Engineering Mechanics Test 2

Number of Questions 35 **Time:60 min.**

Directions for questions 1 to 35: Select the correct alternative from the given choices.

1. Two forces of 500 N and 600 N are acting simultaneously at a point. If the angle between them is 60° then the resultant of these two forces is

(A) 781 N (B) 954 N
(C) 1063 N (D) 881 N

2. A flywheel 400 mm in diameter is brought uniformly from rest to a speed of 240 rpm in 16 seconds. The tangential acceleration of a point on the rim (in m/s^2) is

(A) 1.57 (B) 0.628
(C) 0.314 (D) 0.419

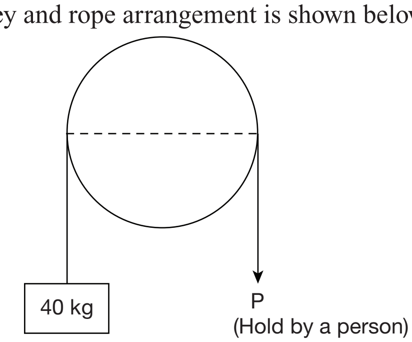
3. A stone of mass 5 kg is tied to a spring of length 2 m and whirled in a horizontal circle at a constant angular speed of 10 rad/sec. The tension in the spring will be

(A) 1000 N (B) 750 N
(C) 500 N (D) 250 N

4. Ratio of moment of inertia of a sphere and that of a cylinder having same radius and mass about their centroidal axis is

(A) $\frac{1}{5}$ (B) $\frac{5}{2}$
(C) $\frac{2}{5}$ (D) $\frac{4}{5}$

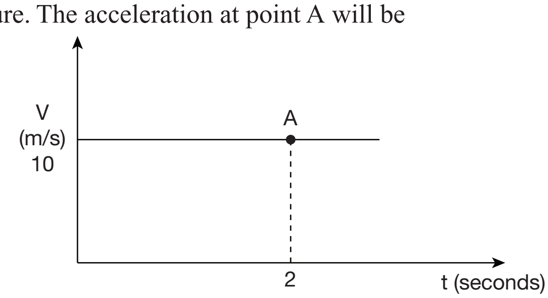
5. A pulley and rope arrangement is shown below



If coefficient of friction between pulley and rope is 0.25 then the holding load by the person will be

(A) 178.91 N (B) 860.64 N
(C) 294.21 N (D) 741.23 N

6. The velocity-time graph of a body is shown in the figure. The acceleration at point A will be



(A) 5 m/s^2 (B) 2.5 m/s^2
(C) 10 m/s^2 (D) Zero

7. If two bodies one light and other heavy have equal kinetic energies and equal mass then which one has a greater momentum?

(A) Heavy body
(B) Light body
(C) Both have equal momentum
(D) None of these

8. A ball of mass 9.81 kg is thrown with an angle α to the horizontal with a velocity of 9.905 m/s. What is the maximum range the ball reaches.

(A) 96.2361 m (B) 9.81 m
(C) 1 m (D) 10 m

9. A rescue airplane flying at a height of 500 m from ground for a flood affected area drops a rescue kit traveling at 200 m/s. How much distance does the airplane travel from the point of releasing the kit to the point of the kit hitting the ground. (Neglect air resistance)

(A) 20.387 km (B) 20.387 m
(C) 2.0192 m (D) 2.019 km

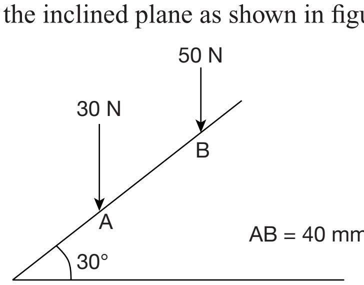
10. A thin solid circular disc of 10 kg is applied by a torque through a shaft connecting at the center of the disc. If the angular velocity reached is 5 rad/sec what is the amount of angular impulse acted upon the circular disc. (take r = 4 m and initially the disc is at rest).

(A) 200 Nms (B) 400 Nms
(C) 500 Nms (D) 1000 Nms

11. The angular speed of the seconds hand in a clock in rad/min is

(A) $\frac{\pi}{30}$ (B) 120 π
(C) 2 π (D) 60 π

12. Determine the point of action of the resultant of forces acting on the inclined plane as shown in figure.



(A) 20 mm from *A* (B) 20 mm from *B*
(C) 25 mm from *A* (D) 25 mm from *B*

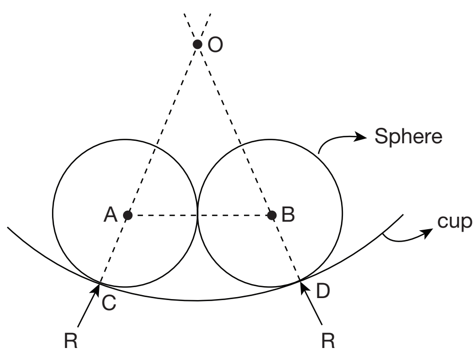
13. A car is moving along a straight road according to the equation $x = 4t^3 + t + 7$, where x is in meters and t is in seconds. What is the average acceleration during the fifth second?

(A) 108 m/s^2 (B) 109 m/s^2
(C) 110 m/s^2 (D) 112 m/s^2

14. The magnitude of the force of friction between two bodies, one lying above the other depends upon the roughness of the
(A) upper body
(B) lower body
(C) both the bodies
(D) the body having more roughness

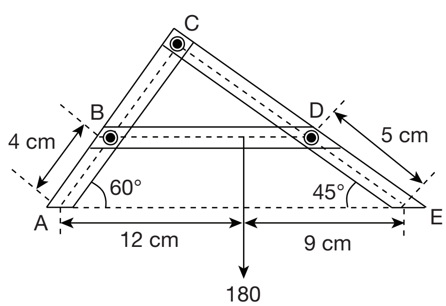
15. If the sum of all the forces acting on a body is zero, then the body may be in equilibrium provided the forces are
(A) Parallel (B) Concurrent
(C) Coplanar (D) Unlike parallel

16. Two sphere of same radius of 100 mm and same mass of 0.5 kg are in equilibrium within a smooth cup of radius 300 mm as shown in the figure. Reaction force between the cup and one sphere will be



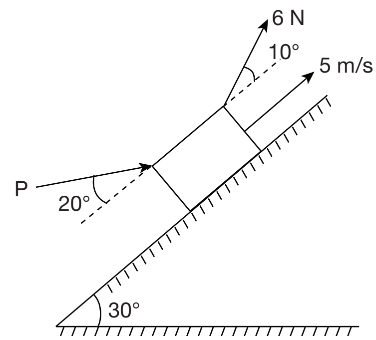
(A) 5.14 N (B) 4.91 N
(C) 6.41 N (D) 5.66 N

17. A *A*-Frame is shown in the given figure. Floor reaction at *A* and vertical pin reaction at *D* are respectively.



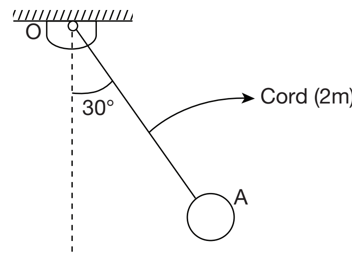
(A) 757 N and 1142 N
(B) 612 N and 1013 N
(C) 757 N and 1241 N
(D) 612 N and 1142 N

18. A block of mass 50 kg is placed on an inclined surface, as shown in the figure. Coefficient of friction between block and surface is 0.3. Find the value of force '*P*' required to be applied on the block to maintain uniform velocity of 5 m/s?



(A) 612 N (B) 574 N
(C) 438 N (D) 451 N

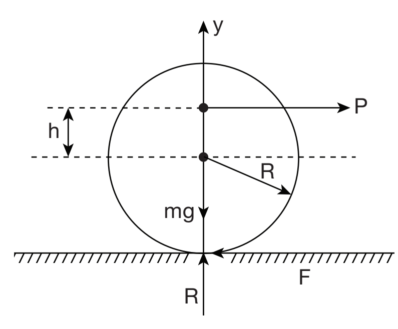
19. Particle *A* of mass '*m*' is tied with 2 m cord at the instant shown in figure. At this instant angular velocity is 2.83 rad/sec. What will be the angular velocity (in rad/sec) when the angle turned by cord is 45°?



(A) 2.54 (B) 2.83
(C) 2.62 (D) 2.93

20. A 200 mm diameter pulley on a generator is being turned by a belt moving with 25 m/s and accelerating with 8 m/s^2. A fan with an outside diameter of 300 mm is attached to the pulley shaft. Linear acceleration of the tip of the fan (in m/s^2) is
(A) 12 (B) 3475
(C) 5671 (D) 9375

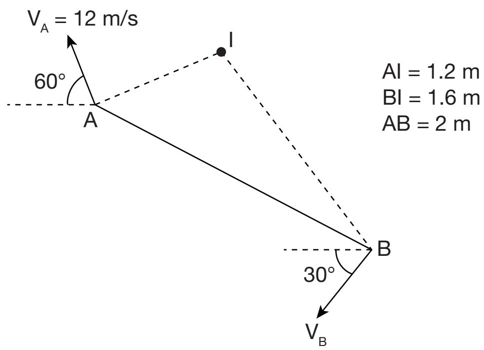
21. A homogenous cylinder of radius '*R*' and mass '*m*' is acted upon by a horizontal force '*P*' applied at various positions along a vertical centre line as shown in the figure. Assume movement upon a horizontal plane. At what radius above the centre (*h*) should the force '*P*' is applied so that the frictional force '*F*' is zero?



(A) R (B) $\frac{R}{3}$

(C) $\frac{R}{2}$ (D) $\frac{R}{4}$

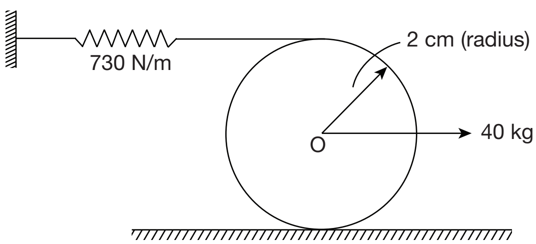
22. Figure shows the line diagram of connecting rod AB of a slider crank mechanism. I is the instantaneous center of rotation of the rod.



Relative velocity of A and B is

(A) 20 m/s (B) 18 m/s
(C) 16 m/s (D) 14 m/s

Statement for linked answer questions 23 and 24:



A 50 kg cylinder of radius 0.4 m rolls without slipping under the action of an 40 kg force. A spring is attached to a cord that is wound around the cylinder. The spring is streched when the 40 kg force is applied.

23. When the cylinder is moved by 0.15 m then the total work done will be

(A) 33 N-m (B) 26 N-m
(C) 92 N-m (D) 59 N-m

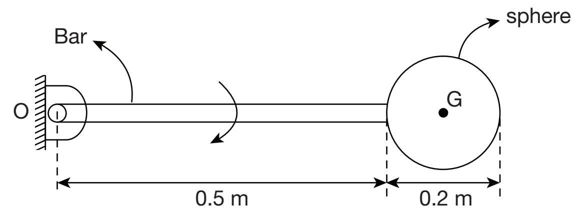
24. What is the speed of the center of the cylinder after it has moved 0.15 m?

(A) 0.613 m/s (B) 0.921 m/s
(C) 0.833 m/s (D) 0.731 m/s

25. A uniform chain of mass 10 kg and length 1 m lies on a smooth table such that one-fourth of its length is hanging vertically down over the edge of the table. Work done to pull the hanging part of the chain on the table is

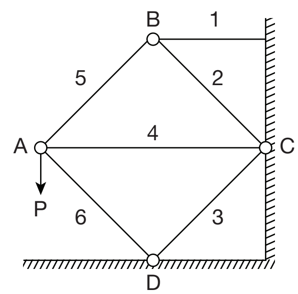
(A) 3.065 J (B) 12.625 J
(C) 24.525 J (D) 6.131 J

26. A homogenous sphere of mass 1 kg is attached to the bar of negligible mass. In the horizontal position shown in the figure, the angular acceleration of the system (in rad/s^2) is



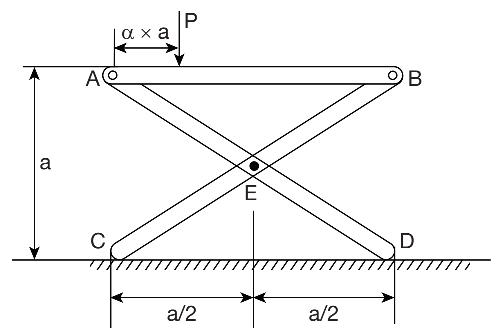
(A) Zero (B) 11.13
(C) 16.17 (D) 19.67

27. $ABCD$ is a square which forms a plane truss with load P at point A. What is the axial force in the bar 1.



(A) 2 P (B) P
(C) 0.707 P (D) 1.414 P

28. A stool rests on a smooth horizontal floor and is loaded with a load P. What is the value of α to have maximum shear force at the point E.



(A) 0 (B) 1
(C) 0 or 1 (D) None of these

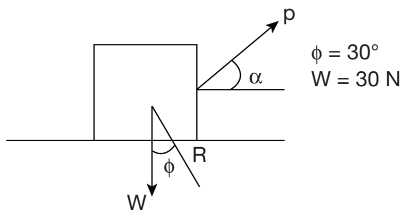
29. A body of mass m is suspended by a string of length L. The body traces a horizontal circle of radius 2 m when the semicone angle at the top is 30°. If the centrifugal force of the non-suspended body of same mass is 23 N while rotating in a circle of radius 4 m with the same angular velocity, what is the tension in the string.

(A) 23 N (B) 11.328 N
(C) 19.91 N (D) 11 N

30. During the replacement of machines in a workshop floor a nail was protruding 5 mm from the floor level. A hammer of 5 kg mass of the head is used to strike the nail to make it level with the floor. Consider the hammer as a free fall from a height of 100 mm and completes the job in single strike. What is the mass of the nail if the resistance offered by the floor is 1.032 N/mm

(A) 45.87 gms (B) 98.77 gms
(C) 198.77 gms (D) 99.385 gms

Common data for questions 31 and 32:



A block of 30 N weight is being pulled by a force P making an angle α with the horizontal. The reactive force R makes an angle of 30° with the vertical (angle of friction, φ).

31. What is the minimum force P_{min} required to impede the block to move

(A) $15\sqrt{3}$ N (B) 30 N
(C) 45 N (D) 15 N

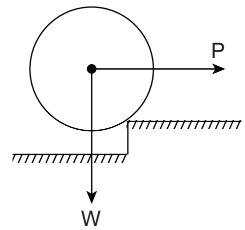
32. What is the value of α interms of the angle of friction when P_{min} is acting on the block.

(A) 2 φ (B) φ/2
(C) φ (D) 90 – φ

33. Two balls of weights 6 N and 2 N are made to collide with each other. The velocities of the balls before collision are 4 m/s and 8 m/s respectively and the 2 N ball is moving in opposite direction to 6 N ball. What is the ratio of velocities of the 6 N ball, after the collision, when the impact is considered to have a coefficient of restitution of 0.5 to when the impact is perfectly elastic.

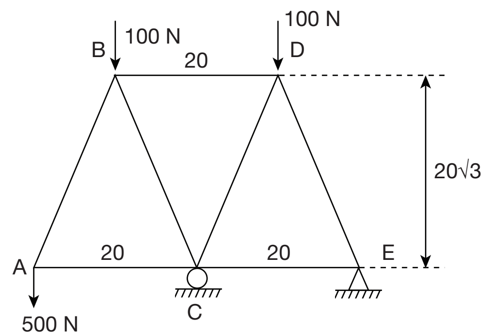
(A) 1 (B) 0.25
(C) 0.5 (D) 0.75

34. The wheel of a trolley bag which is being pulled by a force of 10 N (horizontal force) is of 50 mm radius. If the weight of the bag is 100 N what is the coefficient of rolling resistance in meters



(A) 0.1 (B) 0.005
(C) 0.5 (D) 0.001

35. A plane truss is loaded as shown in the figure. What is magnitude of force in the member CD and is it in compression or tension



(A) 692.82 N, compression
(B) 692.82 N, Tension
(C) 1385.64 N, Compression
(D) 1385.64 N, Tension

Answer Keys

1. B	**2.** C	**3.** D	**4.** D	**5.** B	**6.** D	**7.** C	**8.** D	**9.** D	**10.** A
11. C	**12.** C	**13.** A	**14.** C	**15.** B	**16.** D	**17.** A	**18.** C	**19.** A	**20.** D
21. C	**22.** A	**23.** B	**24.** C	**25.** A	**26.** C	**27.** B	**28.** C	**29.** A	**30.** C
31. D	**32.** C	**33.** B	**34.** B	**35.** B					

Hints and Explanations

1. Resultant force, $R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos\theta}$

or $R = \sqrt{500^2 + 600^2 + 2 \times 500 \times 600 \times \cos 60^o}$

$R = 953.94$ N ~ 954 N Choice (B)

2. Angular acceleration, $\alpha = \dfrac{\omega - \omega_o}{t}$

or $\alpha = \dfrac{\left(\dfrac{2\pi \times 240}{60}\right) - 0}{16} = 1.57\ \text{rad}/\text{sec}^2$

now Tangential acceleration, $a_t = r \times \alpha$
$= 0.2 \times 1.57 = 0.314$ m/s² Choice (C)

3. $F = \dfrac{m\omega^2}{r} = \dfrac{5 \times 10^2}{2}$

$\Rightarrow$ $F = 250$ N Choice (D)

4. For sphere, $I_{GS} = \dfrac{2}{5} mR^2$

For cylinder, $I_{GC} = \dfrac{mR^2}{2}$

$$\therefore \frac{I_{GS}}{I_{GC}} = \frac{\frac{2}{5}mR^2}{\frac{mR^2}{2}} = \frac{4}{5}$$ Choice (D)

5. $\frac{P}{(40 \times 9.81)} = e^{0.25 \times \pi}$

$\therefore$ $P = 860.64$ N   Choice (B)

6. acceleration $= \frac{dV}{dt}$

$\therefore$ Velocity is constant

$\therefore$ acceleration = 0   Choice (D)

7. $\left[\frac{1}{2}mV^2\right]_H = \left[\frac{1}{2}mV^2\right]_L$

$V_H = V_L$

Now momentum = $m \times V$

$\therefore$ Both has same mass and velocities

$\therefore$ Momentum is same for both.

Choice (C)

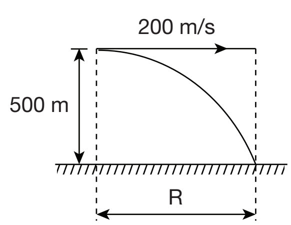
8. Range of a projectile is given as $\frac{V_0^2}{g}\text{Sin}2\alpha$

It is maximum when $\alpha = 45^\circ$

$$\therefore R\text{max} = \frac{V_0^2}{g} = \frac{9.905^2}{9.81} = \frac{98.109025}{9.81}$$

$R_{max} = 10.00091 \simeq 10$ m   Choice (D)

9.



Time taken for the kit to reach ground $= \sqrt{\frac{2 \times 500}{9.81}}$ = 10.096 sec

Distance travelled by air plane in the time = 200 × 10.096 = 2019.2 m

= 2.0192 km   Choice (D)

10. Angular impulse = $I(\omega_2 - \omega_1)$

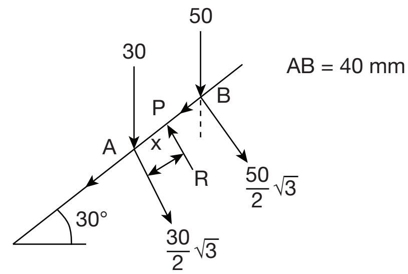
$$I = \frac{mr^2}{2} = \frac{10 \times 4^2}{2} = 40 \text{ kg m}^2$$

Angular Impulse = 40 × (5 – 0) = 200 Nms Choice (A)

11. A seconds hand rotates 2π radians in 60 seconds i.e., in 1 minute.

$\therefore$ $\omega_{sec} = \frac{2\pi}{60} \text{ rad/sec} = 2\pi \text{ rad/min}$ Choice (C)

12.



Let the point P be the point of action of the resultant Taking moments around P.

$\Sigma M_P = 0$

$$\left(\frac{30}{2}\sqrt{3} \times x\right) - \frac{50}{2}\sqrt{3} \times (40 - x) = 0$$

$$\Rightarrow \frac{30}{2}\sqrt{3}x = \frac{50}{2}\sqrt{3}(40 - x) \Rightarrow 80x = 200 \Rightarrow x = 25 \text{ mm}$$

Choice (C)

13. $V = \frac{dx}{dt} = 12t^2 + 1$

$a = \frac{dV}{dt} = 24t$

$\therefore$ change in acceleration during 5th second is

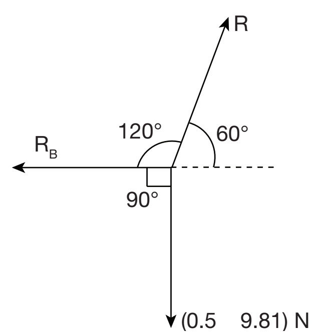
$$a = \frac{\Delta V}{\Delta t} = \frac{V_5 - V_4}{1} = \frac{[(12 \times 25) + 1] - [(12 \times 16) + 1]}{1}$$

$a = 108$ m/s^2 Choice (A)

14. Choice (C)

15. Choice (B)

16. Free body diagram of sphere A



From geometry:

OC = 300 mm, OA = 200 mm, OB = 200 mm,

AB = 200 mm

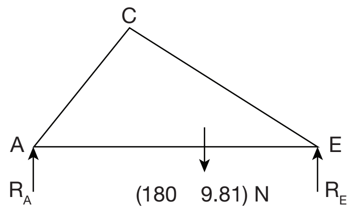
$\therefore$ ΔOAB is equilateral triangle.

$\therefore$ Applying Lami's theorem

$$\frac{R}{\text{Sin}\,90^\circ} = \frac{(0.5 \times 9.81)}{\text{Sin}(120^\circ)}$$

$\Rightarrow$ $R = 5.6638$ N   Choice (D)

17.

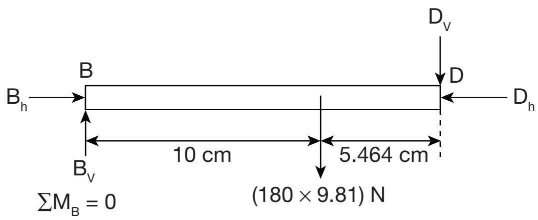


Free Diagram of ACE:

$\Sigma M_E = 0 \Rightarrow R_A \times 0.21 - 1765.8 \times 0.09 = 0$

$\Rightarrow \quad R_A = 756.77$ N ~ 757 N

Free body diagram of BD:

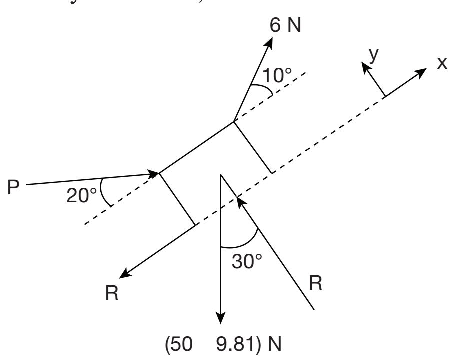


$\Sigma M_B = 0$

$\Rightarrow \quad D_V \times (10 + 5.464) + (180 \times 9.81 \times 10) = 0$

or $D_V = 1142$ N Choice (A)

18. Since velocity is uniform, therefore acceleration is zero.



$\Sigma F_x = ma_x \Rightarrow \Sigma F_x = 0 \quad \{\because a_x = 0\}$ and $\Sigma F_y = 0$

$+ 6 \text{ Cos } 10^\circ + P \text{ Cos} 20^\circ - \mu R - (50 \times 9.81 \times \text{Sin } 30^\circ) = 0$

or $P \text{ Cos} 20^\circ - 0.3 R = 239.341 \rightarrow (1)$

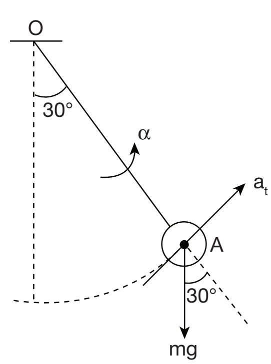
and $6 \text{ Sin} 10^\circ + R - P \text{ Sin} 20^\circ - (50 \times 9.81 \times \text{Cos} 30^\circ) = 0$

or $P \text{ Sin} 20^\circ - R = -423.743 \rightarrow (2)$

From equation (1) and (2) we get, $P = 437.785$ N and $R = 573.474$ N

$\therefore \quad P = 437.785$ N ~ 438 N Choice (C)

19.



$\Sigma F_t = -mg \text{ Sin } 30^\circ$

or $m(a_t) = -mg \text{ Sin } \theta$

$\Rightarrow \quad m(\alpha \times OA) = -mg \text{ Sin } \theta$

$$\Rightarrow \quad \alpha = \frac{-g}{OA} \text{Sin}\,\theta$$

$$\text{Now } \alpha = \frac{d\omega}{dt} = \frac{d\omega}{dt} \times \frac{d\theta}{d\theta} = \omega \frac{d\omega}{d\theta}$$

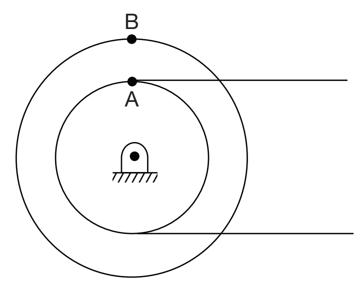
$$\text{or} \quad \omega \frac{d\omega}{d\theta} = \frac{-g}{OA} \text{Sin}\,\theta$$

$$\Rightarrow \int_{2.83}^{\omega} \omega d\omega = \frac{-g}{OA} \int_{30^\circ}^{45^\circ} \text{Sin}\,\theta\, d\theta$$

$$\frac{1}{2}\left[\omega^2 - 2.83^2\right] = +\frac{9.81}{2}\left[\text{Co}45^\circ - \text{Cos}30^\circ\right]$$

$\omega = 2.54$ rad/sec Choice (A)

20.



Tangential component of the linear acceleration of point A

$(a_t)_A = r_A\, \alpha \Rightarrow 8 = (0.1) \times \alpha$

or $\alpha = 80$ rad/sec^2

Angular acceleration of the system, $\alpha = 80$ rad/sec

Now $(a_t)_B = \alpha \times r_B = 80 \times 0.15 = 12$ m/s^2

$$\text{Now } \omega_A = \frac{V_A}{r_A} = \frac{25}{0.1} = 250 \text{ rad/s}$$

Now $\omega_A = \omega_B = 250$ rad/s

Normal component of $B = r\,\omega^2$

$= 0.15 \times 250^2$

$= 9375$ m/s^2

Magnitude of the linear acceleration, $a = \sqrt{9375^2 + 12^2}$

$= 9375$ m/s^2 Choice (D)

21. $\Sigma F_x = P - F = ma_x$ --------- (1)

$\Sigma F_y = R - mg = 0$

Taking moments about R $\Sigma M = P \times h + F \times R = I\alpha$

$$\text{or } P \times h + F \times R = \frac{1}{2} mR^2\, \alpha$$

$$\Rightarrow \quad P \times h + F \times R = \frac{1}{2} mRa_x \; \{\because a_x = R \times \alpha\}$$

Dividing the above equation with $R/2$ we get

$$\frac{2Ph}{R} + 2F = ma_x \qquad \text{------- (2)}$$

Equating right side of equation (1) and (2) we get

$$\frac{2Ph}{R}+2F=P-F$$

$$\text{or } 3F=P\left[1-\frac{2h}{R}\right]$$

$$F=0 \text{ when } 1-\frac{2h}{R}=0 \text{ or } h=\frac{R}{2}$$ Choice (C)

22. I is the centre of rotation of rod AB.

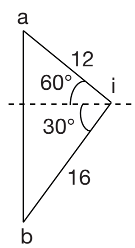
∴ $V_A = V_{AO} = 12$ m/s $= V_{AI}$

∴ $\omega_{AB} \times AI = 12 \Rightarrow \omega_{AB} \times 1.2 = 12$

⇒ $\omega_{AB} \times 10$ rad/sec

∴ $V_B = \omega_{AB} \times BI = 10 \times 1.6 = 16$ m/s

Velocity diagram:



$$\therefore \vec{ab}=\sqrt{12^2+16^2}=20 \text{ m/s}$$ Choice (A)

23. Since the cylinder rolls without slipping, the spring becomes stretched (0.15 × 2) m when the center of the cylinder moves 0.15 m to the right. The work is

$$U=-\frac{1}{2}k\left(x_2^2-x_1^2\right)+\left(F\times s\right)$$

$$=\frac{-1}{2}\times730\times\left[0.3^2-0\right]+\left[40\times9.81\times0.15\right]$$

= 26.01 N-m Choice (B)

24. Initial kinetic energy is zero. Hence the change in kinetic energy,

$$\Delta KE = KE_2 - KE_1 = \frac{1}{2}mv^2+\frac{1}{2}I_o\omega^2$$

$$\Rightarrow \Delta KE=\frac{1}{2}\times50\times v^2+\frac{1}{2}\left[\frac{mr^2}{2}\right]\omega^2$$

$$\Rightarrow \Delta K.E=\frac{1}{2}\times50\times v^2+\frac{50\times0.4^2}{4}\times\left(\frac{v}{0.4}\right)^2$$

Now $U = K.E_2 - K.E_1$

$$\therefore \quad 26.01=\frac{50v^2}{2}+\frac{50}{4}v^2$$

⇒ $v = 0.833$ m/s Choice (C)

25. Weight of the hanging part of the chain $=\frac{\text{mg}}{4}$

$$=\frac{10\times9.81}{4}\text{ N} = 24.525 \text{ N} = \text{Maximum weight to be lifted.}$$

When the entire hanging portion has been pulled, the weight to be lifted equals zero.

∴ Average weight to be pulled $=\frac{1}{2}$ [24.525 + 0]

= 12.2625 N

Work done = Average force × distance moved

$= 12.2625 \times \frac{1}{4} = 3.065$ N-m or J Choice (A)

26. $\Sigma M_{hinge} = I_o \times \alpha$

$$[mg\times(0.5+0.1)]=\left[\frac{2}{5}mR^2+m(OG)^2\right]\times\alpha$$

$$\therefore \quad 0.6\times9.81=\left[\frac{2}{5}\times0.1^2+0.6^2\right]\times\alpha$$

⇒ $\alpha = 16.17$ rad/sec² Choice (C)

27. By the method of joints for equilibrium at point A.

$\Sigma X = \Sigma Y = 0$

$\Sigma X = S_4 + S_5 \text{ Cos}45 + S_6 \text{ Cos}45 = 0$

$\Sigma Y = -P + S_5 \text{ Sin}45 - S_6 \text{ Sin}45 = 0$

At point D

$\Sigma X = -S_6 \text{ Cos}45 + S_3 \text{ Cos}45 = 0 \Rightarrow \quad S_6 = S_3$

$\Sigma Y = S_6 \text{ Sin}45 + S_3 \text{ Sin}45 - R_D = 0$

At point C

$\Sigma X = -S_4 - S_2 \text{ Cos}45 - S_3 \text{ Cos}45 = 0$

$\Sigma Y = S_2 \text{ Sin}45 - S_3 \text{ Sin}45 = 0 \Rightarrow \quad S_2 = S_3$

∴ $S_2 = S_3 = S_6$

At point B

$\Sigma X = S_1 - S_5 \text{ Cos}45 + S_2 \text{ Cos}45 = 0$

$\Sigma Y = -S_5 \text{ Sin}45 - S_2 \text{ Sin}45 = 0 \Rightarrow \quad S_5 = \quad S_2$

∴ $S_2 = S_3 = -S_5 = S_6$

From ΣY equation at point A

$P = S_5 \text{ Sin}45 - S_6 \text{ Sin}45 = 2S_5 \text{ Sin}45 = 1.414\, S_5$

From ΣX equation at point B

$S_1 = S_5 \text{ Cos}45 - S_2 \text{ Cos}45 = 2S_5 \text{ Cos}45 = 1.414\, S_5 = P$

∴ $S_1 = P$ Choice (B)

28. As the floor is smooth, there are only vertical reactions at C and D

Taking moments at C

$R_D.a - (\alpha a).P = 0$

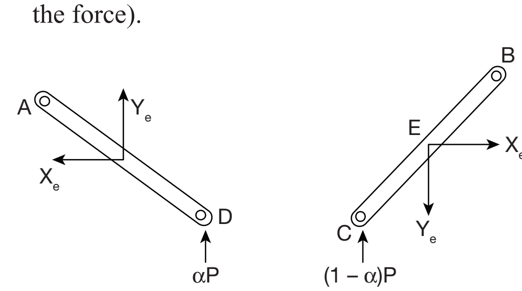
⇒ $R_D = \alpha P$.

Taking moments at D

$R_C.a + (a - \alpha a)P = 0$

⇒ $R_C = (1 - \alpha)P$

Taking separate free body diagrams for the legs AD and BC we get (Taking the reactions instead of the force).



For the bar AD

Taking moments around A

$(\alpha P)a + Y_e(a/2) - X_e(a/2) = 0 \qquad \rightarrow (1)$

Moments around B

$-a.(1-\alpha)P + Y_e(a/2) + X_e(a/2) = 0 \qquad \rightarrow (2)$

Adding (1) and (2)

$\alpha P - (1-\alpha)P + Y_e = 0$

$\Rightarrow \quad Y_e = (1 - 2\alpha)P$

$\Rightarrow \quad X_e = P$

$\therefore$ The resultant on point E is

$$R_e = \sqrt{X_e^2 + Y_e^2} = \sqrt{P^2 + (1-2\alpha)^2 P^2}$$

$$R_e = P\sqrt{1 + (1-2\alpha)^2}$$

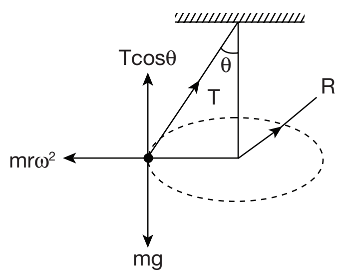
α has the range 0 to 1

$\therefore$ maximum value for R_e is at

When $\alpha = 0$, $R_e = P\sqrt{2}$ and

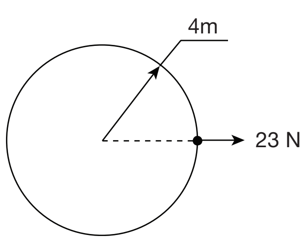
$\alpha = 1$, $R_e = P\sqrt{2}$ Choice (C)

29.



$T \cos\theta = mg$ and $T \sin\theta = mr\,\omega^2$

$$\Rightarrow \tan\theta = \frac{r\omega^2}{g} \Rightarrow \omega = \sqrt{\frac{\tan 30 \times 9.81}{2}} = 1.683 \text{ rad/sec}$$



$\therefore \quad mr_1\,\omega^2 = 23\ N$, $r_1 = 4$ m

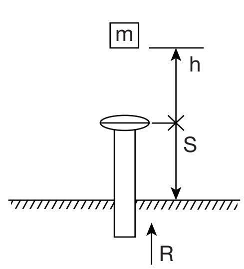
$\therefore \quad m \times 4 \times 1.683^2 = 23$

$m = 2.03$ kg

$$\therefore \quad T\cos\theta = mg \Rightarrow T = \frac{mg}{\cos\theta} = \frac{2.03 \times 9.81}{\cos 30} = 23 \text{ N}$$

Choice (A)

30.



$m = 5$ kg, $h = 100$ mm $= 0.1$ m: $S = 5$ mm $= 5 \times 10^{-3}$ m

$R = 0.54$ N/mm

Energy required to push the nail into the floor $= R \times S$

$= 1.032 \times 5 = 5.16$ N

Energy offered by hammer $= (KE)_{\text{impact}} + (PE)_{\text{penetration}}$

KE during impact $= \frac{1}{2}mv^2$ where $v = \sqrt{2gh}$

PE during penetration $= (M + m)gS$, where M is the mass of the nail

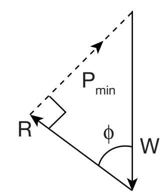
$$5.16 = \frac{1}{2}\text{m}\,(2gh) + (M + m)gS$$

$$5.16 = \left(\frac{1}{2} \times 5 \times 2 \times 9.81 \times 0.1\right) + (5 \times 9.81 \times 0.005) + (M \times 9.81 \times 0.005)$$

$\Rightarrow \quad M = 198.77$ gms Choice (C)

31. $W = 30\ N$, $\phi = 30°$

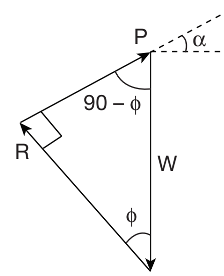
By drawing the vector diagram for the forces taking the weight of the block W vertically and the reactive force making an angle of $\phi = 30°$ with the vertical we get



The minimum distance to complete the triangle is the perpendicular from the head of R to the tail of W.

$\therefore \quad P_{\min} = W \sin\varphi = 30 \sin 30 = 15$ N Choice (D)

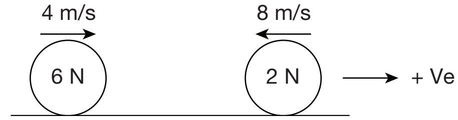
32.



Considering the vectors P and W

$(90 - \phi) + 90 + \alpha = 180° \Rightarrow \alpha = \phi$ Choice (C)

33.



$e = 0.5 = \frac{v_1 - v_2}{u_2 - u_1}$ here v_1, u_1 are for 6 N ball and v_2, u_2 are for 2 N ball.

$\Rightarrow \quad v_1 - v_2 = 0.5 \times (-8 - 4) = -6$ m/s

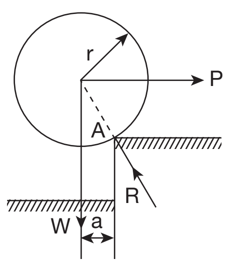
$\Rightarrow \quad v_1 - v_2 = -6 \Rightarrow v_2 = v_1 + 6$

by conservation of momentum

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$
$6 \times 4 + 2 \times (-8) = 6v_1 + 2v_2$
$8 = 6v_1 + 2(6 + v_1)$
$-4 = 8v_1$
$\Rightarrow$ $v_1 = -0.5$ m/s (for e = 0.5)
When the impact is elastic $e = 1$
$\Rightarrow$ $v_1 - v_2 = -12$
$v_2 = v_1 + 12$
From momentum equation, $8 = 6v_1 + 2v_2$
$8 = 6v_1 + 2(v_1 + 12)$
$-16 = 8v_1$
$v_1 = \frac{-16}{8} = -2$ m/s (for $e = 1$)

$\therefore$ $(v_1)_{e=0.5} : (v_1)_{e=1} = \frac{-0.5}{-2} = 0.25$ Choice (B)

34.

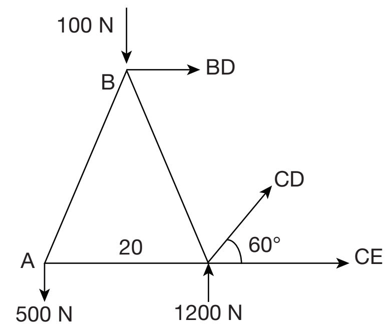


By applying summation of moments about point A
$\Sigma MA = 0 \Rightarrow W \times a - P \times r = 0 \Rightarrow W \times a = P \times r$
here, $W = 100$ N, $r = 0.05$ m, $P = 10$ N

$$\Rightarrow a = \frac{Pr}{W} = \frac{10 \times 0.05}{100} = 0.005\,\text{m}$$

$a = 5$ mm $= 0.005$ m
The distance a is called the coefficient of rolling resistance. Choice (B)

35. By figure, the shapes are equilateral triangles.
By considering moments around E at equilibrium
$\Sigma M_E = 0 \Rightarrow (500 \times 40) + (100 \times 30) - (R_C \times 20) + (100 \times 10) = 0$
$\Rightarrow R_C = 1200$ N
By section method, considering the section ABC.



By taking the vertical forces.
$\Sigma Y = 0 \Rightarrow 1200 - 500 - 100 + CD\ \text{Sin}60 = 0$
$\Rightarrow$ $CD = 692.82$ N
As the value of CD is positive the member is in Tension as per the initial assumption. Choice (B)