PRACTICE QUESTIONS

for SSC-JE : CBT-2

Engineering Mechanics

Mechanical Engineering

09 Engineering Mechanics

Q.1 In what proportion will the maximum range of projectile be increased if the velocity is increased by 15 percent?

(a) 32.25% (b) 22.25%
(c) 25% (d) 12.25%

Q.2 A car is accelerating and in 4 seconds, the car travels 300 m and in next 4 seconds, it travels 500 m. The acceleration of the car will be

(a) 8.33 m/s^2 (b) 3.25 m/s^2
(c) 12.5 m/s^2 (d) 15.62 m/s^2

Q.3 An elevator weighing 10 kN attains an upward velocity of 2 m/s in 2 seconds with uniform acceleration. The tension in the wire rope, is nearly

(a) 6 kN (b) 8 kN
(c) 10 kN (d) 11 kN

Q.4 A wheel rotates with a constant acceleration of 3 rad s^{-2}. If it starts from rest, what will be the number of revolutions it will make in first 10s?

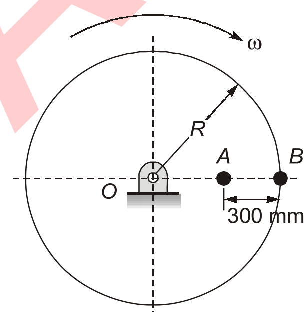
(a) 21.22 (b) 25.42
(c) 23.87 (d) 20.83

Q.5 A bullet after firing from a gun goes through a plank of thickness h and changes its velocity from u to v. The resisting force is proportional to square of velocity. The time of motion of the bullet in the plank is

(a) $\frac{uv}{u-v} \times \left(\frac{-m}{k}\right)$ (b) $\frac{uv}{u+v} \times \left(\frac{-m}{k}\right)$

(c) $\frac{u-v}{uv} \times \left(\frac{-m}{k}\right)$ (d) $\frac{u+v}{uv} \times \left(\frac{-m}{k}\right)$

Q.6 Figure given below shows a wheel rotating about O. Two points A and B located along the radius of wheel have speeds of 60 m/s and 120 m/s respectively. The distance between the points A and B is 300 mm. What will be the diameter of the wheel?



(a) 1200 mm (b) 1150 mm
(c) 1330 mm (d) 1000 mm

Q.7 If the period of oscillation is doubled of simple pendulum

(a) The length of simple pendulum should be doubled.
(b) The length of simple pendulum should be quadrupled.
(c) Mass of pendulum should be double.
(d) The length and mass should be doubled.

Q.8 Two forces, one of which is double the other, has resultant of 260 N. If the direction of larger force is reversed and the other remains unaltered, the resultant reduces to 180 N. The magnitude of the smaller force is

(a) 60 N (b) 76 N
(c) 81 N (d) 100 N

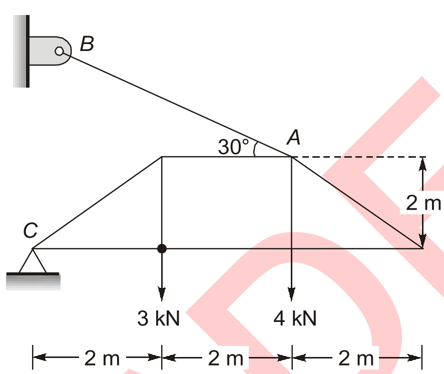
Q.9 A uniform rod of length 10 m has a self weight of 5 N. The rod carries a weight of 30 N hung from one of its ends. From what point the rod must be suspended so that it remains horizontal?

(a) At 0.714 m from centroid towards the load.
(b) At 4.286 m from centroid towards the load.
(c) At 1 m from centroid.
(d) At 4 m from centroid.

Q.10 A tennis ball is dropped onto a plane surface from a height of 1 m. After rebound, the ball rises to 0.64 m height. The coefficient of restitution is

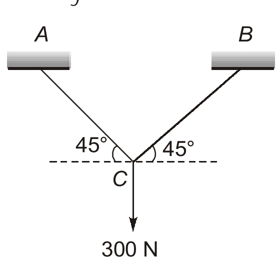
(a) 0.16 (b) 0.48
(c) 0.64 (d) 0.8

Q.11 Consider a truss loaded as shown below. A cable AB is attached at point *A*. The tension in cable AB will be



(a) $\frac{22}{2-\sqrt{3}}$ kN (b) $\frac{14}{2+\sqrt{3}}$ kN
(c) $\frac{22}{2+\sqrt{3}}$ kN (d) $\frac{14}{2-\sqrt{3}}$ kN

Q.12 Two identical inextensible cables support a load of 300 N as shown below. The length and cross section area of each cable is 0.1 m and 141 mm^2, respectively. The stress in cable AC is



(a) 300 N/mm^2 (b) 1.5 N/mm^2
(c) 150 N/mm^2 (d) $\frac{300}{\sqrt{2}}$ N/mm^2

Q.13 Consider the following statements regarding equilibrium of a body which is acted upon by two forces

1. The two forces should be equal in magnitude.
2. The two forces should act in same direction.
3. The two forces should be collinear.
4. The two forces should act in opposite direction.

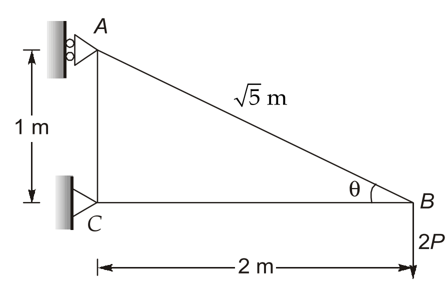
Which of the above statements are correct?

(a) 1 and 3 (b) 1, 2 and 3
(c) 1, 2 and 4 (d) 1, 3 and 4

Q.14 A body weighing 250 N is resting on a horizontal table. A pull of 100 N is applied at an angle of 30° with the horizontal, this pull just causes the body to slide over the table. The value of coefficient of friction between the body and table will be

(a) 0.345 (b) 0.250
(c) 0.433 (d) 0.532

Q.15 A truss carries a concentrated load '2*P*' as shown in figure below:



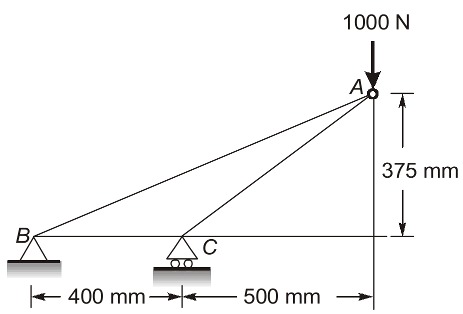
What is the ratio of axial forces in the members *AB*, *BC* and *CA*, respectively?

(a) $1:\sqrt{5}:2$ (b) $2:1:\sqrt{5}$
(c) $\sqrt{5}:2:1$ (d) None of these

Q.16 According to the principle of moments, if a system of coplanar forces are to be in equilibrium, then the algebraic sum of their moments about any point in their plane is

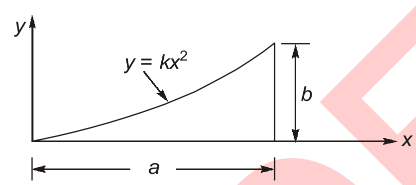
(a) zero
(b) the moment of the maximum force about the same point
(c) the moment of the minimum force about the same point
(d) indeterminate

Q.17 For given truss find the force in the *BC* member.



(a) 1250 N (b) 2000 N
(c) 3000 N (d) 3750 N

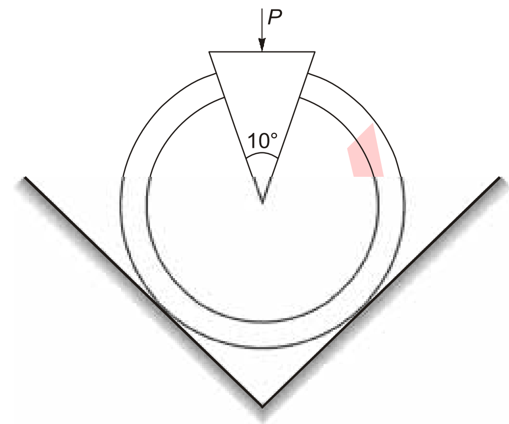
Q.18 What is the *y*-component of the centroid of given figure.



(a) $\frac{3b}{10}$ (b) $\frac{b}{3}$
(c) $\frac{2b}{5}$ (d) None of these

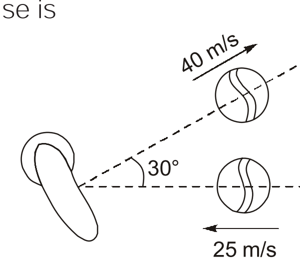
Q.19 The position of a particle moving along a straight line is defined by the relation $x = t^3 - 6t^2 - 15t + 40$, where x is in meters and t is in seconds. What is the distance traveled by the particle from $t = 4$ s to $t = 6$ s.
(a) 2 m (b) 8 m
(c) 10 m (d) 18 m

Q.20 A 10° wedge is used to spread a split ring. The coefficient of static friction between the wedge and the ring is 0.30. Knowing that a force *P* with a magnitude of 120 N was required to insert the wedge, the magnitude of the normal force exerted on the ring by the wedge at left or right during insertion will be (cos 5° = 0.996, sin5° = 0.087) (Ignore the weight of wedge)



(a) 200 N (b) 155 N
(c) 60 N (d) 680 N

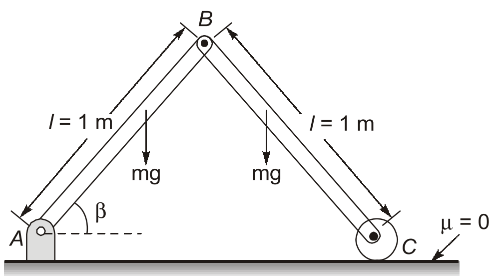
Q.21 A 4 kg baseball is pitched with a velocity of 25 m/s toward a batter. After the ball is hit by the bat, it has velocity 40 m/s in the direction shown. If bat and ball are in contact for 0.015 seconds, the impulse is



(a) 251 Ns (b) 318 Ns
(c) 16,733 Ns (d) None of these

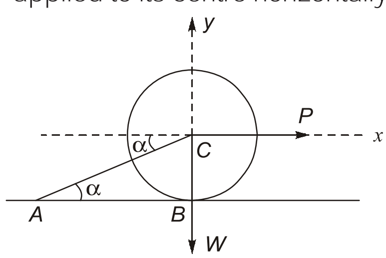
Q.22 A satellite moving at velocity 85×10^5 m/s parallel to earth surface at a height of 664 kms. What will be its velocity when it is at height of 3664 kms? Given earth radius is 6336 kms.
(a) 15×10^5 m/s (b) 41×10^5 m/s
(c) 59×10^5 m/s (d) 71×10^5 m/s

Q.23 Each of the two slender rods shown below is 1 meter long and has a mass of 8 kg. If the system is released from rest at some $\beta > 30°$. What is the moment of inertia of rod *BC* about its instaneous center of rotation when $\beta = 30°$ in kg-m^2?



(a) 3.33 (b) 6.67
(c) 0.67 (d) 2.67

Q.24 A right circular roller of weight W rests on a smooth horizontal plane and is held in position by string AC as shown. The roller is pulled by a force *P* applied to its centre horizontally.

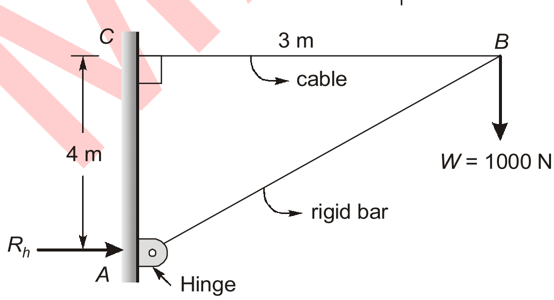


The reaction at *B* will be
(a) $P\cot\alpha + W$ (b) $P\tan\alpha + W$
(c) $W\tan\alpha + P$ (d) $W\cot\alpha + P$

Q.25 Two forces can be in equilibrium if they are
1. equal in magnitude
2. same in direction
3. collinear in action
4. opposite in direction

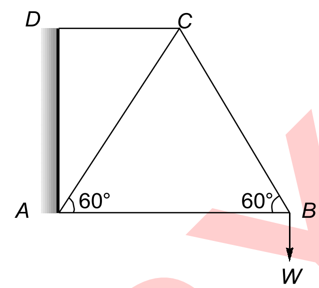
Which of these are the conditions for equilibrium?
(a) 1 and 3 (b) 1, 2 and 3
(c) 1, 2 and 4 (d) 1, 3 and 4

Q.26 For the arrangement shown in below diagram, what will be horizontal reaction at point '*A*'?



(a) 500 N (b) 750 N
(c) 1000 N (d) 1250 N

Q.27 In a framed structure, as shown in figure, the force in the member BC is



(a) $\frac{W}{\sqrt{3}}$ (compression)

(b) $\frac{W}{\sqrt{3}}$ (tension)

(c) $\frac{2W}{\sqrt{3}}$ (compression)

(d) $\frac{2W}{\sqrt{3}}$ (tension)

Q.28 Match **List-I** (Different shapes) with **List-II** (Moment of inertia) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Hollow sphere	1. $\frac{1}{2}mR^2$
B. Solid sphere	2. $\frac{2}{3}mR^2$
C. Righ circular cone	3. $\frac{2}{5}mR^2$
D. Circular lamina	4. $\frac{3}{10}mR^2$

Codes:

	A	B	C	D
(a)	3	1	2	4
(b)	3	2	4	1
(c)	3	2	1	4
(d)	2	3	4	1

Q.29 Area under the acceleration-time graph will give:
(a) the change in acceleration of the body in some time interval
(b) the change in velocity of the body in some time interval
(c) the distance travelled by the body in some time interval
(d) none of the above

Q.30 Consider the following statements:
1. The direction of friction force, acting on a body, is always opposite to that in which motion is intended.
2. Friction force does not depends on area.
3. Only that amount of friction comes into play which is sufficient to prevent motion.
4. Friction exists as long as tractive force act.

Which of the above statements are correct?
(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 3 and 4 (d) 1, 2, 3 and 4

■■■■

Answer Keys

1.	(a)	2.	(c)	3.	(d)	4.	(c)	5.	(c)	6.	(a)	7.	(b)
8.	(d)	9.	(b)	10.	(d)	11.	(c)	12.	(b)	13.	(d)	14.	(c)
15.	(c)	16.	(a)	17.	(c)	18.	(a)	19.	(d)	20.	(b)	21.	(a)
22.	(c)	23.	(b)	24.	(b)	25.	(d)	26.	(b)	27.	(d)	28.	(d)
29.	(b)	30.	(b)										

Detailed Solutions

1. (a)

Range, $R = \frac{u^2 \sin 2\theta}{g}$

$\Rightarrow$ $R \propto u^2$

$\therefore$ $\frac{R_2}{R_1} = \frac{u_2^2}{u_1^2}$

$$\frac{R_2}{R_1} - 1 = \frac{u_2^2}{u_1^2} - 1$$

$$\frac{R_2 - R_1}{R_1} = \frac{u_2^2 - u_1^2}{u_1^2}$$

$$\frac{R_2 - R_1}{R_1} = \frac{(1.15)^2 - 1}{1} = 32.35\%$$

2. (c)

$$s = ut + \frac{1}{2}at^2$$

$$\Rightarrow 300 = 4u + \frac{1}{2}a \times 4^2 \quad \text{...(i)}$$

$$\text{and, } 800 = 8u + \frac{1}{2}a \times 8^2 \quad \text{...(ii)}$$

From (i) and (ii),

$$800 - 600 = \frac{1}{2}a(8^2 - 2 \times 4^2)$$

$$200 = \frac{1}{2}a(64 - 32)$$

$$a = \frac{200}{16} = 12.5 \text{ m/s}^2$$

3. (d)

Given: $v = 2$ m/s, $t = 2$s,

$$a = \frac{v}{t} = \frac{2}{2} = 1 \text{ m/s}^2$$

$$T = M(g + a) = \frac{W}{g}(g + a)$$

$$= \frac{10}{10}(10+1) = 11\,\text{kN}$$

4. (c)

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega_0 = 0$$

$$\theta = \frac{1}{2}\times 3\times 10^2 = 150\,\text{rad}$$

$$\therefore \quad \text{Number of revolutions} = \frac{150}{2\pi} = 23.87$$

5. (c)

$$a = \frac{dv}{dt}$$

Let resisting force be F

$$\therefore \quad F = Kv^2$$

Let m is mass of bullet.

$$\therefore \quad a = \frac{F}{m} = \frac{Kv^2}{m}$$

$$\Rightarrow \quad \frac{dv}{dt} = \frac{Kv^2}{m}$$

$$\Rightarrow \quad \frac{1}{v^2}dv = \frac{K}{m}\cdot dt$$

$$\Rightarrow \quad \left[\frac{v^{-1}}{-1}\right]_u^v = \frac{K}{m}\int_0^t dt$$

$$\Rightarrow \quad \left[\frac{v-u}{uv}\right] = \frac{K}{m}t$$

$$\Rightarrow t = \frac{(u-v)}{uv}\times\left(\frac{-m}{K}\right)$$

6. (a)

$$\omega_A = \omega_B$$

$$\Rightarrow \frac{V_A}{R-0.3} = \frac{V_B}{R} \qquad (\because \quad V = \omega R)$$

$$\Rightarrow \quad \frac{60}{R-0.3} = \frac{120}{R}$$

$$\Rightarrow \quad 60\,R = 120\,R - 36$$

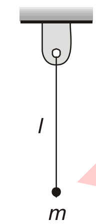
$$\Rightarrow \quad 36 = 60\,R$$

$$\Rightarrow \quad R = \frac{36}{60} = 0.6\text{ m}$$

$\therefore$ $D = 2\,R = 1.2$ m $= 1200$ mm

7. (b)

Simple pendulum (m, l)



$$T = 2\pi\sqrt{\frac{l}{g}}$$

For double the period of oscillation is double the length of simple pendulum should be quadrupled.

8. (d)

Let smaller force be P and second force be Q and angle between them is θ.

$\therefore$ $Q = 2P$ (given)

From parallelogram law of forces,

$$R^2 = P^2 + Q^2 + 2PQ\cos\theta$$

$$260^2 = P^2 + (2P)^2 + 2\times P\times 2P\times\cos\theta \quad \ldots\text{(i)}$$

When direction of larger force i.e. Q is reversed,

$$180^2 = P^2 + (-2P)^2 + 2\times P(-2P)\cos\theta \quad \ldots\text{(ii)}$$

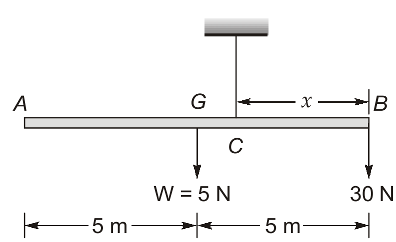
Adding (i) and (ii),

$$260^2 + 180^2 = 10P^2$$

$$P^2 = 10000$$

$$P = 100\text{ N}$$

9. (b)



Taking moment about C,

$$W\times GC - x\times 30 = 0$$

$$25 - 5x - 30x = 0$$

$$x = \frac{5}{7} = 0.714\text{ m}$$

$GC = 5 - 0.714 = 4.286$ m

10. (d)

Let V : initial velocity of plane surface

V_f : final velocity of plane surface

u : initial velocity of ball

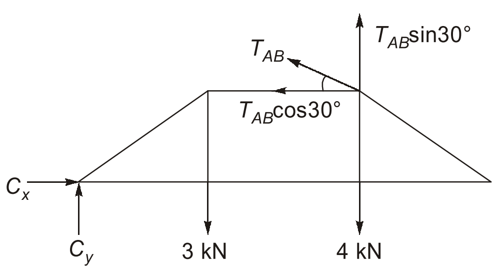
u_f : final velocity of ball

Coefficient of restitution,

$$= \frac{u_f - V_f}{u - V} = \frac{u_f - 0}{u - 0} = \sqrt{\frac{2g\,h_f}{2gh}}$$

$$= \sqrt{\frac{h_f}{h}} = \sqrt{\frac{0.64}{1}} = 0.8$$

11. (c)



Applying equilibrium equations,

$\Sigma F_x = 0 \Rightarrow \; C_x = T_{AB}\cos 30°$ ...(i)

$\Sigma F_y = 0 \Rightarrow \; C_y + T_{AB}\sin 30° = 7$ ...(ii)

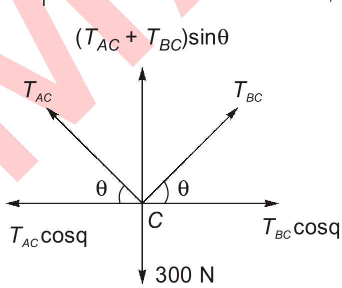
$\Sigma M_c = 0 \;\; \Rightarrow \; 3 \times 2 + 4 \times 4 = T_{AB}\sin 30° \times 4 + T_{AB}\cos 30° \times 2$

$$\Rightarrow \; 22 = T_{AB}\left(2 + \sqrt{3}\right)$$

$$T_{AB} = \frac{22}{2 + \sqrt{3}}\ \text{kN}$$

12. (b)

From equilibrium conditions at C,



Let, $T_{AC} = T_{BC} = T$

$\Rightarrow \quad T_{AC}\cos\theta = T_{BC}\cos\theta$

and, $(T_{AC} + T_{BC})\sin\theta = 300$

$$2T \cdot \frac{1}{\sqrt{2}} = 300$$

$$T = \frac{300}{\sqrt{2}}\ \text{N}$$

Stress in AC,

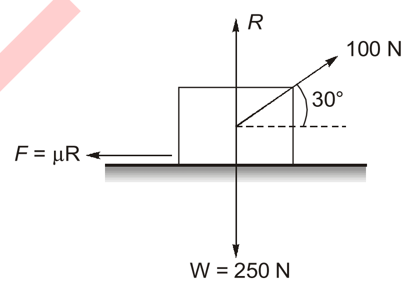
$$\sigma_{AC} = \frac{T}{A}$$

$$\sigma_{AC} = \frac{300}{\sqrt{2} \times 141}\ \text{N/mm}^2$$

$$\sigma_{AC} = \frac{300}{\sqrt{2} \times \sqrt{2} \times 100}\ \text{N/mm}^2$$

$$\sigma_{AC} = \frac{3}{2}\ \text{N/mm}^2 = 1.5\ \text{N/mm}^2$$

14. (c)



From, $\Sigma F_x = 0 \quad \Rightarrow \quad F - 100\cos 30° = 0$

$F = 50\sqrt{3}$ N

From, $\Sigma F_y = 0 \quad \Rightarrow \quad R + 100\sin 30° - 250 = 0$

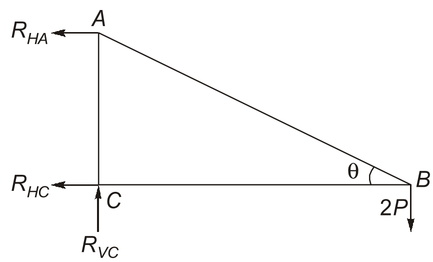
$R = 200$ N

As, $F = \mu R$

$$\mu = \frac{F}{R} = \frac{50\sqrt{3}}{200} = \frac{\sqrt{3}}{4} = \frac{1.732}{4}$$

$\mu = 0.433$

15. (c)



$$\Sigma M_B = 0 \Rightarrow R_{HA} \times 1 - 2P \times 2 = 0$$

$$R_{HA} = 4P$$

$$R_{HC} = -4P$$

$$R_{VC} = 2P(\uparrow)$$

At joint B

$$\Sigma F_y = 0$$

$$F_{AB}\sin\theta - 2P = 0$$

$$F_{AB} = 2\sqrt{5}\,P$$

$$\Sigma F_x = 0$$

$$F_{AB}\cos\theta + F_{BC} = 0$$

$$F_{BC} = -2\sqrt{5}\,P \times \frac{2}{\sqrt{5}} = -4P$$

At joint C

$$\Sigma F_y = 0$$

$$F_{CA} - 2P = 0$$

$$F_{CA} = 2P$$

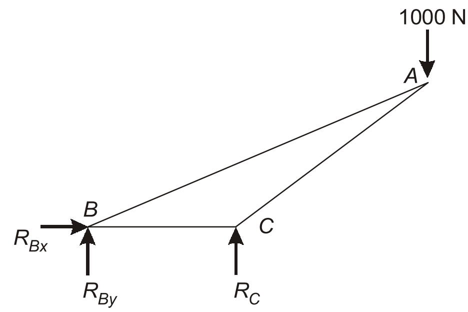
$$F_{AB} : F_{BC} : F_{CA} = 2\sqrt{5} : 4 : 2 = \sqrt{5} : 2 : 1$$

16. (a)

If a system of coplanar forces are to be in equilibrium then the algebraic sum of their moments about any point in their plane is zero. This is called principle of moments.

17. (c)

Drawing FBD of given truss,

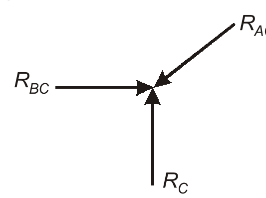


Taking moment about B,

$$R_C \times 400 = 1000 \times (400 + 500)$$

$$\Rightarrow \quad R_C = \frac{9000}{4}\text{ N}$$

Considering C joint



We are considering member AC and BC in compression.

$$\Sigma F_y = 0$$

$$\Rightarrow R_C = R_{AC}\frac{375}{\sqrt{375^2 + 500^2}}$$

$$\Rightarrow \quad R_{AC} = 3750\text{ N}$$

$$\Sigma F_x = 0$$

$$\Rightarrow R_{BC} = R_{AC}\frac{500}{\sqrt{375^2 + 500^2}} = 3000\text{ N}$$

18. (a)

$$y_{cm} = \frac{\int y\,dA}{\int dA} = \frac{\int\left(\frac{kx^2}{2}\right)\left(kx^2\,dx\right)}{\int\left(kx^2\right)dx} = \frac{3}{10}ka^2$$

Also, $\quad b = ka^2$

$$\Rightarrow \quad y_{cm} = \frac{3b}{10}$$

19. (d)

As given: $x = t^3 - 6t^2 - 15t + 40$

$$\frac{dx}{dt} = 3t^2 - 12t - 15 = 3(t^2 - 4t - 5)$$

$= 3(t-5)(t+1)$

$$\Rightarrow \frac{dx}{dt} = 0 \text{ at } 5\text{ s}$$

So we need to calculate value of x at $t = 4$ s, $t = 5$ s and $t = 6$ s

$$x_4 = -52 \text{ m}$$
$$x_5 = -60 \text{ m}$$
$$x_6 = -50 \text{ m}$$

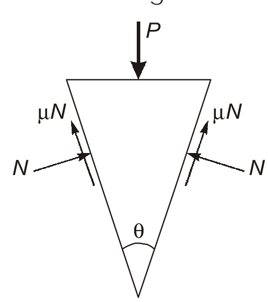
So, the particle move 8 m from t = 4 s to $t = 5$ s in negative x-direction and then 10 m in positive x-direction.

Total distance = 18 m

Note that the particle has negative velocity from $t = 0$ s to $t = 5$ s and then positive velocity after $t = 5$ s.

20. (b)

Drawing FBD of the wedge.



Weight of the wedge is neglected,

$$P = 2\mu N\cos\left(\frac{\theta}{2}\right) + 2N\sin\left(\frac{\theta}{2}\right)$$

$$\Rightarrow 120 = 2N(0.3\cos 5° + \sin 5°)$$

$$\Rightarrow N = 155.43 \text{ N}$$

21. (a)

Impulse = Change in momentum

$$= m(\vec{V}_2 - \vec{V}_1)$$

$$= 4(40\cos 30° i + 40\sin 30° \hat{j}) - (-25\hat{i})$$

$$= 4((20\sqrt{3} + 25)\hat{i} + 20\hat{j})$$

$$|I| = 251.62 \text{ Ns}$$

22. (c)

The satellite will be acted upon by central force, so angular momentum will be conserved.

$$mv_1r_1 = mv_2r_2$$

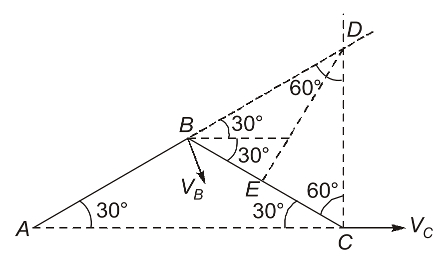
$$\Rightarrow v_2 = \frac{v_1r_1}{r_2}$$

$$= \frac{85\times10^5\times(664+6336)}{(3664+6336)} = \frac{85\times10^5\times7000}{10{,}000}$$

$= 59.5 \times 10^5$ m/s

23. (b)

Rod AB will rotate about A. Velocity of B will be perpendicular to AB. Point C on rod BC will move horizontally. We can find instaneous center of rotation by making line perpendicular to velocity of B and C.



As BCD forms an equilateral triangle,

$$BD = BC = 1 \text{ m}$$
$$DE = BD\sin 60°$$
$$= \frac{\sqrt{3}}{2}\text{m}$$

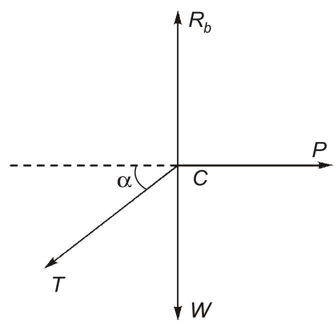
D is instantaneous center of rotation of rod BC and its moment of inertia about D,

$$M = \frac{ml^2}{12} + m(DE)^2 = \frac{8(1)^2}{12} + 8\left(\frac{\sqrt{3}}{2}\right)^2$$

$= 6.67$ kg-m^2

24. (b)

As the roller is in equilibrium under the following forces.



$$\Sigma F_x = 0$$

$$\Rightarrow \quad P - T\cos\alpha = 0$$

or $T = \dfrac{P}{\cos\alpha}$ ...(1)

$$\Sigma F_y = 0$$

$$R_B = T\sin\alpha + W$$

Putting value of 'T' in above equation

$$\Rightarrow R_B = \frac{P}{\cos\alpha} \times \sin\alpha + W$$

$$\Rightarrow R_B = P\tan\alpha + W$$

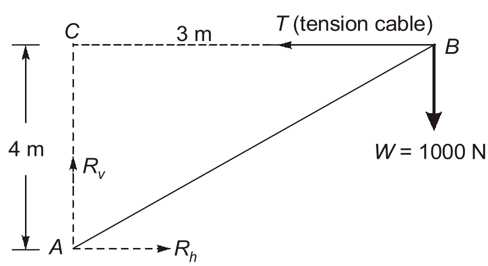
25. (d)

Necessary conditions for equilibrium.

- Equal in magnitude
- Ppposite in direction
- Collinear in action

26. (b)

Considering FBD



Taking moment about A.,

$$\Rightarrow \quad T \times AC = W \times BC$$

$$\Rightarrow T = \frac{BC}{AC} \times W = \frac{3}{4} \times 1000 = 750\text{N}$$

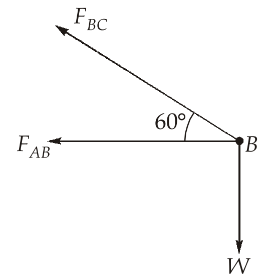
Again at point A,

$$\Sigma F_x = 0$$

$$\Rightarrow \quad R_h - T = 0$$

$$\Rightarrow \quad R_h = T = 750 \text{ N}$$

27. (d)

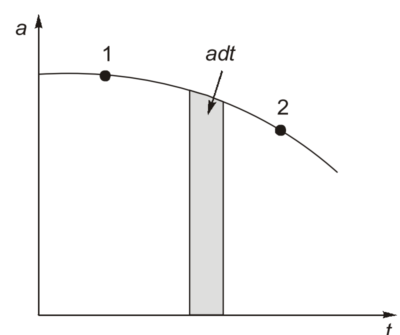


In vertical direction

$$F_{BC}\sin 60° = W$$

$$\Rightarrow F_{BC} = \frac{2W}{\sqrt{3}} \text{(tension)}$$

29. (b)



As $\quad a = \dfrac{dv}{dt}$

$\Rightarrow \quad dv = adt$

where dv = change in velocity in dt time and a is acceleration

$$\Rightarrow \quad v_2 - v_1 = \int_1^2 adt \text{ m/s}$$