PHYSICS CLASS XI
CHAPTER – 5 LAWS OF MOTION

Q.1. Carts with rubber are easier to ply than those with iron types. Explain.

Ans. The carts with rubber tyres are easier to ply than those with iron types because the coefficient of friction between rubber and concrete is less than between iron the road.

Q.2. Friction is a self adjusting force. Is this statement correct?

Ans. "Friction is a self adjusting force" statement is correct because when applied force is zero, friction is zero. As the applied force is increased, friction also increases and becomes equal to the applied force. It come into play till the body does not start moving.

Q.3. A force of 49 N is just sufficient to pull a block of wood weighing 10 kg on a rough horizontal surface. Calculate the coefficient of friction and angle of friction.

Ans. Here, P = applied force = 49 N, m = 10 kg, g = 9.8 m/s^2

Coefficient of friction, $\mu = \frac{f}{R} = \frac{P}{mg} = \frac{49}{10\times 9.8} = 0.5$

As, $\tan\theta = \mu = 0.5$

∴ $\theta = tan^{-1}$ (0.5) = 26°34'

Q.4. The mountain road generally made winding upwards rather than going straight up. Why?

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Ans. When we going up a mountain, the opposing force of friction F = μR = μmg cosθ.

where θ is angle of slope with horizontal. To avoid skidding, F should be large.

∴ cos θ should be large and hence θ must be small. Therefore, mountain roads are generally made winding upwards. The road straight up would have large slope.

Q.5. A body is moving in a circular path such that its speed always remains constant. Should there be force acting on the body?

Ans. When a body is moving along a circular path, then speed always remains constant and a centripetal force is acting on the body.

Q.6. What is the acceleration of a train travelling at 50 ms^{-1} as it goes round a curve of 250 m radius?

Ans. Given, velocity v = 50 ms^{-1}

Radius r = 50 m

Centripetal acceleration a = $\frac{v^2}{r}$

$$a = \frac{50\times50}{250} = 10ms^{-2}$$

Q.7. A heavy point mass tied to the end of string is whirled in a horizontal circle of radius 20 cm with a constant angular speed. What is angular speed if the centripetal acceleration is 980 cms^{-2}?

Ans. Here, radius r = 20 cm

Centripetal acceleration, a = 980 cms^{-2}

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We know that centripetal acceleration, a = $r\omega^2$

$$\omega = \sqrt{\frac{a}{r}} = \sqrt{\frac{980}{20}}$$

$$\omega = \sqrt{49} = 7 \text{ rad/s}$$

Q.8. The outer rail of a curved railway track is generally raised over the inner. Why?

Ans. When the outer rail of a curved railway track is raised over the inner, the horizontal component of the normal reaction of the rails, provides the necessary centripetal force for the train to enable it move along the curved path.

Q.9. A body of mass 2 kg is being dragged with a uniform velocity of 2 ms^{-1} on a rough horizontal plane. The coefficient of friction between the body and the surface is 0.2. Calculate the amount of heat generated per second. Take g = 9.8 ms^{-2} and J = 4.2 $Jcal^{-1}$.

Ans. Given, m = 2 kg, u = 2 ms^{-1}, μ = 0.2

Force of friction, f = μR

F = μmg [R = mg]

f = 0.2 × 2 × 9.8

f = 3.92 N

Distance moved per second s = ut

s = 2 × 1 = 2

Work done per second, W = f · s

W = 3.92 × 2 = 7.84 J

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Heat produced $H = \frac{W}{J} \Longrightarrow H = \frac{7.84}{4.2}$

$H = 1.87$ cal

Q.10. If the speed of 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

(i) the stone moves radially outwards,

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

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

Ans. The second part correctly describes the trajectory of the stone after the spring breaks because when a stone tied to one end of a string is whirled round in a circle then velocity of the stone at any point is along the tangent at that point. If the string breaks suddenly then stone flies off tangentially, along the direction of its velocity.

Q.11. You may have seen in a circus a motorcyclist driving in vertical loops inside a death well (a hallow 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?

Ans. When the motorcyclist is at the uppermost point of the death well, then weight of the cyclist as well as the normal reaction R. These forces are balanced by the outward centrifugal force acting on the motorcyclist.

∴ $R + mg = \frac{mv^2}{r}$

where, v = speed of the motorcyclist

m = mass of (motorcycle + driver)

r = radius of the death well.

As the forces acting on the motorcyclist are balanced, therefore motorcyclist does not fall down.

The minimum speed required to perform a vertical loop is given by $mg = \frac{mv_{min}^2}{r}$

(∵ In the case weight of the object = centripetal force)

or $v_{min} = \sqrt{rg} = \sqrt{25 \times 9.8} = 15.65$ m/s

Q.12. In physics classroom teacher asks to his student that a car driver along with his car has to move on a level turn of radius 45 m. If the coefficient of static friction between the tyre and the road is $\mu_s = 2$. Then,

(i) What will be the speed of car so that the car does not skid?

(ii) What type of teaching skill of the teacher is being represented here?

Ans. (i) Let the mass of the car be M. The forces on the car are

(a) weight Mg downward

(b) normal force N by the road upwards

(c) friction f_1 by the road towards the centre.

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The car is going on a horizontal circle of radius R, so it is accelerating. The acceleration is towards the centre and its magnitude is v^2/R, where v is the speed. For vertical direction, acceleration = 0. Resolving the force in vertical and horizontal directions and applying Newton's laws, we have

$$N = mg$$

and $$f_1 = Mv^2 / R$$

As we are looking for the maximum speed for no skidding it is a acse of limiting friction and hence $f_s = \mu_s N = \mu_s Mg$.

So, we have

$$\mu_s Mg = Mv^2/R$$

or $$v^2 = \mu_s gR$$

Putting the values, $v = \sqrt{2 \times 10m/s^2 \times 45m}$

$= 30$ m/s

$= 108$ km/h

Here, the teacher want to reach the student through an easy example. This act of teacher shows the experience and ideality of the teacher.

Q.13. A 70 kg man stands in contact against the inner wall of a hollow cylindrical drum 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?

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Ans. Radius of the cylinder drum (r) = 3m

Coefficient of friction between the wall and his clothing (μ) = 0.15

Frequency (v) = 200 rev/min

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

The normal reaction of the wall on the man acting horizontally provides the required centripetal force.

R = mr ω^2 ....(i)

The frictional force F, acting upwards balances his weight

i.e.. F = mg ....(ii)

The man will remain stuck to the wall without slipping, if

$\mu R \geq$ F or F $\leq \mu R$

mg $\leq \mu \times$ mr ω^2 or $\omega^2 \geq \frac{g}{\mu r}$

$\omega \geq \sqrt{\frac{g}{\mu R}}$

For minimum angular speed of rotation,

$\omega_{min} = \sqrt{\frac{9.8}{0.15\times3}}$ = 4.67 rad/s

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