CLASS TEST

S.No.: 05DLSKCE_FGHI_171125

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ENGINEERING MECHANICS

CIVIL ENGINEERING

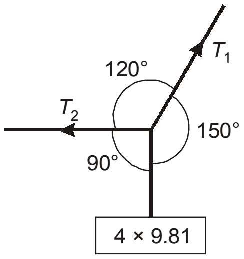
Date of Test : 17/11/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (a)



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

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

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

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

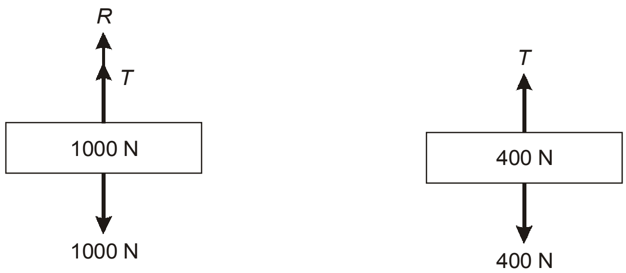
$$\Rightarrow \quad T_2 = 22.65 \text{ N}$$

2. (b)

Drawing free diagram of blocks, we have,

For 400 N, block:

$$T = 400 \text{ N}$$



Now, for 1000 N block:

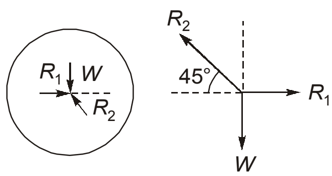
$$T + R = 1000$$

$$\therefore \quad 400 + R = 1000$$

$$R = 600 \text{ N}$$

This is the reaction from the ground and it is the same force with which the 1000 N block press against the floor.

3. (b)



$$R_2 \cos 45° = R_1$$

$$R_2 \sin 45° = W$$

$$\Rightarrow \quad R_2 = W\sqrt{2}$$

$$\therefore \quad R_1 = W\sqrt{2}\times\frac{1}{\sqrt{2}} = W$$

$$W = 50 \text{ N}$$

$$\therefore \quad R_1 = 50 \text{ N}$$

4. (c)

Normal reaction, $N = 200 - P\sin 30° = 200 - 100 \times 0.5 = 150$ N

Frictional force, $F = \mu N = 0.3 \times 150 = 45$ N

5. (d)

For no tipping or prevent overturning

$$Ph < \frac{Wb}{2}$$

where $W \rightarrow$ weight of block

and $b \rightarrow$ width of block

$$h < \frac{Wb}{2P} \quad \text{...(1)}$$

and for slipping without tipping

$$P > f(\text{force of friction})$$

$$P > \mu W \quad \text{...(2)}$$

From (1) and (2)

$$h < \frac{b}{2\mu}$$

$$\therefore \quad h < \frac{60}{0.6}$$

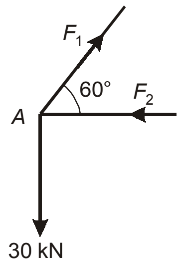
$$\therefore \quad h < 100 \text{ mm}$$

Option (d) is correct.

6. (c)

Consider the free body diagram of joint A with the direction of forces assumed as shown.

Joint *A*,



Equations of equilibrium are:

$$\Sigma F_x = 0$$

$$F_1 \cos 60° - F_2 = 0$$

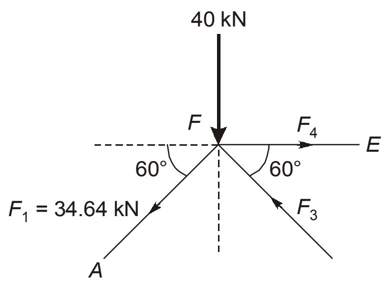
Also, $$\Sigma F_y = 0$$

$$F_1 \sin 60° - 30 = 0$$

$$\therefore \quad F_1 = 34.64 \text{ kN}$$

$$F_2 = F_1 \cos 60° = 34.64 \times 0.5 = 17.32 \text{ kN (compression)}$$

Joint *F*,

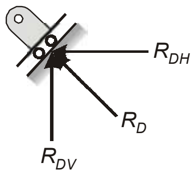


$$\Sigma F_x = 0$$
$$F_4 - F_3 \cos 60° - 34.64 \cos 60° = 0$$
$$F_4 = 0.5 F_3 + 17.32$$
$$\Sigma F_y = 0$$
$$F_3 \sin 60° - 34.64 \sin 60° - 40 = 0$$
$$F_3 = 80.81 \text{ kN}$$
$$F_4 = 0.5 \times 80.81 + 17.32$$
$$= 57.72 \text{ (tension)}$$
$$\therefore \quad \frac{F_4}{F_2} = 3.332$$

7. **(c)**

Truss is supported on rollers at D,

$\therefore$ Reaction at this support will be normal to the support i.e. inclined at 45° with vertical.



Let, R_A = Reaction at A

R_D = Reaction at D

$$\therefore \quad R_{DH} = R_{DV} = R_D \cos 45° = 0.707 R_D$$

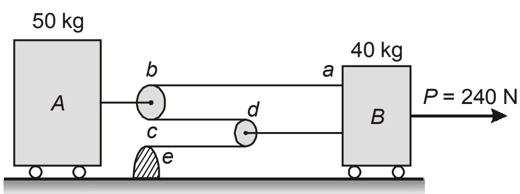
Taking moments about A,

$$R_{DV} \times 9 - R_{DH} \times 4 = (5 \times 3) + (2 \times 6)$$
$$(0.707 R_D \times 9) - (0.707 R_D \times 4) = 27$$
$$\therefore \quad R_D = 7.64 \text{ kN}$$
$$\therefore \quad R_{DH} = R_{DV} = 7.64 \times 0.707 = 5.4 \text{ kN}$$
$$R_{AV} = (5 + 2) - 5.4 = 1.6 \text{ kN}$$
$$R_{AH} = R_{DH} = 5.4$$
$$R_A = \sqrt{1.6^2 + 5.4^2} = 5.63 \text{ kN}$$

According to question, $R_A = x\%$ of R_D

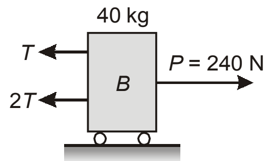
$$5.63 = \frac{x}{100} \times 7.64$$
$$\therefore \quad x = 73.69\%$$

8. **(c)**



As given, acceleration $a_A = 1.5\, a_B$

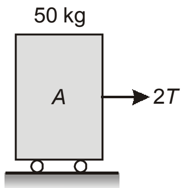
For block B:



$$\Sigma F = \text{Mass} \times \text{Acceleration}$$

$$240 - 3T = 40\, a_B \qquad \text{...(i)}$$

For block *A*:



$\Rightarrow$ $$\Sigma F = \text{Mass} \times \text{Acceleration}$$

$\Rightarrow$ $$2T = 50\, a_A \qquad \text{...(ii)}$$

$\Rightarrow$ $$2T = 50 \times 1.5\, a_B$$

$\Rightarrow$ $$2T = 75\, a_B \qquad \text{...(iii)}$$

Using equation (i) and (iii), we get

$\Rightarrow$ $$240 - 1.5 \times 75\, a_B = 40\, a_B$$

$\Rightarrow$ $$152.5\, a_B = 240$$

$\therefore$ $$a_B = 1.57 \text{ m/s}^2$$

9. (c)

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

$$\text{Area of graph} = m\,(V_f - V_i)$$

$$\frac{1}{2} \times 10 \times 10 + (20 \times 14) + (\frac{1}{2} \times 15 \times 14) = m\,(V - 0)$$

But, $$m = 1 \text{ kg}$$

$\therefore$ $$V = 435 \text{ m/s}$$

$$\text{Average force} = \frac{\text{Area of graph}}{\text{Total time}} = \frac{435}{45} = 9.666\,\text{N}$$

$\therefore$ $$\text{Acceleration} = 9.666 \text{ m/s}^2 \qquad (\because\ a = F/M)$$

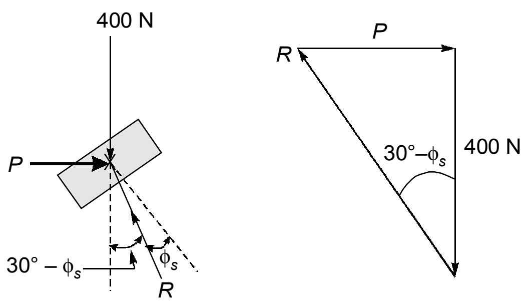
$\therefore$ $$\text{Displacement, } S = \frac{1}{2} \times 9.666 \times 45^2 + (15 \times 435)$$

($\because$ Body will travel with constant velocity of 435 m/s for the next 15 seconds after the removal of force)

$$S = 16312.5 \text{ m} \simeq 16.3 \text{ km}$$

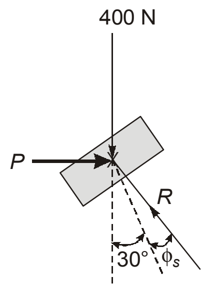
10. (b)

FBD for impending motion downwards,



$$\phi_s = \tan^{-1}\mu_s = \tan^{-1}0.25 = 14.036°$$
$$P = 400\tan(30° - \phi_s) = 400\tan(15.96°) = 114.42\text{ N}$$

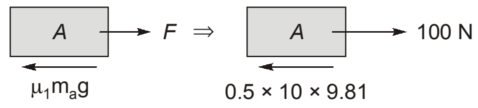
FBD for impending motion upwards,



$$P = 400\tan(30 + \phi_s)$$
$$= 400\tan 44.036° = 386.76\text{ N}$$
$$\therefore \quad 115\text{ N} \le P \le 386\text{ N}$$

11. **(b)**

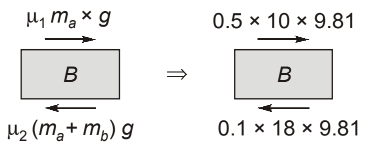
Free body diagram of A:



Writing equation of motion for A.

$$100 - 0.5 \times 10 \times 9.81 = 10a_a$$
$$\Rightarrow \quad a_a = 5.095\text{ m/s}^2$$

Free body diagram of B:



Writing equation of motion for B.

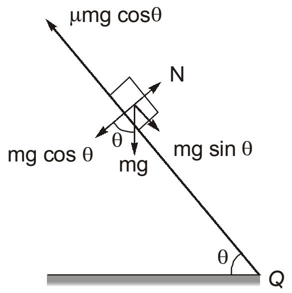
$$49.05 - 17.658 = 8\,a_b$$
$$\Rightarrow \quad a_b = 3.924\text{ m/s}^2$$

After 0.1s,
$$V_A = U_a + a_a t.$$
$$V_A = 0 + 5.095 \times 0.1$$
$$V_A = 0.5095\text{ m/s}$$

Similarly,
$$V_B = 0 + 3.924 \times 0.1$$
$$V_B = 0.3924\text{ m/s}$$

$\therefore$ Relative velocity of A w.r.t. B $= V_A - V_B$
$$= 0.5095 - 0.3924 \simeq 0.12\text{ m/s}$$

12. (a)



From Newton's second law

$$mg\sin\theta - \mu mg\cos\theta = ma$$

$$\therefore \quad a = g(\sin\theta - \mu\cos\theta)$$

$$\Rightarrow \quad a = g\cos\theta(\tan\theta - \mu)$$

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

$$\Rightarrow \quad s = 0 + \frac{1}{2}g\cos\theta(\tan\theta - \mu)\cdot t^2$$

$$\therefore \quad t = \sqrt{\frac{2s}{g\cos\theta(\tan\theta - \mu)}}$$

13. (b)

$$x = 10\sin 2t + 15\cos 2t + 100$$

$$v = \frac{dx}{dt} = 20\cos 2t - 30\sin 2t$$

$$a = \frac{dv}{dt} = -40\sin 2t - 60\cos 2t \qquad ...(i)$$

For a_{max},
$$\frac{da}{dt} = 0$$

$$\Rightarrow \quad -80\cos 2t + 120\sin 2t = 0$$

$$\tan 2t = \frac{2}{3}$$

$$\Rightarrow \quad 2t = 33.69$$

Now using equation (i), we get

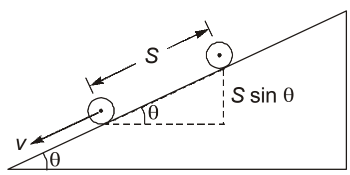
$$a_{max} = -40\sin(33.69) - 60\times\cos(33.69) = -72.11\ \text{mm/s}^2$$

14. (c)

$$I = \frac{mr^2}{2} = \frac{10\times 0.1^2}{2} = 0.05\ \text{kgm}^2$$

$$V = 5\ \text{m/s}$$

$$\omega = \frac{V}{r} = \frac{5}{0.1} = 50\ \text{rad/s}$$



$$\text{KE} = \frac{1}{2}mV^2 + \frac{I}{2}\omega^2$$

$$= \frac{1}{2}\times 10\times 5^2 + \frac{0.05}{2}\times 50^2$$

$$= 125 + 62.5 = 187.5 \text{ Nm}$$

$$\text{Gain in KE} = \text{Loss in PE} \qquad \text{(frictionless condition)}$$

$$\therefore \quad 187.5 = mg.S.\sin\theta$$

$$= 10g \sin 30° \text{ S} = 5\,gS$$

$$S = \frac{187.5}{5\times 9.81} = 3.82\,\text{m}$$

15. (a)

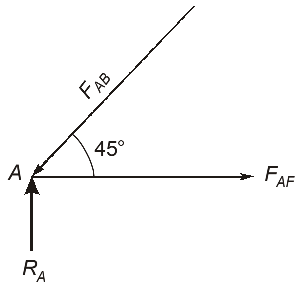
Reaction at A is R_A

Taking moments about point E,

$$W\times\frac{a}{2}+Wa = 2a\cdot R_A$$

$$\therefore \quad R_A = 0.75 \text{ W}$$

Joint A



$$F_{AB}\sin 45° = R_A$$

$$F_{AB} = 1.06\,\text{W (compressive)}$$

16. (b)

$$\Sigma M_A = 0$$

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

$$\Rightarrow \quad R_{C_v} = 0.433\ P \uparrow$$

$$R_{C_h} = 0$$

$$\Rightarrow \quad R_C = 0.433\ P$$

$A \rightarrow (1)$

Reaction at A

$$\Sigma F_y = 0$$

$$\Rightarrow \quad R_{A_v} = 0.433P\ (\downarrow)$$

$$\Sigma F_x = 0;\ R_{A_h} = P\ (\leftarrow)$$

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

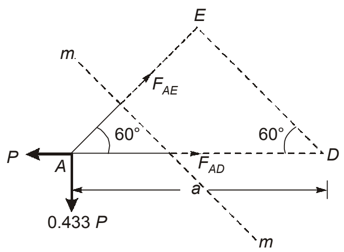
$B \rightarrow (4)$

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 m-m as shown,



$$\Sigma M_E = 0$$

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

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

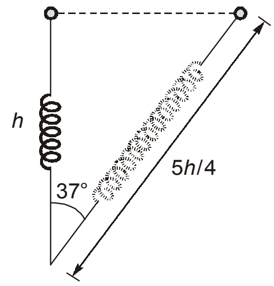
$$\Rightarrow \quad F_{AD} = P - 0.25P = 0.75P$$

$C \rightarrow (2)$

17. (b)

∴ The kinetic energy of the ring will be given by the potential energy of spring.

∴ Let V be the speed of the ring when the spring becomes vertical



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

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

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

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

18. (a)

$$5g(2.1) = \frac{1}{2} \times 5 \times V^2 + \frac{1}{2}k\delta^2 \qquad [\because\ k = 10000\ \text{N/m}]$$

$$\Rightarrow \quad 10.5g = 2.5V^2 + \frac{1}{2} \times 10000 \times (0.1)^2$$

$$\Rightarrow \quad 10.5 \times 9.81 = 2.5\ V^2 + 50$$

$$\Rightarrow \quad V^2 = 21.202$$

$$\therefore \quad V = 4.6\ \text{m/s}$$

19. (c)

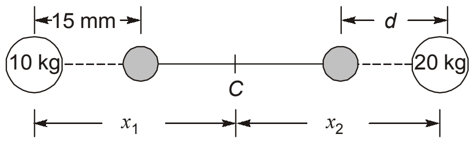
$$\text{Resistance} = mg + W = 200 \times 9.81 + 100 = 2062\ \text{N}$$

$$\therefore \quad a = \frac{2062}{200}$$

$$a = 10.31\ \text{m/s}^2$$

$$\frac{V^2}{2a} = S = \frac{4^2}{2 \times 10.31} = 0.776\ \text{m}$$

20. (c)



To keep centre of mass at C

$$m_1x_1 = m_2x_2 \quad \rightarrow \quad (\text{Let } 10 \text{ kg} = m_1, 20 \text{ kg} = m_2)$$

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

21. (c)

Normal reaction, $N = 200 - P \sin 30° = 200 - 100 \times 0.5 = 150$ N

Frictional force, $F = \mu N = 0.3 \times 150 = 45$ N

22. (a)

Let V' and V'' be the speed of Y and X respectively after collision.

Applying conservation of angular momentum,

$$mV = 2mV' - mV'' \quad \text{...(a)}$$

Applying conservation of kinetic energy,

$$\frac{1}{2}mV^2 = \frac{1}{2}2mV'^2 + \frac{1}{2}mV''^2 \quad \text{...(b)}$$

Solving (a) and (b), $V' = 2V''$

$$V = 3V''$$

$$\Rightarrow \quad V'' = \frac{V}{3}$$

$$\Rightarrow \quad V' = \frac{2V}{3}$$

23. (b)

For a statically determinate frame,

We know, $m = 2j - 3$

Where, m = Number of members

j = Number of joints

On comparing with, $y = mx + c$

$c = -3;\ m = \tan\theta = 2$

$\therefore \quad \theta = 63.43°$

24. (b)

As per given information,

$$m = 30 \text{ kg}; \qquad r = 0.2 \text{ m}$$
$$\omega = 20 \text{ rad/s}; \qquad T = 5 \text{ Nm}$$
$$F = 10 \text{ N}$$

$$I = \frac{1}{2}mr^2 = \frac{1}{2}\times 30 \times 0.2^2 = 0.6 \text{ kg.m}^2$$

Let the disk rotate an angle of θ rad.

From work energy principle

$$T\cdot\theta + F\times r\cdot\theta = \frac{1}{2}\times I\times\omega^2 \qquad [\because \text{ Workdone = change in energy}]$$

$$5\cdot\theta + 10\times 0.2\times\theta = \frac{1}{2}\times 0.6\times(20)^2$$

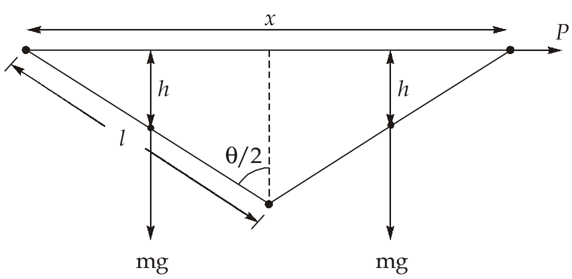
$$7\cdot\theta = 120$$

$$\theta = 17.14 \text{ rad}$$

$$\text{Number of revolution} = \frac{\theta}{2\pi} = \frac{17.14}{2\pi} = 2.73 \text{ rev}$$

25. (b)

Apply virtual work method,



$$x = 2l\sin\left(\frac{\theta}{2}\right)$$

$$h = \frac{l}{2}\cos\left(\frac{\theta}{2}\right)$$

$$\Rightarrow \quad dx = 2l\cos\left(\frac{\theta}{2}\right)\frac{d\theta}{2}$$

$$dh = -\frac{l}{2}\sin\left(\frac{\theta}{2}\right)\frac{d\theta}{2}$$

$$\Rightarrow \quad \frac{dx}{\cos\left(\frac{\theta}{2}\right)} = -\frac{dh}{\sin\left(\frac{\theta}{2}\right)}\times 4$$

By principle of virtual work,

$$\Rightarrow \quad Pdx + 2mgdh = 0 = \text{WD}$$

$$\Rightarrow \quad P\times dx = 2mg\times\tan\left(\frac{\theta}{2}\right)\times\frac{dx}{4}$$

$$\Rightarrow \quad \frac{2P}{mg} = \tan\left(\frac{\theta}{2}\right)$$

$$\Rightarrow \quad \theta = 2\times\tan^{-1}\left(\frac{2P}{mg}\right)$$

$$\theta = 90°$$

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