion, the net force on the drop of rain is zero.
(b) As the cork is floating on water, its weight is being balanced by the upthrust (equal to.weight of water displaced). Hence net force on the cork is zero.
(c) Net force on a kite skilfully held stationary in sky is zero because it is at rest.
(d) Since car is moving with a constant velocity, the net force on the car is zero.
(e) Since electron is far away from all material agencies producing electromagnetic and gravitational forces, the net force on electron is zero.

Question 5. 2. 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, .
(b) during its downward motion,
(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 1 Ignore air resistance.
Answer:
(a) When the pebble is moving upward, the acceleration g is acting downward, so the force is acting downward is equal to F = mg = 0.05 kg x 10 ms^{-2} = 0.5 N.
(b) In this case also F = mg = 0.05 x 10 = 0.5 N. (downwards).
(c) The pebble is not at rest at highest point but has horizontal component of velocity. The direction and magnitude of the net force on the pebble will not alter even if it is thrown at 45° because no other acceleration except 'g' is acting on pebble.

Question 5. 3. 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,
(b) just after it is dropped from the window of a train running at a constant velocity of 36 km/ h,
(c) just after it is dropped from the window of a train accelerating with 1 ms^{-2},
(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:
(a) Mass of stone = 0.1 kg

Net force, F = mg = 0.1 x 10 = 1.0 N. (vertically downwards).
(b) When the train is running at a constant velocity, its acceleration is zero. No force acts on the stone due to this motion. Therefore, the force on the stone is the same (1.0 N.).
(c) The stone will experience an additional force F′ (along horizontal) i.e.,F = ma = 0.1 x l = 0.1 N
As the stone is dropped, the force F′ no longer acts and the net force acting on the stone F = mg = 0.1 x 10 = 1.0 N. (vertically downwards).
(d) As the stone is lying on the floor of the train, its acceleration is same as that of the train.
∴ force acting on the stone, F = ma = 0.1 x 1 = 0.1 N.
It acts along the direction of motion of the train.

Question 5. 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) $T-mv^2/l$, (iii) $T+mv^2/l$, (iv) 0
T is the tension in the string. [Choose the correct alternative].
Answer: (i) T.
The net force T on the particle is directed towards the centre. It provides the centripetal force required by the particle to move along a circle.

Question 5. 5. A constant retarding force of 50 N is applied to a body of mass 20 kg moving initially with a speed of 15 ms^{-3}. How long does the body take to stop?
Answer: Here m = 20 kg, F = - 50 N (retardation force)
As F = ma

$$\Rightarrow \quad a = \frac{F}{m} = \frac{-50}{20} = -2.5 \text{ ms}^{-2}$$

Using equation, $v = u + at$
Given, $u = 15 \text{ ms}^{-1}, \quad v = 0$
Now, $0 = 15 + (-25)\, t$
or, $t = 6$ s.

Question 5. 6. A constant force acting on a body of mass 3.0 kg changes its speed from 2.0 ms^{-1} to 3.5 ms^{-1} in 25 s. The direction of the motion of the body remains unchanged. What is the magnitude and direction of the force?
Answer:
Here, $m = 3.0 \text{ kg}, \quad u = 2.0 \text{ ms}^{-1}$
$v = 3.5 \text{ ms}^{-1}, \quad t = 25 \text{ s}$
As $F = ma$
or $F = m\left(\frac{v-u}{t}\right) \qquad \left[\because a = \frac{v-u}{t}\right]$

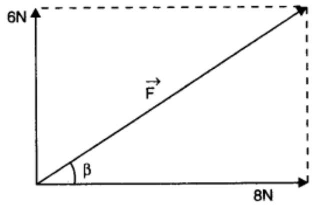
$$\Rightarrow \quad F = \frac{3.0\,(3.5-2.0)}{25} = 0.18 \text{ N}.$$

The force is along the direction of motion.

Question 5. 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:

Here $m = 5$ kg

$F_1 = 8$ N and $F_2 = 6$ N



The resultant force on the body

$$F = \sqrt{F_1^2 + F_2^2} = \sqrt{8^2 + 6^2}\ N$$

$$\Rightarrow \quad F = \sqrt{64 + 36}\ \text{N} = 10\,\text{N}.$$

The acceleration, $a = \frac{F}{m}$

$\Rightarrow$ $a = \frac{10}{5} = 2\ \text{ms}^{-2}$ in the same direction as the resultant force.

The direction of acceleration,

$$\tan \beta = \frac{6}{8} = \frac{3}{4} = 0.75$$

or $\beta = \tan^{-1}(0.75)$

$= 37°$ with 8 N force.

Question 5. 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:

Here mass of three-wheeler mi = 400 kg, mass of driver = m_2 = 65 kg,

initial speed of auto u = 36 km/h = 36 x — m/s 10 ms^{-1},

final speed, v = 0 and t = 4s.

As acceleration, $a = \frac{v-u}{t} = \frac{0-10}{4} = -2.5\ \text{ms}^{-2}$

Now $F = (m_1 + m_2)\,a = (400 + 65) \times (-2.5)$

$= -1162.5\ \text{N} = -1.2 \times 10^3\ \text{N}.$

The $-ve$ sign shows that the force is retarding force.

Question 5. 9. A rocket with a lift-off mass 20,000 kg is blasted upwards with an initial acceleration of 5.0 ms^{-2}. Calculate the initial thrust (force) of the blast.

Answer:

Here, m = 20000 kg = 2 x 10^4 kg

Initial acceleration = 5 ms^{-2}

Clearly, the thrust should be such that it overcomes the force of gravity besides giving it an upward acceleration of 5 ms^{-2}.

Thus the force should produce a net acceleration of 9.8 + 5.0 = 14.8 ms^{-2}.

Since, thrust = force = mass x acceleration

F = 2 x 10^4 x 14.8 = 2.96 x 10^5 N.

Question 5. 10. A body of mass 0.40 kg moving initially with a constant speed of 10 ms^{-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 = -5 s, 25 s, 100 s.

Answer:

Here $\quad m = 0.40$ kg, $\quad u = 10$ ms^{-1}, $\quad F = -8$ N (retarding force)

As $\quad a = \frac{F}{m} = -\frac{8}{0.4} = -20$ ms^{-2}

Also $\quad S = ut + \frac{1}{2}at^2$

(*i*) Position at $\quad t = -5$s

$$S = 10(-5) + \frac{1}{2} \times 0 \times (-5)^2 = -50 \text{ m}$$

(*ii*) Position at $\quad t = 25$ s

$$S_1 = 10 \times 25 + \frac{1}{2} \times (-20) \times (25)^2 = -6000 \text{ m} = -6 \text{ km}$$

(*iii*) Position at $\quad t = 100$ s

$$S_2 = 10 \times 30 + \frac{1}{2} \times (-20) \times (30)^2 = -8700 \text{ m}$$

At $\quad t = 30$ s, $\quad v = u + at$

$$v = 10 - 20 \times 30 = -590 \text{ ms}^{-1}$$

Now, for motion from 30 s to 100 s

$$S_3 = -590 \times 70 + \frac{1}{2}(0) \times (70)^2 = -41300 \text{ m}$$

Total distance $= S_2 + S_3 = -8700 - 41300 = -50000$ m $= -50$ km.

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