DPP – 4 (Circular Motion)

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Q 1. A railway track is banked for a speed v, by making the height of the outer rail h higher than that of the inner rail. The distance between the rails is d. The radius of curvature of the track is r.

(a) $\frac{h}{d} = \frac{v^2}{rg}$

(b) $\tan\left(sin^{-1}\frac{h}{d}\right) = \frac{v^2}{rg}$

(c) $\tan^{-1}\left(\frac{h}{d}\right) = \frac{v^2}{rg}$

(d) $\frac{h}{r} = \frac{v^2}{dg}$

Q 2. An automobile enters a turn whose radius is R. The road is banked at angle θ for speed v. Friction is negligible between wheels of the automobile and road. Mass of the automobile is m and speed is v. Select the correct alternative:

(a) net force on the automobile is zero

(b) normal reaction on the automobile is mg cos θ

(c) normal reaction on the automobile is mg sec θ

(d) net force on the automobile is $\sqrt{(mg)^2 + (mv^2/R)^2}$

Q 3. A hemispherical bowl of radius r is rotated about its axis of symmetry which is kept vertical. A small block is kept at a position where the radius makes an angle θ with the vertical. The block rotates with the bowl without any slipping. The friction coefficient between the block and the bowl is μ. The maximum speed for which the block will not slip

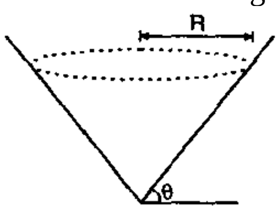
(a) $\left[\frac{g(sin\,\theta-\mu\,cos\,\theta)}{r\,sin\,\theta(cos\,\theta+\mu\,sin\,\theta)}\right]^{1/2}$

(b) $\left[\frac{g(sin\,\theta+\mu\,cos\,\theta)}{r\,sin\,\theta(cos\,\theta+\mu\,sin\,\theta)}\right]^{1/2}$

(c) $\left[\frac{g(sin\,\theta+\mu\,cos\,\theta)}{r\,sin\,\theta(cos\,\theta-\mu\,sin\,\theta)}\right]^{1/2}$

(d) none of these

Q 4. A block of mass in is moving in a circle of radius R with speed v inside a smooth cone as shown in figure. Choose the wrong options.



(a) N = 0 if v = $\sqrt{Rg\,tan\,\theta}$

(b) N sin θ = $\frac{mv^2}{R}$

(c) block is in equilibrium

(d) block is accelerated

Q 5. A car moves along a horizontal circular road of radius r with velocity v. The coefficient of friction between the wheels and the road is μ. Which of the following statement is not true?

(a) The car will slip if v > $\sqrt{\mu r g}$.
(b) The car will slip if μ < $\frac{v^2}{rg}$
(c) The car will slip if r > $\frac{v^2}{\mu g}$
(d) The car will slip at a lower speed, along with some acceleration, than if it moves at constant speed.

Q 6. A curved section of a road is banked for a speed v. If there is no friction between the road and the tyres then
(a) a car moving with speed v will not slip on the road
(b) a car is more likely to slip on the road at speeds higher than v, than at speeds lower than v
(c) a car is more likely to slip on the road at speeds lower than v, than at speeds higher than v
(d) a car can remain stationary on the road without slipping

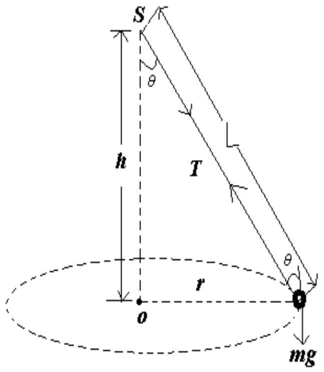
Q 7. A cyclist moves along a curved road with a velocity v. The road is banked for speed v. The angle of banking is θ. Which of the following statements is **not true**?
(a) The cyclist will lean away from the vertical at an angle θ.
(b) The normal reaction of the road is greater than weight of cycle plus cyclist system.
(c) There will be no force of friction between the tyres and the road.
(d) The cyclist is in equilibrium with respect to the ground.

Q 8. A curved road of 50 m in radius is banked to correct angle for a given speed. If the speed is to be doubled, keeping the same banking angle, the radius of curvature of the road should be changed to
(a) 100 m (b) 150 m (c) 200 m (d) 250 m

Q 9. A simple pendulum of length *l* is set in motion such that the bob, of mass m, moves along a horizontal circular path, and the string makes a constant angle θ with the vertical. The time period of rotation of the bob is t and the tension in the thread is T.
(a) t = 2π$\sqrt{l/g}$ (b) t = 2π$\sqrt{l\cos\theta/g}$
(c) T = $\frac{4\pi^2 ml}{t^2}$ (d) The bob is in equilibrium

Passage (Q.10 to Q.12)

A string of length 1m is fixed at one end and carries a mass of 100g at the other end. The string makes $(2/\pi)$ revolutions per second around vertical axis through the fixed end. As shown in the figure then



Q 10. The tension in the string is

(a) 1.0 N (b) 1.6 N
(c) 6 N (d) 3 N

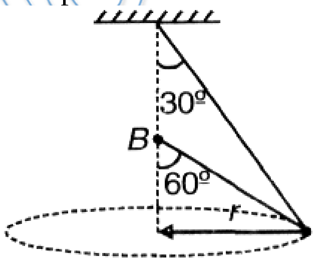
Q 11. The angle of inclination of the string with the vertical is

(a) $cos^{-1}(8/5)$ (b) $sin^{-1}(5/8)$
(c) $tan^{-1}(5/8)$ (d) $cos^{-1}(5/8)$

Q 12. The linear velocity of the mass is

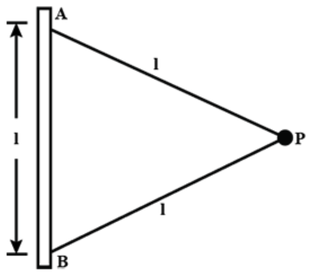
(a) 3.12 m/s (b) 6.24m/s
(c) 1.56m/s (d) 12.48m/s

Q 13. A single wire ACB passes through a ring C which revolves at a constant speed in the horizontal circle of radius r, as shown in the figure. The speed of revolution is



(a) $\sqrt{rg}$ (b) $\sqrt{2rg}$ (c) $2\sqrt{2rg}$ (d) $2\sqrt{rg}$

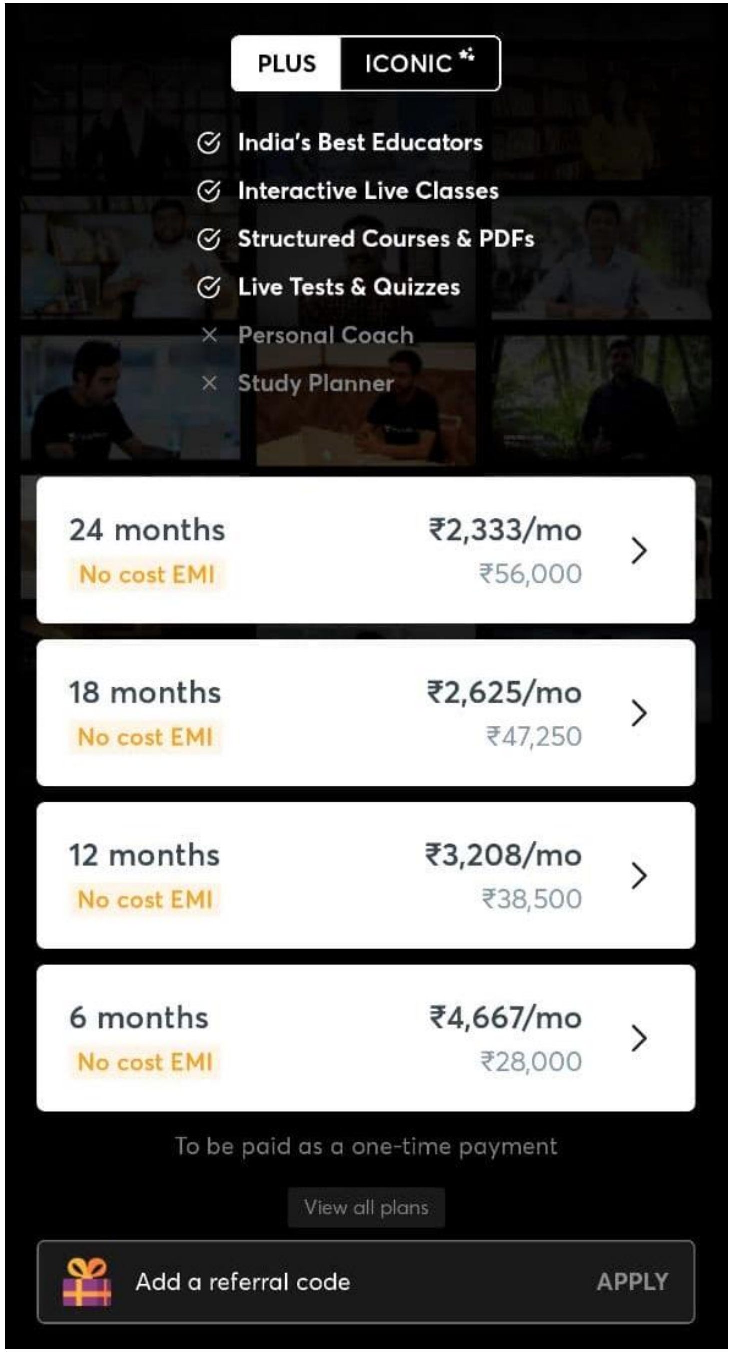
Q 14. A particle P of mass m is attached to a vertical axis by two strings AP and BP of length l each. The separation AB = l. P rotates around the axis with an angular velocity ω. The tensions in the two strings are T_1 and T_2.



(a) $T_1 = T_2$ (b) $T_1 + T_2 = m\omega^2 l$
(c) $T_1 - T_2 = 2mg$ (d) BP will remain taut only if $\omega \geq \sqrt{2g/l}$

Answer Key

Q.1 b	**Q.2 c**	**Q.3 c**	**Q.4 c, a**	**Q.5 c**
Q.6 a	**Q.7 d**	**Q.8 c**	**Q.9 b, c**	**Q.10 b**
Q.11 d	**Q.12 a**	**Q.13 a**	**Q.14 b, c, d**	



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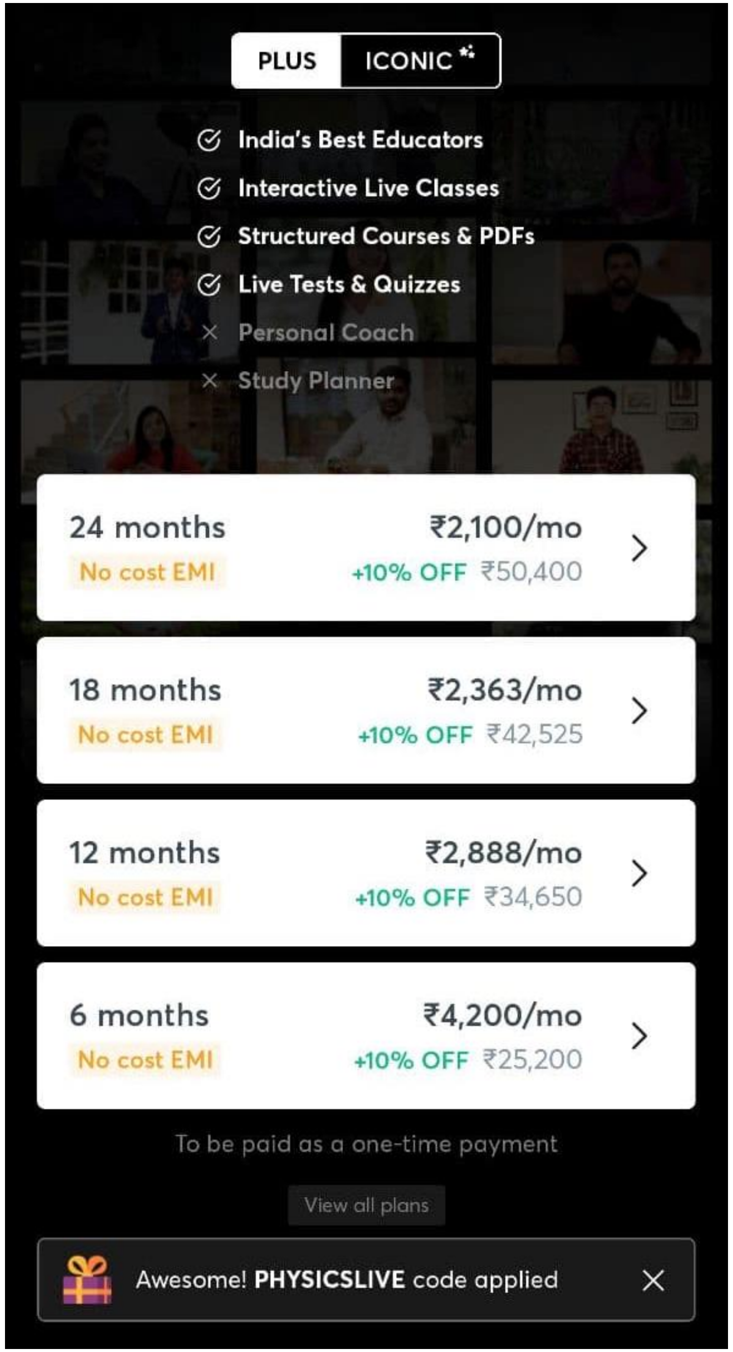
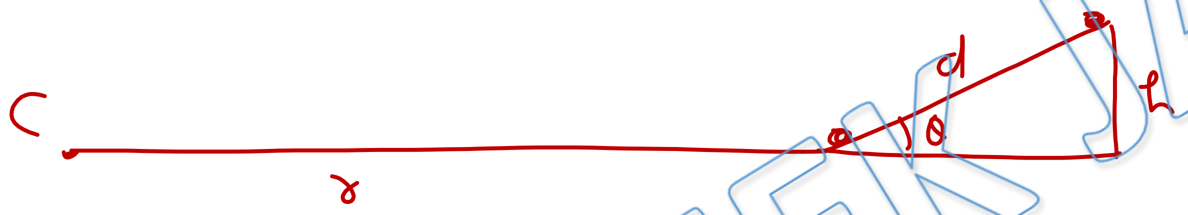


Written Solution

DPP - 4 ,Conical Pendulum, Motion of vehicle on circular path, Banking of roads

By Physicsaholics Team

Q1) A railway track is banked for a speed v, by making the height of the outer rail h higher than that of the inner rail. The distance between the rails is d. The radius of curvature of the track is r.



(a) $\frac{h}{d} = \frac{v^2}{rg}$

(b) $\tan\left(\sin^{-1}\frac{h}{d}\right) = \frac{v^2}{rg}$

(c) $\tan^{-1}\left(\frac{h}{d}\right) = \frac{v^2}{rg}$

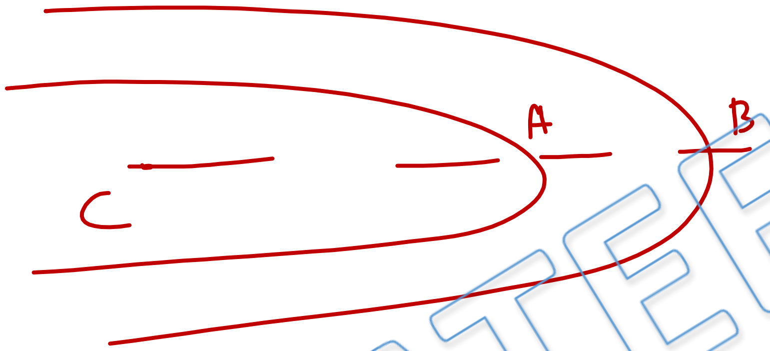
(d) $\frac{h}{r} = \frac{v^2}{dg}$

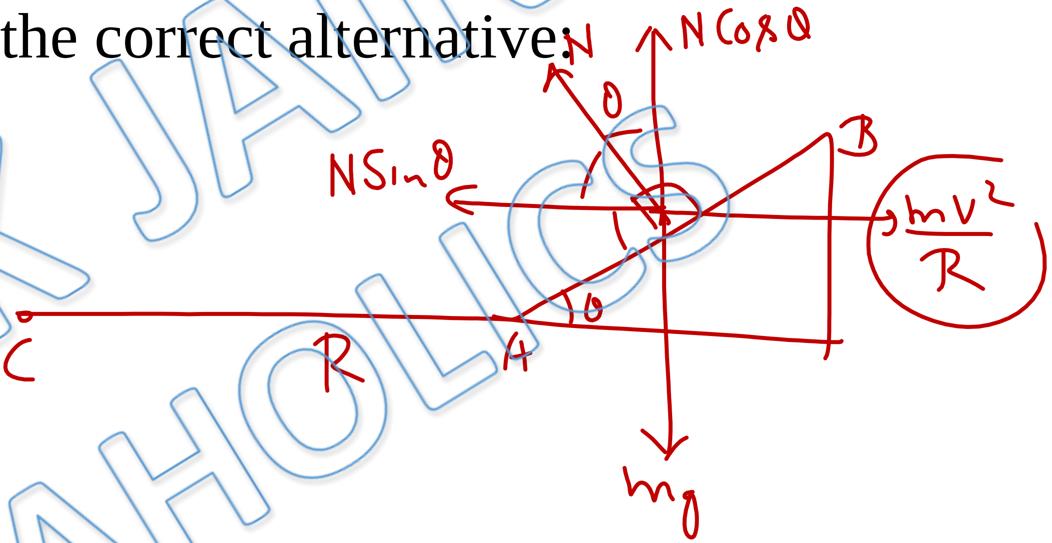
$\sin\theta = h/d.$

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

$\tan\left(\sin^{-1}(h/d)\right) = \frac{v^2}{rg}$

Q2) An automobile enters a turn whose radius is R. The road is banked at angle θ for speed v. Friction is negligible between wheels of the automobile and road. Mass of the automobile is m and speed is v. Select the correct alternative:





(a) net force on the automobile is zero

(b) normal reaction on the automobile is mg cos θ

(c) normal reaction on the automobile is mg sec θ

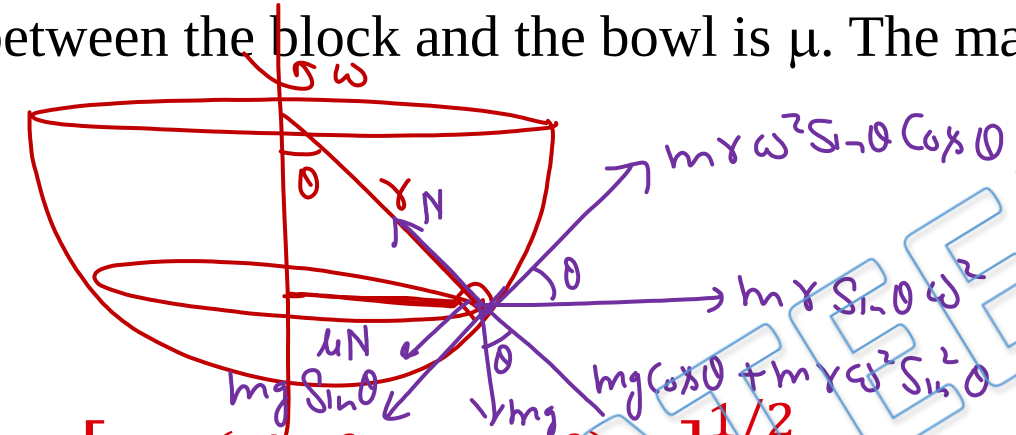
(d) net force on the automobile is $\sqrt{(mg)^2 + (mv^2/R)^2}$

$N\cos\theta = mg$

$N = mg\sec\theta$

$F_{net} = ma_c = \frac{mv^2}{R}$

Q3) A hemispherical bowl of radius r is rotated about its axis of symmetry which is kept vertical. A small block is kept at a position where the radius makes an angle θ with the vertical. The block rotates with the bowl without any slipping. The friction coefficient between the block and the bowl is μ. The maximum speed for which the block will not slip



$N = mg\cos\theta + mr\omega^2\sin^2\theta$

$\mu N + mg\sin\theta = mr\omega^2\sin\theta\cos\theta$

$\mu mg\cos\theta + \mu mr\omega^2\sin^2\theta + mg\sin\theta = mr\omega^2\sin\theta\cos\theta$

(a) $\left[\frac{g(\sin\theta-\mu\cos\theta)}{r\sin\theta(\cos\theta+\mu\sin\theta)}\right]^{1/2}$

(b) $\left[\frac{g(\sin\theta+\mu\cos\theta)}{r\sin\theta(\cos\theta+\mu\sin\theta)}\right]^{1/2}$

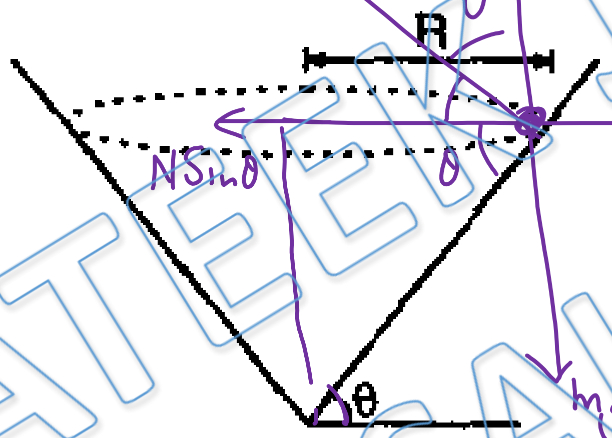
(c) $\left[\frac{g(\sin\theta+\mu\cos\theta)}{r\sin\theta(\cos\theta-\mu\sin\theta)}\right]^{1/2}$ ✓

(d) none of these

$mg(\sin\theta+\mu\cos\theta) = mr\omega^2\sin\theta(\cos\theta-\mu\sin\theta)$

$\omega^2 = \frac{g}{r}\,\frac{\sin\theta+\mu\cos\theta}{(\cos\theta-\mu\sin\theta)\sin\theta}$

Q4) A block of mass in is moving in a circle of radius R with speed v inside a smooth cone as shown in figure. Choose the wrong options.



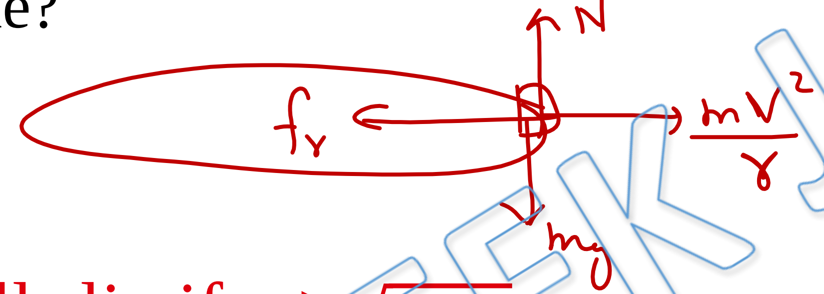
(a) N = 0 if $v = \sqrt{Rg \tan\theta}$

(b) $N \sin\theta = \frac{mv^2}{R}$

(c) block is in equilibrium

(d) block is accelerated

Q5) A car moves along a horizontal circular road of radius r with velocity v. The coefficient of friction between the wheels and the road is μ. Which of the following statement is not true?



for no sliding

$\mu mg > \frac{mv^2}{r}$

$\mu > \frac{v^2}{rg}$

$v < \sqrt{\mu g R}$

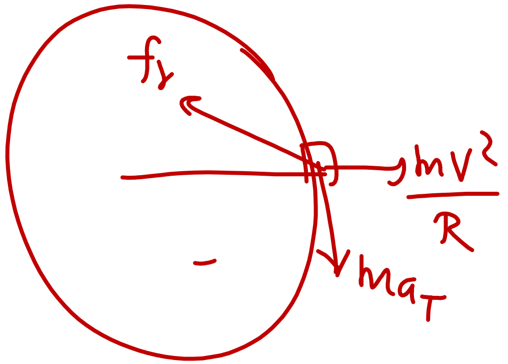
$r > \frac{v^2}{\mu g}$

(a) The car will slip if $v > \sqrt{\mu r g}$.

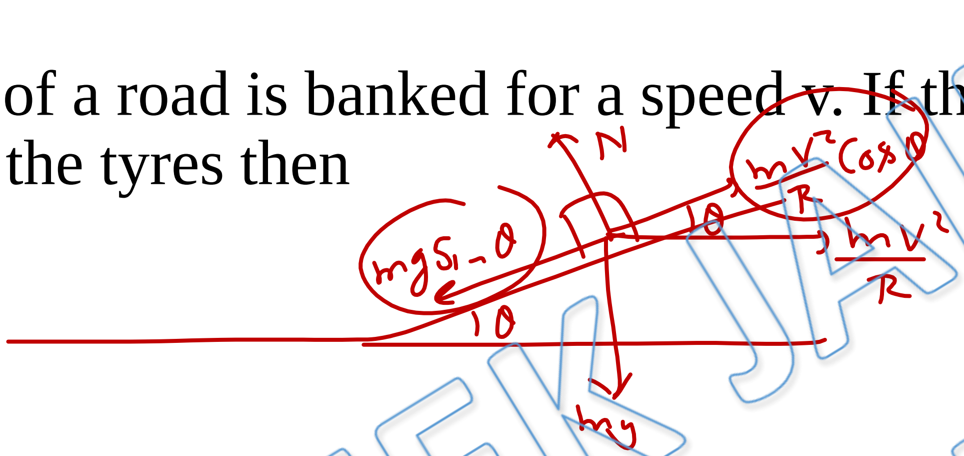
(b) The car will slip if $\mu < \frac{v^2}{rg}$

(c) The car will slip if $r > \frac{v^2}{\mu g}$

(d) The car will slip at a lower speed, along with some acceleration, than if it moves at constant speed.



Q6) A curved section of a road is banked for a speed v. If there is no friction between the road and the tyres then



(a) a car moving with speed v will not slip on the road

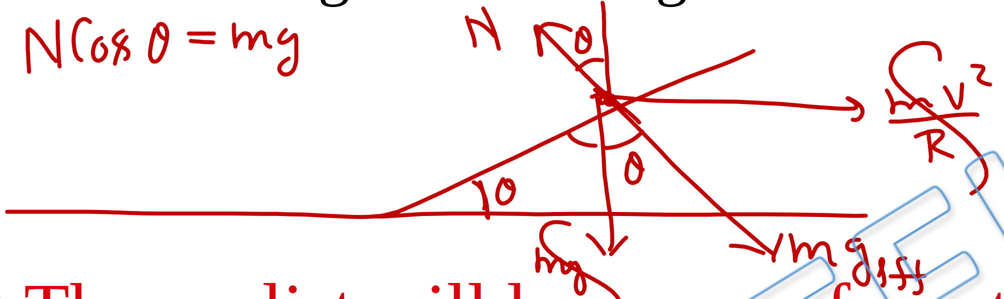
(b) a car is more likely to slip on the road at speeds higher than v, than at speeds lower than v

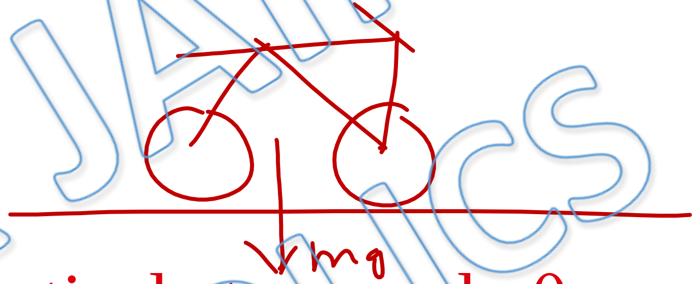
(c) a car is more likely to slip on the road at speeds lower than v, than at speeds higher than v

(d) a car can remain stationary on the road without slipping

Q7) A cyclist moves along a curved road with a velocity v. The road is banked for speed v. The angle of banking is θ. Which of the following statements is **not true**?

$N\cos\theta = mg$





(a) The cyclist will lean away from the vertical at an angle θ.

(b) The normal reaction of the road is greater than weight of cycle plus cyclist system.

(c) There will be no force of friction between the tyres and the road.

(d) The cyclist is in equilibrium with respect to the ground.

Q8) A curved road of 50 m in radius is banked to correct angle for a given speed. If the speed is to be doubled, keeping the same banking angle, the radius of curvature of the road should be changed to

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

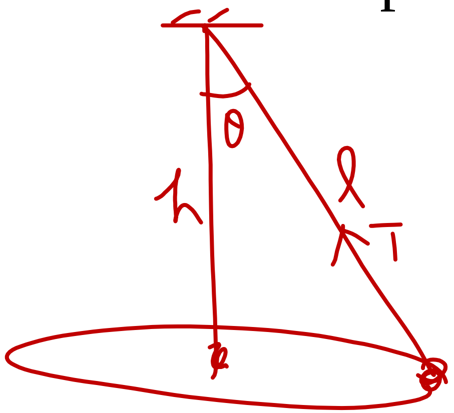
$v^2 \rightarrow$ 4 times

$\tan\theta \rightarrow$ Constant

$$r = \frac{v^2}{g\tan\theta}$$

(a) 100 m (b) 150 m (c) 200 m ✓ (d) 250 m

Q9) A simple pendulum of length *l* is set in motion such that the bob, of mass m, moves along a horizontal circular path, and the string makes a constant angle θ with the vertical. The time period of rotation of the bob is t and the tension in the thread is T.



$$t = 2\pi\sqrt{\frac{h}{g}} = 2\pi\sqrt{\frac{l\cos\theta}{g}}$$

$$T = ml\omega^2 = \frac{ml\,4\pi^2}{t^2}$$

(a) $t = 2\pi\sqrt{l/g}$

(b) $t = 2\pi\sqrt{l\cos\theta/g}$

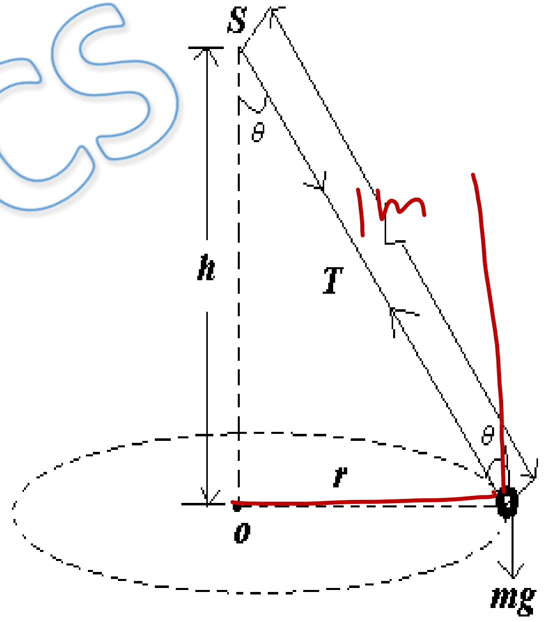
(c) $T = \frac{4\pi^2 ml}{t^2}$

(d) The bob is in equilibrium

Passage

A string of length 1m is fixed at one end and carries a mass of 100g at the other end. The string makes $(2/\pi)$ revolutions per second around vertical axis through the fixed end. As shown in the figure then

$\omega = \frac{2}{\pi}$ rev/sec $= 4$ rad/sec



(Q10) The tension in the string is

(a) 1.0 N
(b) 1.6 N ✓
(c) 6 N
(d) 3 N

$T = ml\omega^2 = .1 \times 1 \times 16 = 1.6\text{N}$

Q11) The angle of inclination of the string with the vertical is

$T\cos\theta = mg$

$16\cos\theta = 1 \times 10$

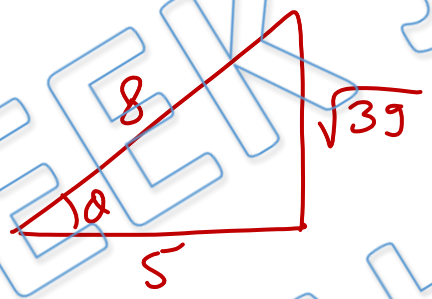
$\cos\theta = 5/8.$

(a) $\cos^{-1}(8/5)$ (b) $\sin^{-1}(5/8)$

(c) $\tan^{-1}(5/8)$ (d) $\cos^{-1}(5/8)$

Q12) The linear velocity of the mass is

$\cos\theta = 5/8$



$V = \omega r$

$= 4 \times 1 \sin\theta$

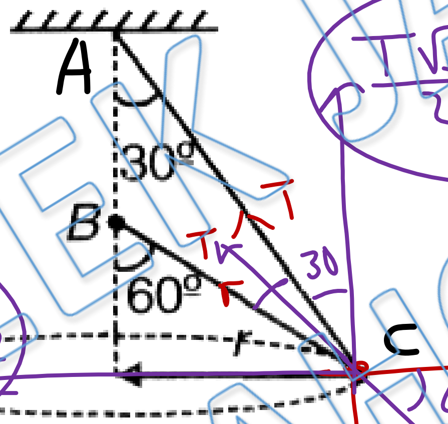
$= \frac{4 \times \sqrt{39}}{8}$

$= \frac{\sqrt{39}}{2}$

(a) 3.12 m/s (b) 6.24m/s

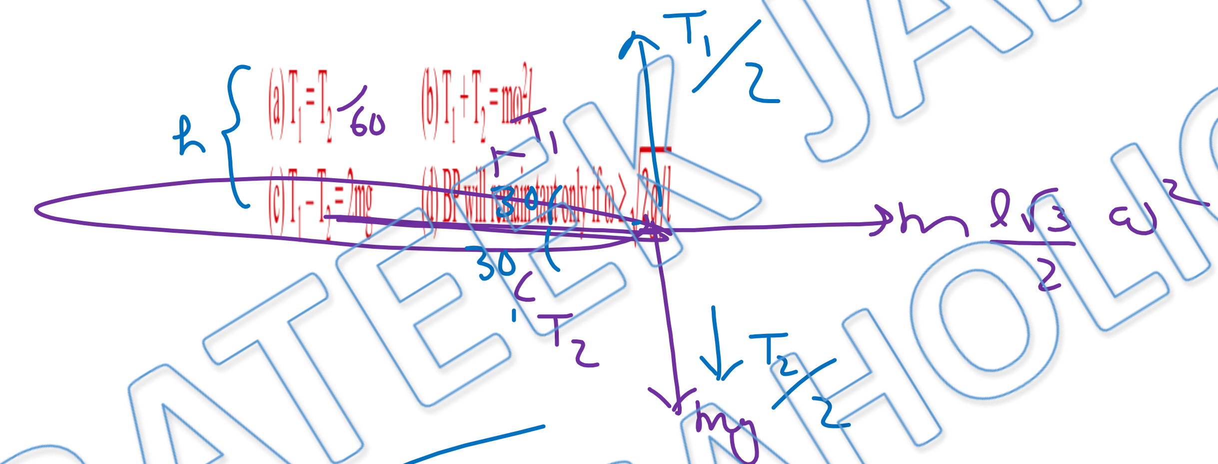
(c) 1.56m/s (d) 12.48m/s

Q13) A single wire ACB passes through a ring C which revolves at a constant speed in the horizontal circle of radius r, as shown in the figure. The speed of revolution is



(a) $\sqrt{rg}$ (b) $\sqrt{2rg}$ (c) $2\sqrt{2rg}$ (d) $2\sqrt{rg}$

Q14) A particle P of mass m is attached to a vertical axis by two strings AP and BP of length l each. The separation AB = l. P rotates around the axis with an angular velocity ω. The tensions in the two strings are T_1 and T_2.



(a) $T_1 = T_2$

(b) $T_1 + T_2 = m\omega^2 l$

(c) $T_1 - T_2 = 2mg$

(d) BP will remain taut only if $\omega \geq \sqrt{2g/l}$

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