ENGINEERING MECHANICS TEST 1

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

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

1. A body is moving in a curved path with speed of 10 m/s and tangential acceleration of 3 m/s^2. If radius of curvature be 25 m, the total acceleration of body in m/s^2 is
(A) 3 (B) 4
(C) 5 (D) 6

2. A stone of mass m at the end of a string of length '↓' is whirled in a vertical circle at a constant speed. The tension in the string will be maximum when the stone is
(A) at the top of the circle
(B) half way down from the top
(C) quarter – way down from the top
(D) at the bottom of the circle

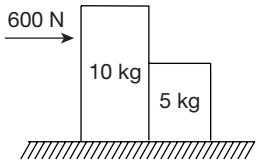
3. For maximum range of a projectile, the angle of projection should be
(A) 30° (B) 45°
(C) 60° (D) 90°

4. The resultant of two forces P and Q inclined at angle θ will be inclined at following angle with respect to P.
(A) $\tan^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$ (B) $\tan^{-1}\left(\frac{Q\cos\theta}{Q+P\sin\theta}\right)$
(C) $\tan^{-1}\left(\frac{P\sin\theta}{Q+P\cos\theta}\right)$ (D) $\text{Tan}^{-1}\left(\frac{P\cos\theta}{Q+P\sin\theta}\right)$

5. If n = number of members and j = number of joints, then for a perfect frame n =
(A) $j-2$ (B) $2j-1$
(C) $2j-3$ (D) $3j-2$

6. A body of mass 15 kg moving with velocity of 2 m/s is acted upon by a force of 75 N for two seconds. The final velocity will be
(A) 10 m/s (B) 11 m/s
(C) 12 m/s (D) 15 m/s

7. Two blocks with masses 10 kg and 5 kg are in contact with each other and are resting on a horizontal frictionless floor as shown in figure. When horizontal force 600 N is applied to the heavier, the blocks accelerate to the right. The force between the two blocks is



(A) 300 N (B) 200 N
(C) 100 N (D) 50 N

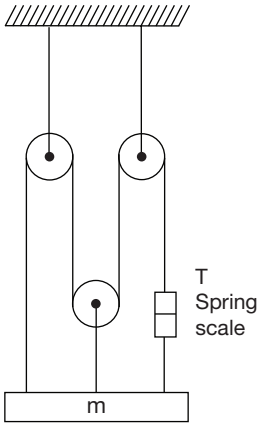
8. Two particles with masses in the ratio 1 : 9 are moving with equal kinetic energies. The magnitude of their linear momentums will conform to the ratio.
(A) 1 : 3 (B) 1 : 9
(C) $\sqrt{3}$: 1 (D) 3 : 1

9. Match List – I with List – II

	List – I		List – II
P.	Collision of particles	1.	Euler's equation of motion
Q.	Stability	2.	Minimum kinetic energy
R.	Satellite motion	3.	Minimum potential energy
S.	Spinning top	4.	Impulse momentum principle

	P	Q	R	S
(A)	1,	2,	3,	4
(B)	4,	2,	1,	3
(C)	3,	1,	4,	2
(D)	4,	3,	2,	1

10. A spring scale indicates a tension to 10 N in the right hand cable of the pulley system shown in the figure. Neglecting the mass of the pulleys, ignoring friction between the cable and pulley the mass m is (Take g = 10 m/s^2)



(A) 10 kg (B) 40 kg
(C) 1 kg (D) 4 kg

11. Two bodies of mass m_1 and m_2 are dropped from different heights h_1 and h_2 respectively. Neglecting the effect of friction, the ratio of time taken to drop though the given heights would be
(A) $\frac{m_1}{m_2}$ (B) $\left(\frac{h_1}{h_2}\right)^{1/2}$
(C) $\left(\frac{h_1}{h_2}\right)^{2}$ (D) $\left(\frac{h_2}{h_1}\right)^{1/2}$

12. A sphere '*M*' impinges directly on to another identical sphere '*N*' at rest. If the co–efficient of restitution is 0.5, the ratio of velocities $\frac{V_N}{V_M}$ after the impact would be

(A) 1 : 3 (B) 3 : 1
(C) 1 : 2 (D) 2 : 1

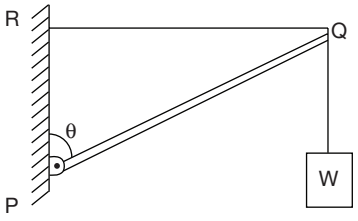
13. A block of steel is loaded by a tangential force on its top surface while the bottom surface is held rigidly. The deformation of the block is due to

(A) Shear only (B) Torsion only
(C) Bending only (D) Shear and bending

14. The co-efficient of friction depends on

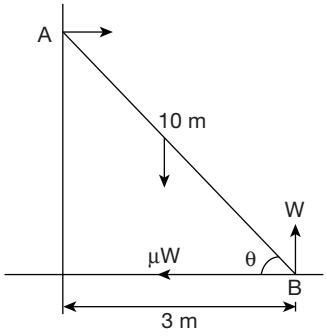
(A) Nature of the surface (B) Area of contact
(C) Strength of surface (D) All of the above

15. The force induced in member *PQ* due to load *W* in figure will be



(A) $W \sec\theta$ (B) $W \cos\theta$
(C) $W \tan\theta$ (D) $W \operatorname{cosec}\theta$

16. A 10 m long ladder is placed against a smooth vertical wall with its lower end 3 m from the wall. For ladder to remain in equilibrium as shown in figure, what should be the co-efficient of friction between ladder and floor?

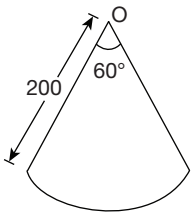


(A) 0.16 (B) 0.25
(C) 0.36 (D) 0.45

17. Three forces acting on a particle in equilibrium are $2P$ and $\sqrt{3}\,P$. Angle between $2P$ and P is 120°. What will be angle between P and $\sqrt{3}\,P$.

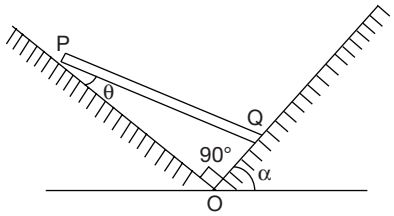
(A) 45° (B) 60°
(C) 90° (D) 135°

18. A plane lamina of 200 mm radius is shown in figure given below. The centre of gravity of lamina from the point *O*



(A) 150 mm (B) 140 mm
(C) 128 mm (D) 108 mm

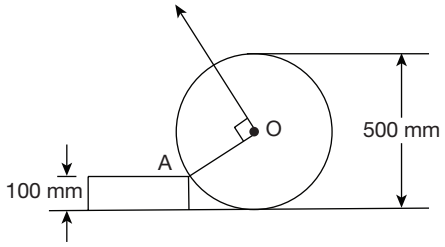
19. A uniform rod *PQ* remains in equilibrium position resting on a smooth inclined plances *PO* and *QO* which are at an angle of 90° as shown in figure.



If the plane *QO* makes angles of α with the horizontal, then what is the inclination θ of the rod *PQ* with the plane *PO*

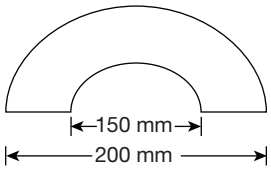
(A) equal to α (B) less than α
(C) greater than α (D) equal to 90°

20. A uniform wheel of 500 mm diameter, weighing 5 kN rests against a rigid rectangular block of 100 mm height as shown in figure. The least pull, through the centre of the wheel, required just to turn the wheel over the corner *A* of the block is



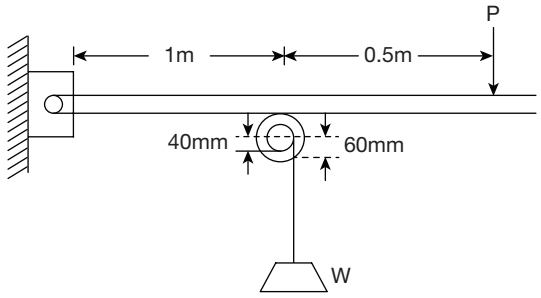
(A) 2 kN (B) 3 kN
(C) 4 kN (D) 5 kN

21. A hollow semicircular section has it outer and inner diameter of 200 mm and 150 mm respectively shown in figure. The moment of inertia about the base *AB* in mm^4 is



(A) 5×10^6 (B) 10×10^6
(C) 17×10^6 (D) 27×10^6

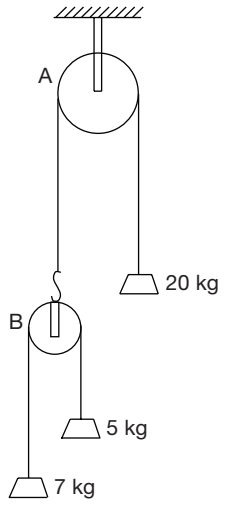
22. What is the maximum load (W) which a force P equal to 6 kN will hold up, if the co–efficient of friction at C is 0.2 in the arrangement shown in figure, neglect other friction and weight of the member?



(A) 2.7 kN (B) 3.5 kN
(C) 4.0 kN (D) 5.0 kN

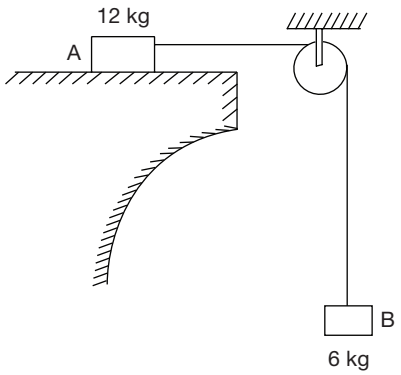
23. A load of 3 kN is to be raised by a screw jack with mean diameter of 60 mm and pitch of 10 mm. The co–efficient of friction between the screw and nut is 0.075. The efficiency of screw jack is
(A) 38.54% (B) 41.24%
(C) 42.25% (D) 44.15%

24. A system of masses connected by string, passing over pulley A and B is shown in figure.



The acceleration of mass 20 kg is
(A) 2.45 m/s^2 (B) 2.01 m/s^2
(C) 1.89 m/s^2 (D) 1.255 m/s^2

25. A solid body A of mass 12 kg, when it is being pulled by another body B of mass 6 kg along a smooth horizontal plane as shown in figure. The tension in the string is (Take $g = 9.8$ m/s^2)



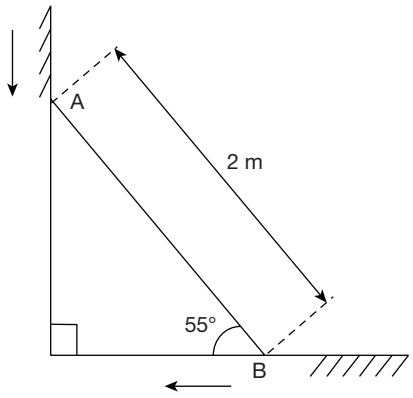
(A) 39.2 N (B) 25.0 N
(C) 12.5 N (D) 6 N

26. A simple pendulum consists of a 500 mm long chord and a bob of mass 2 kg is suspended inside a train, accelerating smoothly on a level track at the rate of 3.2 m/s^2. Find the angle which the chord will make with the vertical.
(A) 12° (B) 14°
(C) 16° (D) 18°

27. A body of mass 0.6 kg oscillates about an axis at a distance 300 mm from the centre of gravity. If the mass moments of inertia about the centroidal axis, parallel to the axis of rotation, be 0.125 kg-m^2, the length of the equivalent simple pendulum is.
(A) 0.6 m (B) 0.8 m
(C) 0.9 m (D) 1.0 m

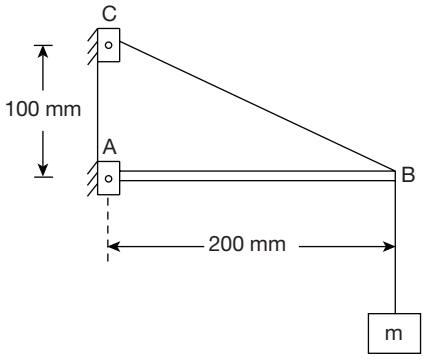
28. A conical pendulum 2 m long is revolving at 35 revolutions per minute. Find the angle which the string will make with the vertical, if the bob describes a circle of 500 mm radius.
(A) 15.2° (B) 29.8°
(C) 32.5° (D) 35°

29. A rod of length 2 m is sliding in a corner, as shown in figure. At an instant when the rod makes an angle of 55 degrees with the horizontal plane, the angular velocity of the rod is 5 rad/s. The velocity of the rod at point B is



(A) 1.50 m/s (B) 2.50 m/s
(C) 5.01 m/s (D) 8.19 m/s

30. A mass 40 kg is suspended from a weightless bar *AB* which is supported by a cable *CB* and a point at *A*, as shown in figure. The tension in the cable is

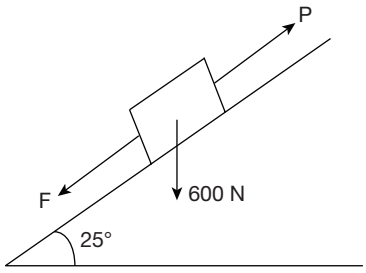


(A) 876.5 N (B) 755.5 N
(C) 654.5 N (D) 500 N

31. An elevator weighting 1000 kg attains an upward velocity of 4 m/sec in two sec with uniform acceleration. The tension in the supporting cables will be
(A) 2000 kg (B) 1200 kg
(C) 1000 kg (D) 800 kg

Common Data for Questions 32 and 33:

A body of weight 600 N is lying on a rough plane inclined at an angle of 25° with the horizontal. It is supported by an effort (*P*) parallel to the plane as shown in figure. The angle of friction is 20°



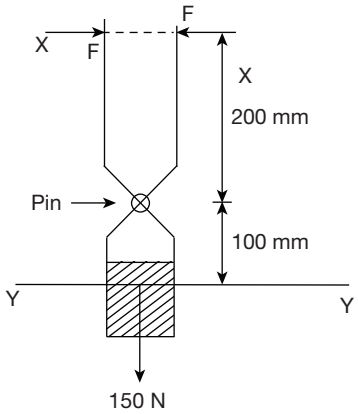
32. The minimum value of *P* for which the equilibrium can exist.
(A) 45.25 kN (B) 55.65 kN
(C) 85.55 kN (D) 105.25 kN

33. The maximum value of *P* for which the equilibrium can exist.
(A) 115.5 kN (B) 250.5 kN
(C) 350.5 kN (D) 451.5 kN

Linked Answer for Questions 34 and 35:

The figure below shown a pair of pin jointed gripper tongs holding an object weighting 1500 N. The co-efficient of friction (μ) at the gripping surface is 0.1. $X-X$ is the line of action of the input force and $Y-Y$ is the line of application of gripping force.

Assuming pin joint is friction less.



34. The reaction force at the gripping surface is
(A) 10,000 N (B) 7500 N
(C) 5000 N (D) 3750 N

35. The magnitude of force *F* required to hold the weight is
(A) 7500 N (B) 5000 N
(C) 3750 N (D) 2000 N

Answer Keys

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

Hints and Explanations

1. Radial acceleration $a_r = V^2/r = \frac{10^2}{25} = 4$ m/s^2

Tangential acceleration $a_t = 3$ m/s^2

$\therefore$ Total acceleration $a = \sqrt{a_r^{\,2} + a_t^{\,2}}$

$= \sqrt{4^2 + 3^2} = 5$ m/s^2 Choice (C)

4. Tan θ = $\frac{Q \sin\theta}{P + Q\cos\theta}$ Choice (A)

6. Force = mass × acceleration

$75 = (15) \times a$; $a = 5$ m/s^2

Velocity after 2 seconds

$v = u + at$

$= 2 + 5 \times 2 = 2 + 10 = 12$ m/s Choice (C)

7. Let N force b/w the block. Form free body diagram.

$600 - N = (10)a$ (i)

$N = (5)a$ (ii)

From (i) & (ii)

$600 - N = 10\left(\frac{N}{5}\right)$

$3N = 600$

$N = 200$ N Choice (B)

8. $KE_1 = \frac{m_1 v_1^{\,2}}{2}$

$KE_2 = \frac{m_2 v_2^{\,2}}{2}$

Given that $KE_1 = KE_2$

$\frac{m_1}{m_2} = \frac{1}{9}$

$m_1 v_1^{\,2} = m_2 v_2^{\,2}$

$\left(\frac{v_1}{v_2}\right)^2 = \frac{m_2}{m_1} = 9$; $\frac{v_1}{v_2} = \sqrt{9} = 3$.

Momentum ratio = $\frac{m_1 v_1}{m_2 v_2} = \frac{m_1}{m_2} \times \frac{v_1}{v_2}$

$= \frac{1}{9} \times \frac{3}{1} = \frac{1}{3}$ Choice (A)

10. referring figure $4T = Mg$

$M = \frac{4T}{g}$

$= \frac{4 \times 10}{10}$

$M = 4$ kg Choice (D)

11. $s = ut + \frac{gt^2}{2}$

$u = 0$, $H_1 = \frac{gt^2}{2}$

$H_2 = \frac{gt^2}{2}$

$\left(\frac{t_1}{t_2}\right)^2 = \left(\frac{h_1}{h_2}\right)$; $\frac{t_1}{t_2} = \left(\frac{h_1}{h_2}\right)^{1/2}$ Choice (B)

12. let sphere M = body 1

sphere N = body 2

m_1 and m_2 are mass of sphere M and sphere N

v_1, v_2 are the velocities before impact

v_1^1, v_2^1 are the velocities after impact

$\therefore$ $m_1 v_1 = m_1 \cdot v_1^1 + m_2 v_2^1$

As the balls are identical $m_1 = m_2$

$v_1 = v_1^1 + v_2^1$

Given that $0.5 = \frac{v_2^1 - v_1^1}{v_1 - v_2} = \frac{v_2^1 - v_1^1}{V_1}$

$(\therefore V_2 = 0)$

$\therefore$ $0.5 = \frac{v_2^1 - v_1^1}{v_1^1 + v_2^1}$

$\frac{v_2^1}{2} + \frac{v_1^1}{2} = v_2^1 - v_1^1$

$\frac{3}{2} v_1^1 = \frac{v_2^1}{2}$

$\frac{v_2^1}{v_1^1} = 3 : 1$ Choice (B)

13. Choice (D)

14. Choice (A)

15. Cosθ = $\frac{W}{PQ}$

$PQ = \frac{W}{\cos\theta} = W \sec\theta$ Choice (A)

16. Taking moments about A

$W \times 3 - W \times \frac{10}{2}\cos\theta = \mu W \times 10 \sin\theta$

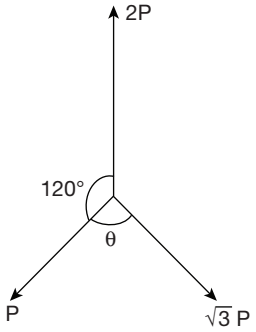
$3 - 5 \times \frac{3}{10} = \mu \times 10 \times \frac{\sqrt{91}}{10}$

From the figure Cosθ = 3/10 , Sinθ = $\frac{\sqrt{91}}{10}$

$3 - 3/2 = \mu \times 9.53$

$\mu = \frac{1.5}{9.53} = 0.157 \approx 0.16$ Choice (A)

17. $\frac{\sqrt{3}P}{\text{Sin}120} = \frac{2P}{\text{Sin}\,\theta}$



$\frac{\sqrt{3}}{\sin 120} = \frac{2P}{\text{Sin}\,\theta}$

$\frac{\sqrt{3}}{\sqrt{3}/2} = \frac{2P}{\text{Sin}\,\theta} \Rightarrow \text{Sin}\theta = 1$

$\theta = 90°$ Choice (C)

18. As the lamina is symmetrical about $y - y$ axis, bisecting the lamina, its centre of gravity lies on the axis.

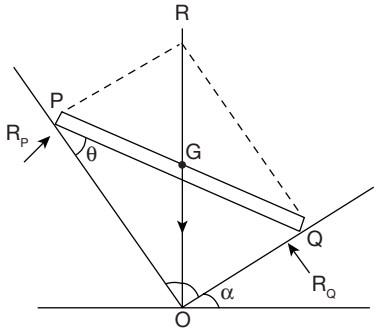
$\alpha = 30° = \frac{\pi}{6}$

Centre of gravity of the lamina $\bar{y} = \frac{2r\,\text{Sin}\,\alpha}{3\alpha}$

$= \frac{2\times 200}{3} \times \frac{\text{Sin}\,30}{\frac{\pi}{6}} = \frac{400}{3} \times \frac{0.5}{\left(\frac{\pi}{6}\right)}$

= 128 mm Choice (C)

19.



$PR \perp PO$ and $QR \perp QO$ therefore $PR \parallel QO$
$QR \parallel PO$
$\angle PRQ = 90°$
$PG = QG$
$\angle GPO = \angle GOP$
$\theta = \alpha$ Choice (A)

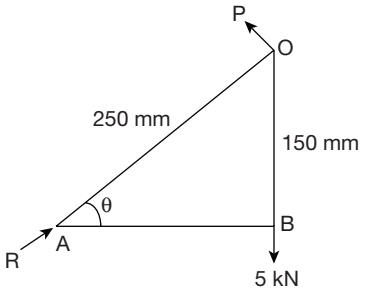
20. Diameter of the wheel = 500 mm
Weight of wheel = 5 kN
Height of the block = 100 mm
Let P = Least pull required just to turn the wheel in kN

$\text{Sin}\theta = \frac{150}{250} = 0.6$

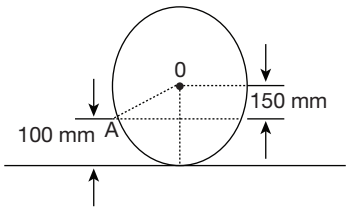
$\theta = 36.86°$

$AB = \sqrt{(250)^2 - (150)^2}$

= 200 mm



Taking moments about A
$P \times 250 = 5 \times 200$



$P = \frac{1000}{250} = 4$ kN Choice (C)

21. $D = 200$ mm, $R = 100$ mm
$d = 150$ mm, $r = 75$ mm
$I_{AB} = 0.393\,(R^4 - r^4)$
$= 0.393\,[100^4 - 75^4] = 26.86 \times 10^6$ mm^4 Choice (D)

22. Let R = normal reaction of the pulley on the beam at C
$R \times 1 = 6 \times 1.5$
$R = 9$ kN
Maximum force of friction at $C = \mu R$
$= 0.2 \times 9 = 1.8$ kN
Taking moments about the centre of pulley
$W \times 40 = 1.8 \times 60$

$W = 1.8 \times \frac{60}{40} = 2.7$ kN Choice (A)

23. Load (W) = 3 kN
Mean diameter of the screw (d) = 60 mm
Pitch (p) = 10 mm
$\mu = \tan\phi = 0.075$

$\tan(\alpha) = \frac{P}{\pi d} = \frac{10}{\pi \times 60} = 0.053$

Efficiency $\eta = \frac{\tan\alpha}{\tan(\alpha + \varphi)}$

$= \frac{\tan\alpha}{\frac{\tan\alpha + \tan\varphi}{1 - \tan\alpha\tan\varphi}} = \frac{0.053}{\frac{0.053 + 0.075}{1 - (0.053 \times 0.075)}}$

0.4124 = 41.24% Choice (B)

24. Let $m_1 = 20$ kg, $m_2 = 70$ kg, $m_3 = 5$ kg
From the system of pulleys and masses, we find that at pulley A, the 20 kg mass will come down with some acceleration as the total mass on the other side of the string is less than 20 kg
At pulley B, the 7 kg mass will come down with some acceleration.
Acceleration of 20 kg mass is

$$= \frac{g(m_1 - m_2)}{m_1 + m_2} = \frac{9.81(20-(7+5))}{20+(7+5)}$$

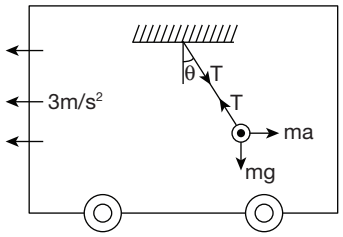
$= 2.45$ m/s^2 Choice (A)

25. Let $m_1 = 12$ kg
$m_2 = 6$ kg
$g = 9.8$ m/s^2

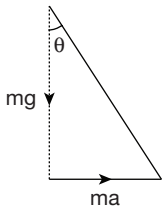
Tension in the string, $T = \frac{m_1 m_2 g}{m_1 + m_2} = \frac{12 \times 6 \times 9.8}{12+6}$

$= 39.2$ N Choice (A)

26. Let θ = Angle, which the chord will make with the vertical



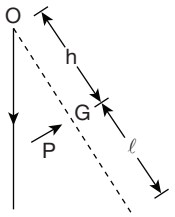
Weight of the hob = $mg = 2 \times 9.8 = 19.6$ N
Inertia force acting on the hob (Opposite to the acceleration of the train)
$= ma = 2 \times 3.2 = 6.4$ N



$\therefore \quad \text{Tan}\theta = \frac{6.4}{19.6}$

$\theta = 18°$ Choice (D)

27. $m = 0.5$ kg, $h = 300$ m $= 0.3$ m



$I_G = 0.125$ kg-m^2
$I_G = m K_G^2$

$0.125 = 0.6 K_G^2$

$K_G^2 = \frac{0.125}{0.6} = 0.208$

Length of equivalent simple pendulum

$L = h + \frac{K_G^2}{h} = 0.3 + \frac{0.208}{0.3}$

$= 0.993$ m Choice (C)

28. $L = 2$ m
$N = 35$ rpm
$r = 500$ m $= 0.5$ m

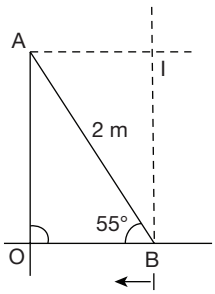
angular velocity of the bob $\omega = \frac{2\pi N}{60} = \frac{2\pi \times 30}{60}$

$\omega = 3.35$rad/s

$\tan\theta = \frac{\omega^2 r}{g} = \frac{(3.35)^2 \times 0.5}{9.8} = 0.572$

$\theta = \tan^{-1}(0.572) = 29.8°$ Choice (B)

29.



$\omega = 5$ rad/s
V_A = Velocity along the vertical
V_B = Velocity along the horizontal
$I_A = OB = L\cos\theta = 2 \times \cos 55°$
$I_B = OA = L\sin\theta = 2 \times \sin 55°$
$\therefore \quad V_B = \omega \times IB$
$= 5 \times 2 \times \text{Sin}55° = 8.19$ m/s Choice (D)

30. $T\,\text{Cos}(90 - \theta) = mg$
$T\,\text{Sin}\theta = mg$

$\text{Tan}\theta = \frac{100}{200}$

$\theta = 26.56°$

$T = \frac{mg}{\text{Sin}\,\theta} = \frac{40 \times 9.8}{\text{Sin}(26.56)}$

$= 876.5$ N Choice (A)

31. Velocity = acceleration × time
$4 = a \times 2$
$a = 2$ m/sec^2

Tension in Cable $= \frac{W}{g}(g + a)$

$= \frac{1000}{9.81}(9.81 + 2) = \frac{11,810}{9.81}$

≈ 1200 kg Choice (B)

32. For the minimum value of P, the body is at the point of sliding downwards.

$$\therefore \quad P = W \times \frac{\text{Sin}(\alpha - \varphi)}{\text{Cos}\,\varphi}$$

$$= 600 \times \frac{\text{Sin}(25 - 20)}{\text{Cos}\,20}$$

$$= 55.65 \text{ kN}$$ Choice (B)

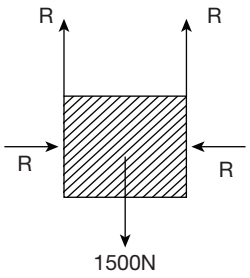
33. For the maximum value of P, the body is at the point of sliding upwards.

$$\therefore \quad P = W \times \frac{\text{Sin}(\alpha + \varphi)}{\text{Cos}\,\varphi}$$

$$= 600 \times \frac{\text{Sin}(25 + 20)}{\text{Cos}\,20}$$

$$= 451.5 \text{ kN}$$ Choice (D)

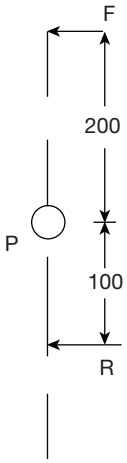
34.



$2\mu R = 1500$ N

$$R = \frac{1500}{2 \times 0.1} = 7500 \text{ N}$$ Choice (B)

35.



Taking moments about Pin

$(R) \times 100 = F \times 200$

$$F = \frac{7500 \times 100}{200}$$

$F = 3750$ N Choice (C)