CLASS TEST

S.No. : 01 **JP_ME_A_110619**

Engineering Mechanics

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MECHANICAL ENGINEERING

Engineering Mechanics

Duration : 1:00 hr. Maximum Marks : 50

Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

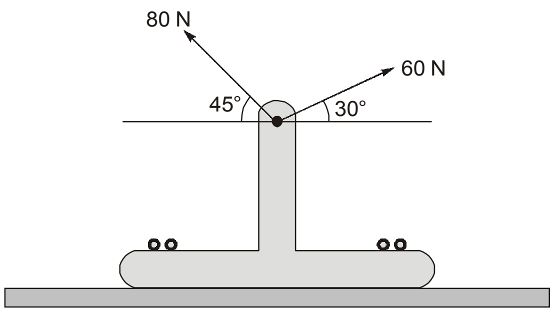
DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 A particle of mass m is at $x = 0$ with velocity $v = u$ in x-direction at $t = 0$. It is subjected to a friction force $-bv$, where b is a positive constant. The position of particle at $t \to \infty$ is

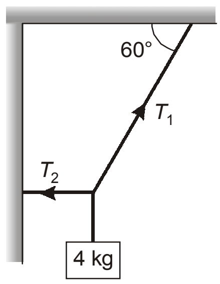
(a) mu/b (b) u/mb
(c) $2mu/b$ (d) $mu/2b$

Q.2 The resultant of two forces shown in figure, is



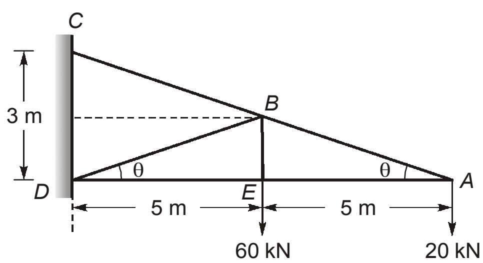
(a) 76.69 N (b) 86.69 N
(c) 96.89 N (d) 68.60 N

Q.3 The value of tensions T_1 and T_2 in the string are respectively,



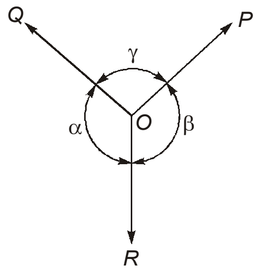
(a) 45.26 N, 22.63 N
(b) 22.63 N, 45.26 N
(c) 16.82 N, 32.64 N
(d) 32.64 N, 16.82 N

Q.4 For the cantilever truss shown in figure, the force in the member BE is:



(a) 50 kN (Tensile)
(b) 60 kN (Tensile)
(c) 50 kN (Compressive)
(d) 60 kN (Compressive)

Q.5 Three co-planer forces P, Q and R (as shown in figure) are acting on a point O. If these forces are in equilibrium, then



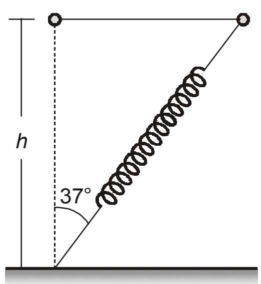
(a) $\frac{P}{\sin\beta} = \frac{Q}{\sin\alpha} = \frac{R}{\sin\gamma}$

(b) $\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$

(c) $\frac{P}{\sin\gamma} = \frac{Q}{\sin\alpha} = \frac{R}{\sin\beta}$

(d) $\frac{P}{\sin\alpha} = \frac{Q}{\sin\gamma} = \frac{R}{\sin\beta}$

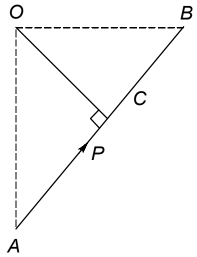
Q.6 One end of a spring of natural length h and spring constant k is fixed at the ground and the other is fitted with a smooth ring of mass m which is allowed to slide on a horizontal rod fixed at a height h. Initially the spring makes an angle of 37°, when system is released from rest. The speed of ring when the spring becomes vertical is



(a) $\frac{h\sqrt{k/m}}{8}$ (b) $\frac{h\sqrt{k/m}}{4}$

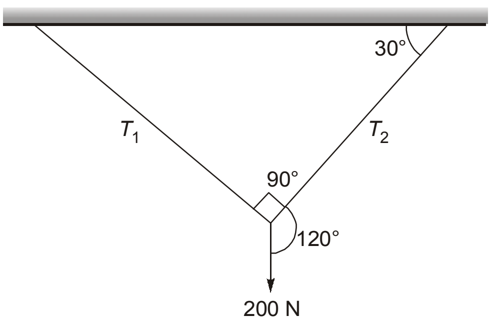
(c) $\frac{h\sqrt{k/m}}{2}$ (d) $\frac{h\sqrt{2k/m}}{2}$

Q.7 The moment of the force *P* about *O* as shown in figure below is



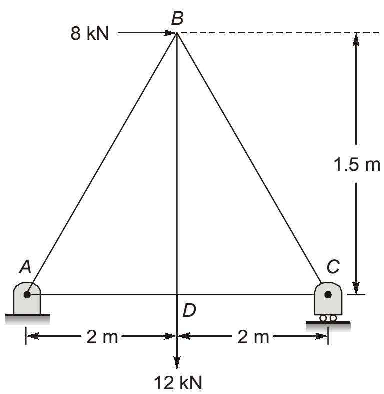
(a) $P \times OA$ (b) $P \times OB$
(c) $P \times OC$ (d) $P \times AC$

Q.8 A weight of 200 N is supported by two metallic ropes as shown in the figure. The ratio of tensions $\frac{T_1}{T_2}$ is



(a) 1.91 (b) 1.73
(c) 1.34 (d) 2.12

Q.9 Figure shows a framed structure of 4 m span and 1.5 m height subjected to two point loads at *B* and *D*. Then the reaction at support *C* will be



(a) 7 (b) 8
(c) 9 (d) 10

Q.10 A particle motion on a space curve is governed by $x = 2\sin t$, $y = 3\cos t$ and $z = \sqrt{5}\sin t$. The speed of the particle any instant will be? (*t* is time)

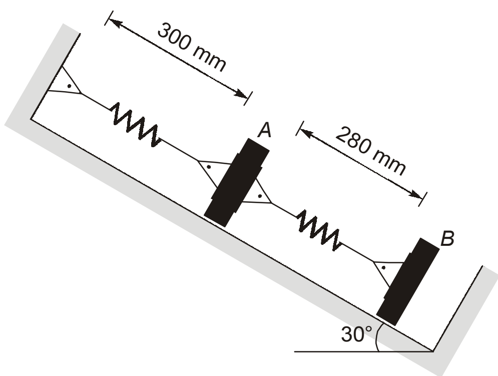
(a) $3\sqrt{2}\sin t$
(b) $3\sqrt{\cos 2t}$
(c) $3\sqrt{\sin 2t}$
(d) independent of time

Q.No. 11 to Q.No. 30 carry 2 marks each

Q.11 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 proportional to

(a) $(u - v)u^{-2}$
(b) $(u - v)v^{-2}$
(c) $(u - v)(uv)^{-1}$
(d) $(u^2 - v^2)(uv)^{-2}$

Q.12 Two springs as shown in figure are identical. Both have unstretched lengths of 250 mm and spring constant k = 1000 N/m. If the inclined surface is smooth then the masses (in kg) of blocks *A* and *B* respectively are

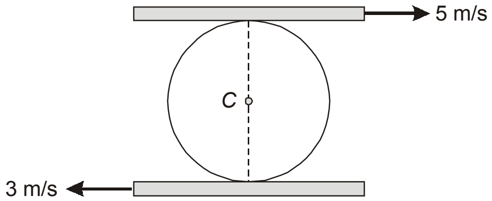


(a) 3.06 and 4.6 (b) 6.12 and 4.08
(c) 4.08 and 6.12 (d) 4.6 and 3.06

Q.13 A circular solid disc of uniform thickness of 20 mm, radius 200 mm and mass 20 kg, is used as a flywheel. If it rotates at speed of 500 rpm, then the kinetic energy of the flywheel is
(a) 547.68 J (b) 648.31 J
(c) 732.81 J (d) 932.81 J

Q.14 Two cars are moving in the same direction with a speed of 50 km/hr and a distance of 12 km separates them. If a car coming from the opposite direction meets these two cars at time difference of 5 minutes, its speed would be
(a) 44 km/hr (b) 64 km/hr
(c) 84 km/hr (d) 94 km/hr

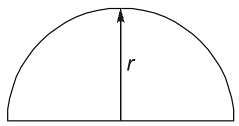
Q.15 A cylindrical roller, 50 cm in diameter, is in contact with two horizontal conveyor belts running at uniform speeds of 5 m/s and 3 m/s. The angular velocity of roller is
[Assume no slip at contact points]



(a) 4 (b) 9
(c) 16 (d) 21

Q.16 If the rotating mass of a rim type flywheel is distributed on another rim type flywheel whose mean radius is half the mean radius of the former, then energy stored in the later at the same speed will be
(a) Four times the first one
(b) one and a half times the first one
(c) same as the first one
(d) one fourth of the first one

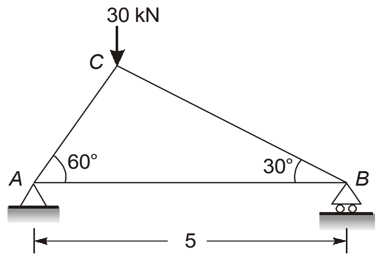
Q.17 Area moment of inertia for the semi-circle shown below about its diameter is



(a) $\frac{\pi r^4}{8}$ (b) $\frac{\pi r^4}{16}$
(c) $\frac{\pi r^4}{32}$ (d) $\frac{\pi r^4}{64}$

Q.18 Two particle system with the particles having masses 10 kg and 20 kg. If the first particle is pushed towards the centre of mass through a distance 15 mm, then by what distance (in mm) should the second particle be moved so as to keep the centre of mass at the same position
(a) 4.5 (b) 6.5
(c) 8.5 (d) 7.5

Q.19 The force in member AB is

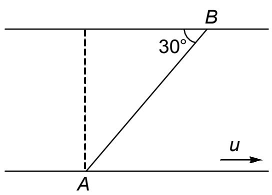


(a) 12.99 kN, compressive
(b) 12.99 kN, tensile
(c) 25.97 kN, compressive
(d) 25.97, tensile

Q.20 A simple pendulum took 36 seconds to complete 20 oscillations when the effective length was kept at 80 cm then the acceleration (in m/s^2) due to gravity from this data will be
(a) 9.75 (b) 8.24
(c) 7.81 (d) 11.36

Q.21 The wheel of a motor, accelerated uniformly from rest rotates through 2.5 radian during first second then the angle rotated during the next second will be
(a) 7.5 radian (b) 8.9 radian
(c) 10.1 radian (d) 15.8 radian

Q.22 A man wants to reach point *B* on the opposite bank of a river flowing at a speed as shown in figure. What is the minimum speed relative to the water which the man should have so that he can reach point *B*?



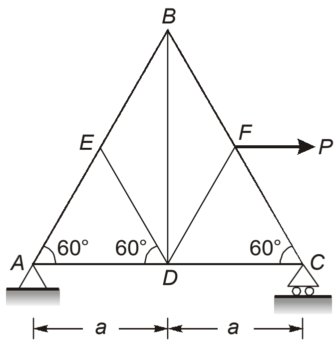
(a) 1.414 u (b) u
(c) 0.707 u (d) 0.5 u

Q.23 Three particles are situated at the vertices of an equilateral triangle of side d at time $t = 0$. Each of the particles moves with constant speed v, towards each other along the side formed at any instant. At what time will the particles meet each other?

(a) $\frac{2d}{3v}$ (b) $\frac{3d}{2v}$

(c) $\frac{\sqrt{3}d}{4v}$ (d) $\frac{3d}{\sqrt{2}v}$

Q.24 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:



List-I	List-II
A. Reaction at C	1. $0.433P$
B. Reaction at A	2. $0.75P$
C. Force in member AD	3. 0
D. Force in member DE	4. $1.09P$

Codes:

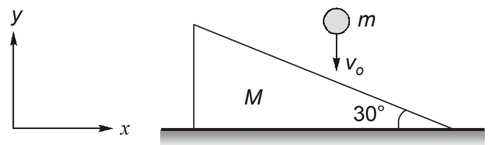
	A	B	C	D
(a)	4	1	3	2
(b)	1	4	2	3
(c)	1	2	3	4
(d)	2	1	4	3

Q.25 A heavy particle hanging from a fixed point by a light inextensible string of length l is projected horizontally with speed $\sqrt{gl}$. What is the speed of the particle and the inclination of the string to the vertical respectively at the instant of the motion when tension in the string is equal to the weight of the particle?

(a) $\sqrt{\frac{gl}{3}}, \cos^{-1}\left(\frac{1}{3}\right)$ (b) $\sqrt{\frac{2gl}{3}}, \cos^{-1}\left(\frac{2}{3}\right)$

(c) $\sqrt{\frac{gl}{3}}, \cos^{-1}\left(\frac{2}{3}\right)$ (d) $\sqrt{\frac{gl}{2}}, \cos^{-1}\left(\frac{1}{3}\right)$

Q.26 A ball of mass $m = 1$ kg falling vertically with a velocity $v_o = 2$ m/s strikes a wedge of mass $M = 2$ kg kept on a smooth horizontal surface as shown in figure. The coefficient of restitution between the ball and the wedge is 0.5. What is the velocity of the wedge and the ball respectively immediately after collision?



(a) $\frac{-2}{\sqrt{3}}\hat{i}$ m/s, $\frac{-2}{\sqrt{3}}\hat{j}$ m/s

(b) $\frac{-1}{\sqrt{3}}\hat{i}$ m/s, $\frac{+2}{\sqrt{3}}\hat{i}$ m/s

(c) $\frac{2}{\sqrt{3}}\hat{i}$ m/s, $\frac{1}{\sqrt{3}}\hat{j}$ m/s

(d) $\frac{-2}{\sqrt{3}}\hat{i}$ m/s, $\frac{-1}{\sqrt{3}}\hat{i}$ m/s

Q.27 Two boats A and B are 20 km apart on a line running south to north. Boat A further north is streaming west at 10 km/h and boat B is streaming north at 10 km/h. The time taken by the boats to reach the distance of closest approach is

(a) 1 hour (b) 5 hour

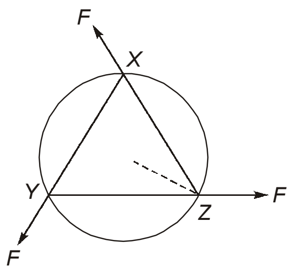
(c) 7 hour (d) 9 hour

Q.28 A small bar starts sliding down on an inclined plane making an angle 45° with the horizontal. The coefficient of friction depends on the distance x as $\mu = 5x$. The distance covered by the bar till it stops is

(a) 0.4 m (b) 0.8 m

(c) 1.6 m (d) 3.2 m

Q.29 A uniform disc of mass 1.5 kg and radius 0.5 m is initially at rest on a horizontal frictionless surface. Three forces of equal magnitude F = 0.5 N are applied simultaneously along the three sides of an equilateral triangle XYZ with its vertices on the perimeter of the disc. The angular speed of the disc in rad s^{-1} after 1s of application of forces will be:



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

Q.30 A particle having a velocity $v = v_o$ at $t = o$ is declared at the rate of $|a| = \alpha\sqrt{v}$ where α is a positive constant

(a) The particle comes to rest at $t = \dfrac{2\sqrt{v_o}}{\alpha}$

(b) The particle will come to rest at infinity

(c) The distance travelled by the particle is $\dfrac{2v^{3/2}}{\alpha}$

(d) The distance travelled by the particle is $\dfrac{2v^{3/2}}{3\alpha}$

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CLASS TEST 2019-2020

MECHANICAL ENGINEERING

Date of Test : 11/06/2019

ANSWER KEY ➤ Engineering Mechanics

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

DETAILED EXPLANATIONS

1. (a)

$$a = \frac{f}{m} = -\frac{bv}{m}$$

but, $$a = v\frac{dv}{dx}$$

$\therefore$ $$\frac{vdv}{dx} = -\frac{bv}{m}$$

(at time infinity means steady state)

$$\int_u^0 dv = -\frac{b}{m}\int_0^x dx$$

$$-u = -\frac{b}{m}\times x$$

$\Rightarrow$ $$x = mu/b$$

2. (b)

Resolving the forces in horizontal and vertical components.

$$\text{Horizontal components, } \Sigma F_X = 60\cos 30° - 80\cos 45° = -4.607$$

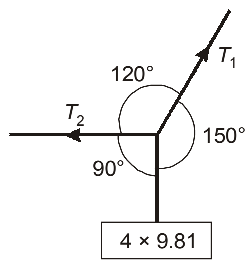
$$\text{Vertical components, } \Sigma F_Y = 80\sin 45° + 60\sin 30° = 86.568$$

$$\text{Resultant, } R = \sqrt{(\Sigma F_X)^2 + (\Sigma F_Y)^2} = \sqrt{(-4.607)^2 + (86.568)^2}$$

$$= 86.69\text{ N}$$

3. (a)

As the body is in equilibrium, using Lami's theorem



$\therefore$ $$\frac{T_1}{\sin 90°} = \frac{4\times 9.81}{\sin(120°)}$$

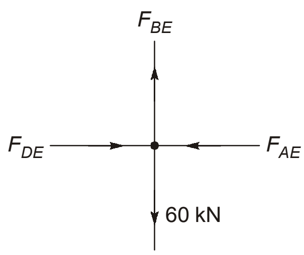
$\therefore$ $$T_1 = 45.310\text{ N}$$

$$\frac{T_2}{\sin 150°} = \frac{4\times 9.81}{\sin 120°}$$

$\Rightarrow$ $$T_2 = 22.65\text{ N}$$

4. (b)

Consider joint (E)

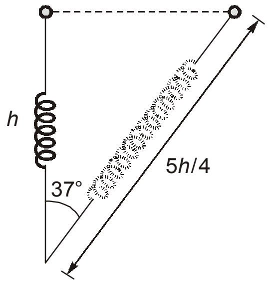


$$F_{BE} = 60\text{ kN (Tensile)}$$

6. (b)

$\therefore$ The kinetic energy of the ring will be given by the potential energy of spring.

$\therefore$ Let V be the speed of the ring when the spring becomes vertical



$$\frac{1}{2}mV^2 = \frac{1}{2}k[X]^2$$

$$X = \frac{5h}{4} - h = \frac{h}{4}$$

$$mV^2 = k\left[\frac{h}{4}\right]^2$$

$$V = \frac{h}{4}\sqrt{\frac{k}{m}}$$

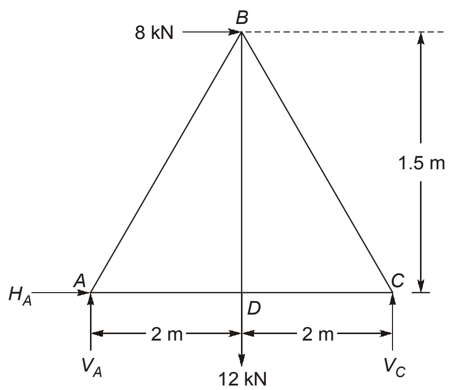
8. (b)

Using Lami's Theorem,

$$\frac{T_1}{\sin 120°} = \frac{T_2}{\sin(360° - (90° + 120°))}$$

$$\frac{T_1}{T_2} = \frac{\sin 120°}{\sin 150°} = 1.732$$

9. (c)



∵ Taking moments about A,

$$V_C \times 4 = 8 \times 1.5 + 12 \times 2$$

$$V_C = \frac{12 + 24}{4} = \frac{36}{4} = 9 \text{ kN}$$

Reaction of support C, V_C = 9 kN

10. (d)

Let u, v, w be the components of velocity in x, y and z direction respectively.

$$u = \frac{dx}{dt} = 2\cos t$$

Similarly,
$$v = -3\sin t$$
$$w = \sqrt{5}\cos t$$
$$V = \sqrt{u^2 + v^2 + w^2}$$
$$= \sqrt{(2\cos t)^2 + (-3\sin t)^2 + (\sqrt{5}\cos t)^2}$$
$$V = \sqrt{4\cos^2 t + 9\sin^2 t + 5\cos^2 t}$$
$$V = \sqrt{9(\sin^2 t + \cos^2 t)} = 3\,\text{units}$$

11. (c)

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

Let resisting force, $F = Kv^2$

if m is mass of the bullet then,

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

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

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

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

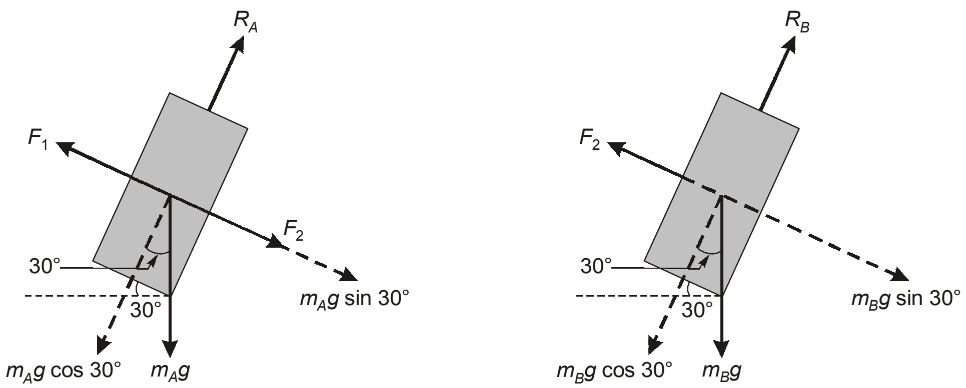
$\Rightarrow$ $$\left[\frac{v-u}{uv}\right] = \frac{K}{m}t$$

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

$\therefore$ $$t \propto (u-v)(uv)^{-1}$$

12. (c)

The FBD of the blocks A and B are shown below



Here F_1 and F_2 are the spring forces.

$$F = k\Delta z = k(x_0 - x_{unstretched})$$
$$F_1 = 1000 \times (0.3 - 0.25) = 50 \text{ N}$$

and
$$F_2 = 1000 \times (0.28 - 0.25) = 30 \text{ N}$$

At equilibrium,

ΣForces along the plane for mass $A = 0$

$$\Rightarrow \quad -F_1 + F_2 + m_A g \sin 30° = 0$$

$$\Rightarrow \quad m_A = \frac{F_1 - F_2}{g \sin 30°} = \frac{50 - 30}{9.81 \times 0.5} = 4.08 \text{ kg}$$

and ΣForces along the plane for mass $B = 0$

$$\Rightarrow \quad -F_2 + m_B g \sin 30° = 0$$

$$\Rightarrow \quad m_B = \frac{F_2}{g \sin 30°}$$
$$= \frac{30}{9.81 \times 0.5} = 6.12 \text{ kg}$$

13. (a)

$$\text{K.E.} = \frac{1}{2} I\omega^2$$

$$I = \frac{mr^2}{2} = \frac{20 \times (0.2)^2}{2} = 0.4 \text{ kgm}^2$$

$$\omega = \frac{2\pi N}{60} = \frac{2 \times 3.14 \times 500}{60} = 52.33 \text{ rad/s}$$

$$\text{K.E.} = \frac{1}{2} \times 0.4 \times 52.33^2 = 547.68 \text{ J}$$

14. (d)

Let speed of car moving in opposite direction is V m/s.

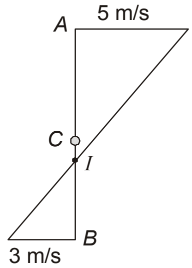
From relative velocity approach

$$\frac{12}{V + 50} = \frac{5}{60}$$
$$12 \times 60 = 5v + 250$$
$$V = 94 \text{ km/hr}$$

15. (c)

$\because$ Velocities are in opposite directions,

$\therefore$ I will lie between A and B,

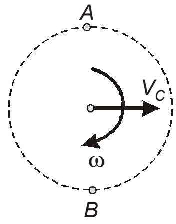


$$\frac{IA}{IB} = \frac{V_a}{V_b} = \frac{5}{3}$$

$$\Rightarrow \quad \frac{0.5 - IB}{IB} = \frac{5}{3}$$
$$IB = 0.1875 \text{ m}$$
$$IA = 0.3125 \text{ m}$$
$$\omega = \frac{V_A}{IA} = \frac{5}{0.3125} = 16 \text{ rad/s}$$

Alternatively,

$$\therefore \quad V_A = V_C + R\omega$$
$$V_B = R\omega - V_C$$
$$\therefore \quad V_C + R\omega = 5$$
$$R\omega - V_C = 3$$
$$V_C + 0.25\,\omega = 5 \quad \text{...(a)}$$
$$0.25\,\omega - V_C = 3 \quad \text{...(b)}$$



On solving (a) and (b),

$$\omega = 16 \text{ rad/s}$$
$$V_C = 1 \text{ m/s}$$

where V_C = velocity of centre C.

16. (d)

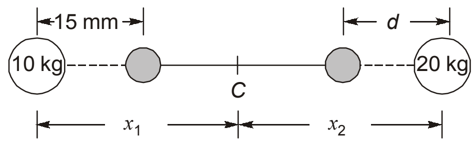
$$E = \frac{1}{2}I\omega^2$$
$$I = MR^2$$
$$E = \frac{1}{2}MR^2\omega^2$$
$$\frac{E_1}{E_2} = \frac{MR_1^2\omega^2}{MR_2^2\omega^2} = 4$$

17. (a)

$$I_y = I_x = \frac{1}{2}I_{\text{circle}} = \frac{1}{2}\times\pi\times\frac{D^4}{64} = \frac{\pi r^4}{8}$$

18. (d)

To keep centre of mass at C



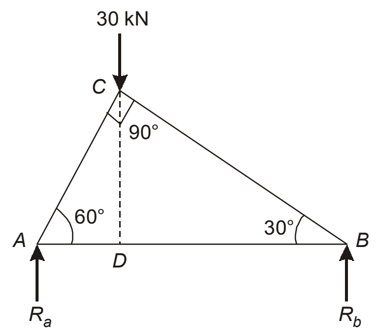
$$m_1x_1 = m_2x_2$$

$\rightarrow$ (Let 10 kg = m_1, 20 kg = m_2)

and

$$m_1(x_1 - 15) = m_2(x_2 - d)$$
$$15\,m_1 = m_2 d$$
$$d = \frac{15\times 10}{20} = 7.5 \text{ mm}$$

19. (b)



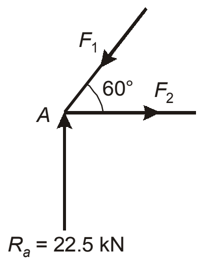
$$AC = AB\cos 60° = 2.5 \text{ m}$$
$$AD = AC\cos 60° = 2.5\times 0.5 = 1.25$$

$\therefore$ Taking moments about A,

$$R_b\times 5 = 30\times 1.25$$

$$R_b = 7.5 \text{ kN}, \quad R_a = 30 - 7.5 = 22.5 \text{ kN}$$

Considering joint A,



$$\Sigma F_x = 0, \quad F_2 - F_1 \cos 60° = 0$$

$$F_1 \sin 60° - R_a = 0$$

$$F_1 = \frac{R_a}{\sin 60°} = \frac{22.5}{\sin 60°} = 25.97 \text{ kN} \qquad \text{(compressive)}$$

$$F_2 = F_1 \cos 60° = 12.99 \text{ kN} \qquad \text{(tensile)}$$

∴ AB is in tension.

20. (a)

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

$$g = \frac{4\pi^2 L}{T^2}$$

In given problem $T = \frac{36}{20} = 1.8$ s

∴ $$g = \frac{4 \times \pi^2 \times 0.8}{1.8^2} = 9.74 \text{ m/s}^2$$

21. (a)

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

$$2.5 = \frac{1}{2}\alpha (1)^2$$

$$\alpha = 5 \text{ rad/s}^2$$

The angle rotated during 1st two second

$$= \frac{1}{2} \times 5 \times 2^2 = 10 \text{ radian}$$

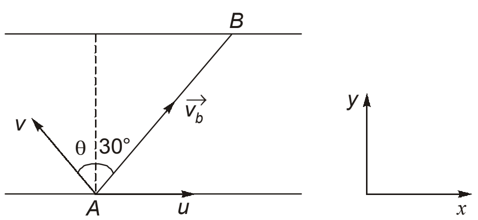
then

Angle rotated during the 2nd second is

$$10 - 2.5 = 7.5 \text{ radian}$$

22. (d)

Let v be the speed of boatman in still water



Resultant of u and v should be along AB. Components of $\vec{v}_b$ (absolute velocity of boatman) along x and y -direction are :

$$v_x = u - v\sin\theta,\ v_y = v\cos\theta$$

$$\tan 30° = \frac{v_y}{v_x}$$

$$\Rightarrow \quad 0.577 = \frac{v\cos\theta}{u - v\sin\theta}$$

$$0.577u - 0.577\,v\sin\theta = v\cos\theta$$

$$\Rightarrow \quad v = \frac{0.577u}{0.577\sin\theta + \cos\theta}$$

$$v = \frac{(0.577 \times \cos 30°)u}{\sin 30° \sin\theta + \cos 30° \cos\theta}$$

$$v = \frac{0.49964}{\sin(\theta + 30°)}$$

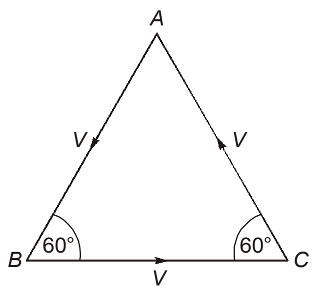
$$v \text{ is minimum at } \theta = 60°,$$

$$\Rightarrow \quad v_{\min} = 0.49964$$

$$v_{\min} \simeq 0.54$$

23. (a)

Velocity of A is v along AB and velocity of particle B is along BC, its component along BA is $v\cos 60° = \frac{v}{2}$.



Thus separation AB decreases at the rate of

$$v + \frac{v}{2} = \frac{3v}{2}$$

Since this rate is constant, time taken in reducing separation from AB from d to zero is

$$t = \frac{d}{3v/2} = \frac{2d}{3v}$$

24. (b)

$$\Sigma M_A = 0$$

$$\Rightarrow \quad P \times a\sin 60° = 2a \cdot R_{cv}$$

$$\Rightarrow \quad R_{cv} = 0.433\,P \uparrow$$

$$R_{CH} = 0$$

$$\Rightarrow \quad R_c = 0.433\,P$$

$A \rightarrow (1)$

Reaction at A

$$\Sigma F_y = 0$$

$$\Rightarrow \quad R_{AV} = 0.433P$$

$$\Sigma F_x = 0;\ R_{AH} = P$$

$$R_A = \sqrt{(0.433P)^2 + P^2} = 1.09\,P$$

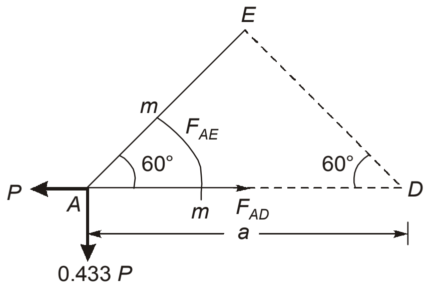
$B \rightarrow (4)$

At joint E, members AE and EB are collinear and member DE is joined at E.

$$\Rightarrow \quad F_{DE} = 0$$

$D \rightarrow (3)$

Taking section mm as shown,



$$\Sigma M_E = 0$$

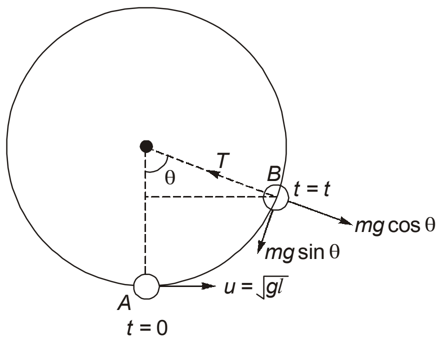
$\Rightarrow$ $$P \times a \times \sin 60° = 0.433 P \times a \sin 30° + F_{AD} \times a \sin 60°$$

$\Rightarrow$ $$0.866 P = 0.2165 P + 0.866\ F_{AD}$$

$\Rightarrow$ $$F_{AD} = P - 0.25 P = 0.75 P$$

$C \rightarrow (2)$

25. (c)



Let $T = mg$ at angle θ shown in figure

$$h = l(1 - \cos\theta) \quad ...(1)$$

Apply conservation of mechanical energy between points A and B,

$$\frac{1}{2} m\left(u^2 - v^2\right) = mgh$$

$$u^2 = gl \quad ...(2)$$

v = Speed of particle in position on B

$$v^2 = u^2 - 2gh \quad ...(3)$$

$$T - mg\cos\theta = \frac{mv^2}{l}$$

$$mg - mg\cos\theta = \frac{mv^2}{l}$$

$\Rightarrow$ $$v^2 = gl(1 - \cos\theta) \quad ...(4)$$

Substituting the values of v^2, u^2 and h from equations (4), (2) and (1) in equation (3).

$$gl(1 - \cos\theta) = gl - 2gl(1 - \cos\theta)$$

$$\cos\theta = \frac{2}{3}$$

$$\theta = \cos^{-1}\left(\frac{2}{3}\right)$$

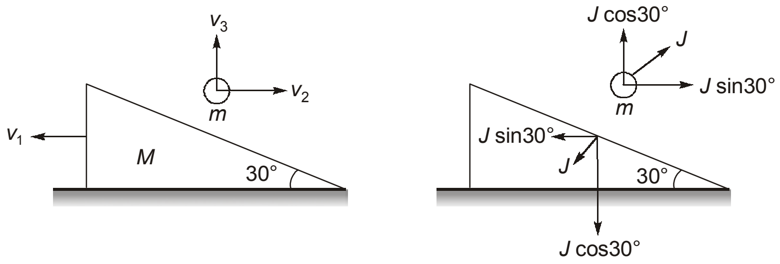
Substituting $\cos\theta = \frac{2}{3}$ in equation (4),

$$v = \sqrt{\frac{gl}{3}}$$

26. (b)

Given:

$$M = 2 \text{ kg and } m = 1 \text{ kg}$$



Let J be the impulse between ball and the wedge during collision and v_1, v_2 and v_3 be the components of the velocity of the wedge and the ball in horizontal and vertical directions respectively.

$$\text{Impulse} = \text{Change in momentum}$$

$$J\sin 30° = Mv_1 - mv_2$$

$$\Rightarrow \quad \frac{J}{2} = 2v_1 - v_2 \quad \text{...(1)}$$

$$J\cos 30° = m(v_3 + v_o)$$

$$\Rightarrow \quad \frac{\sqrt{3}}{2}J = v_3 + 2 \quad \text{...(2)}$$

$$\frac{\text{Relative speed of separation}}{\text{Relative speed of approach}} = \text{Coefficient of restitution}$$

$$\frac{(v_1 + v_2)\sin 30° + v_3 \cos 30°}{v_o \cos 30°} = \frac{1}{2}$$

$$\Rightarrow \quad v_1 + v_2 + \sqrt{3}v_3 = \sqrt{3} \quad \text{...(3)}$$

Solving equations (1), (2) and (3),

$$v_1 = \frac{-1}{\sqrt{3}} \text{ m/s}$$

$$v_2 = \frac{2}{\sqrt{3}} \text{ m/s and } v_3 = 0$$

$$\text{Thus velocity of wedge} = \frac{-1}{\sqrt{3}}\hat{i} \text{ m/s}$$

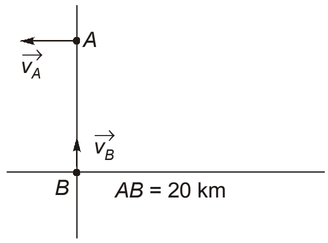
$$\text{Velocity of ball} = \frac{2}{\sqrt{3}}\hat{i} \text{ m/s}$$

27. (a)

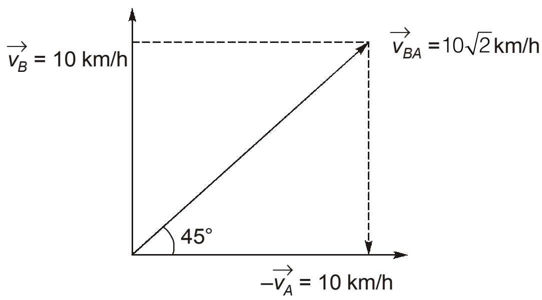
Boats A and B are moving with same speed 10 km/h in the directions shown in figure. It corresponds to a 2-dimensional, 2 body problem with zero acceleration.

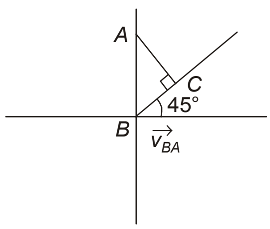
$$\overrightarrow{v_{BA}} = \overrightarrow{v_B} - \overrightarrow{v_A}$$

$$\left|\overrightarrow{v_{BA}}\right| = \sqrt{(10)^2 + (10)^2} = 10\sqrt{2} \text{ km/h}$$



In can be assumed that A is at rest and B is moving with $\overrightarrow{v_{BA}}$ in the direction shown

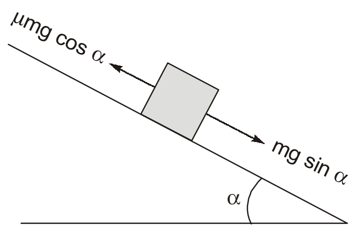




$$\text{Minimum distance} = AC = AB\sin 45° = \frac{20}{\sqrt{2}}\text{ km} = 10\sqrt{2}\text{ km}$$

$$\text{time is } t = \frac{BC}{|\overrightarrow{V_{BA}}|} = \frac{10\sqrt{2}}{10\sqrt{2}} = 1\text{ hr}$$

28. (a)



Here, $\alpha = 45°$

We have: $a = \frac{dV}{dt} \Rightarrow a = \frac{dV}{dx}\times\frac{dx}{dt}$

$\therefore$ $a = \frac{dV}{dx}\times V$

Also, $a = \frac{mg\sin\alpha - \mu mg\cos\alpha}{m}$

$a = g[\sin\alpha - \mu\cos\alpha]$

$\therefore$ $g[\sin\alpha - \mu\cos\alpha] = \frac{dV}{dx}\times V$

$\therefore$ $g[\sin\alpha\cdot dx - 5x\cos\alpha\, dx] = V\cdot dV$

On integrating,

$$g\left[\sin\alpha\cdot x - 5\cos\alpha\times\frac{x^2}{2}\right] = \left[\frac{V^2}{2}\right]_0^0$$

$$g\left[\sin\alpha\cdot x - 5\cos\alpha\times\frac{x^2}{2}\right] = 0$$

$$\Rightarrow \qquad \sin\alpha \cdot x = 5\cos\alpha \times \frac{x^2}{2}$$

$$x = \frac{2\tan\alpha}{5} \Rightarrow \frac{2\tan 45°}{5} = 0.4\,\text{m}$$

29. (b)

We have,

$$\text{Torque} = I\alpha$$

$$\therefore \qquad 3F\sin 30° \times 0.5 = I\alpha$$

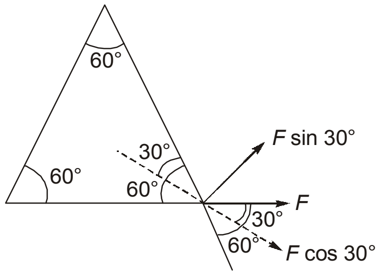
$$3 \times 0.5 \times \frac{1}{2} \times 0.5 = 1.5 \times \frac{0.5^2}{2} \times \alpha$$

$$\therefore \qquad \alpha = 2\ \text{rad/s}^{-1}$$

$$\therefore \qquad \omega = \omega_0 + \alpha t$$

$$\omega = 0 + 2 \times 1$$

$$\omega = 2\ \text{rad s}^{-1}$$



30. (a)

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

$$\Rightarrow \qquad \alpha\sqrt{v} = \frac{dv}{dt}$$

$$\Rightarrow \qquad \alpha\int_{t=0}^{t} dt = \int_{v_o}^{0} \frac{dv}{\sqrt{v}}$$

$$\Rightarrow \qquad \alpha t = \frac{v_0^{-1/2+1}}{\frac{-1}{2}+1}$$

$$\Rightarrow \qquad t = \frac{2\sqrt{v_o}}{\alpha}$$

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