CLASS TEST

S.No. : 01 JP_CE_A_110619

Engineering Mechanics

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CIVIL 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 For perfectly elastic bodies, the value of coefficient of restitution is
(a) 0 (b) 1
(c) infinity (d) can't say

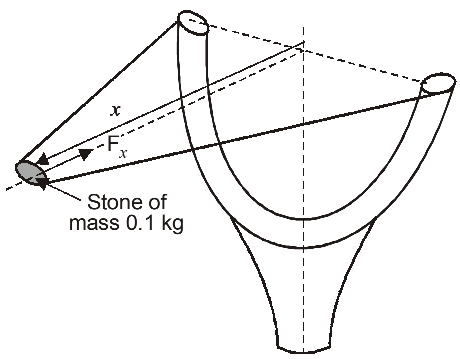
Q.2 A wheel rotates with a constant acceleration of 2 rad s^{-2}. If it starts from rest, the number of revolutions it will make in first 10 s is
(a) 6.23 (b) 9.67
(c) 15.92 (d) 19.12

Q.3 Which one of the following is conserved during inelastic collision of two particles?
(a) Total linear momentum only
(b) Total kinetic energy only
(c) Both linear momentum and kinetic energy
(d) Neither linear momentum nor kinetic energy

Q.4 A stone with a mass of 0.1 kg is catapulted as shown in the figure. The total force F_x (in N) exerted by the rubber band as a function of distance x (in m) is given by,

$$F_x = 300x^2$$

If the stone is displaced by 0.1 m from the un-stretched position (x = 0) of the rubber band then the energy stored in the rubber band is



(a) 0.1 Joules (b) 1 Joules
(c) 10 Joules (d) 100 Joules

Q.5 The rotor of an electric motor has an angular velocity of 3600 rpm when the load and power are cut off. The 50 kg rotor, which has a centroidal radius of 180 mm, then comes to rest. Knowing that kinetic friction results in a couple of magnitude 3.5 Nm exerted on the rotor, the number of revolutions that the rotor executes before coming to rest is
(a) 4082 (b) 4867
(c) 5235 (d) 5691

Q.6 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 600 rpm then the kinetic energy of the flywheel is
(a) 450 Joules (b) 630 Joules
(c) 790 Joules (d) 820 Joules

Q.7 A force F has components, F_x = 200 N, F_y = – 346.4 N, F_z = 300 N. The angle of inclination of the force F with x-axis is
(a) 33.21° (b) 48.25°
(c) 66.42° (d) 96.50°

Q.8 A rail road freight car weighs 1000 kN with wheels having a radius of 750 mm. If the rolling resistance of the rail road freight car is 30 N, then the coefficient of rolling resistance is
(a) 22.5×10^{-3} mm (b) 17.2×10^{-3} mm
(c) 13.1×10^{-3} mm (d) 11.9×10^{-3} mm

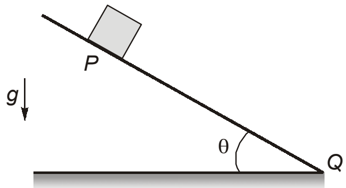
Q.9 A lift of total mass 400 kg is moving upward with an acceleration of 3 m/s^2. The tension in the cable supporting the lift is (g = 10 m/s^2)
(a) 0 (b) 2800 N
(c) 4000 N (d) 5200 N

Q.10 A pile hammer of weight 12 kN strikes on a pile of weight 4 kN with a velocity of 4 m/s. The distance by which the pile will move by a single blow of hammer will be
[Take a uniform ground resistance to pile driving as 200 N]
(a) 0.16 m (b) 0.32 m
(c) 0.64 m (d) 1.29 m

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

Q.11 The combined motion of rotation and translation may be assumed to be a motion of pure rotation about some centre which goes on changing from time to time. The centre in question is known as
(a) Shear centre
(b) Meta centre
(c) Gravitational centre
(d) instantaneous centre

Q.12 A block of mass M is released from a point P on a rough inclined plane with inclination angle θ as shown in the figure below. The coefficient of friction is μ. If $\mu < \tan\theta$ then the time taken by the block to reach another point Q on the inclined plane, where $PQ = s$, is



(a) $\sqrt{\dfrac{2s}{g\cos\theta\,(\tan\theta-\mu)}}$

(b) $\sqrt{\dfrac{2s}{g\cos\theta(\tan\theta+\mu)}}$

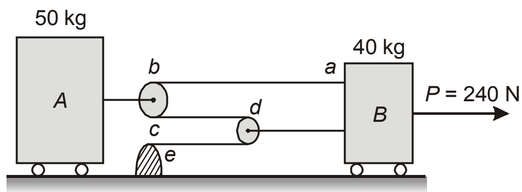
(c) $\sqrt{\dfrac{2s}{g\sin\theta\,(\tan\theta-\mu)}}$

(d) $\sqrt{\dfrac{2s}{g\sin\theta\,(\tan\theta+\mu)}}$

Q.13 A particle is moving along a circular path. Equation of angular velocity is $\omega = 12 + 9t - 3t^2$ rad/s, where t is in seconds. What is maximum angular speed (in rad/s) of particle and at what time (in sec) it reaches the maximum speed?

(a) 18.75 and 3.0 (b) 9.25 and 3.0
(c) 18.75 and 1.5 (d) 9.25 and 1.5

Q.14 Blocks A and B are connected through a cable $abcde$ as shown in the figure given below. If a force P is applied on block B then the acceleration of block B is
[Consider acceleration of block A as 1.5 times of acceleration of block B]



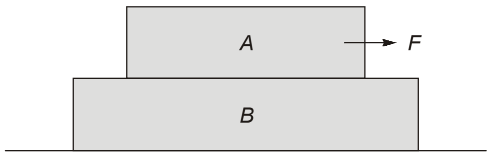
(a) 1.08 m/s^2 (b) 1.23 m/s^2
(c) 1.57 m/s^2 (d) 1.72 m/s^2

Q.15 One ship A, sailing east with a speed of 20 km/h passes a certain point O at noon, a second ship B, sailing north at the same speed of 20 km/h passes the same point O at 2 p.m. The shortest distance in km between them would be

(a) $\dfrac{20}{\sqrt{2}}$ (b) $\sqrt{20}$

(c) $20\sqrt{2}$ (d) $\dfrac{40}{\sqrt{2}}$

Q.16 Block A of mass 10 kg rests on a second block B of mass 8 kg. A force F equal to 100 N pulls block A. The coefficient of friction between A and B is 0.5 and between B and ground, is 0.1. The speed of block A relative to block B in 0.1 s if system starts from rest is [Take g = 9.81 m/s^2]



(a) 0.06 m/s (b) 0.12 m/s
(c) 0.18 m/s (d) 0.24 m/s

Q.17 A block of 5 kg falls freely from a height of 2.1 m on the top of a spring of stiffness 10 N/mm. If the spring is compressed by 0.1 m, then the velocity of the block is

(a) 2.3 m/s (b) 3.4 m/s
(c) 4.6 m/s (d) 6.8 m/s

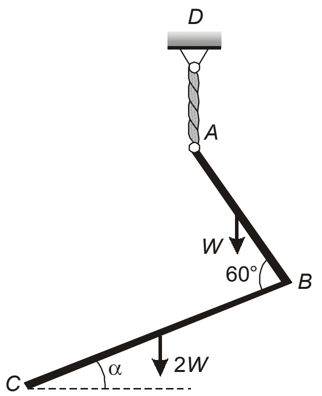
Q.18 A bullet of mass 25 gram strikes and gets embedded in a stationary block of mass 5 kg, which moves horizontally after impact. If the bullet was travelling at 500 m/s before impact then the percentage of energy lost is

(a) 91.5% (b) 93.5%
(c) 96.5% (d) 99.5%

Q.19 A ball is dropped on the ground from the height of 1 m. The coefficient of restitution is 0.6. The height to which the ball will rebound is

(a) 0.6 m (b) 0.4 m
(c) 0.36 m (d) 0.16 m

Q.20 Two prismatic bars *AB* and *BC* of lengths *L* and 2*L* respectively are rigidly joined at *B* and suspended by a string *AD* as shown below. If the bar is assumed under the action of their weights *W* and 2*W* then in the position of equilibrium as shown below, the angle α is



(a) 10.12° (b) 15.10°
(c) 17.88° (d) 19.11°

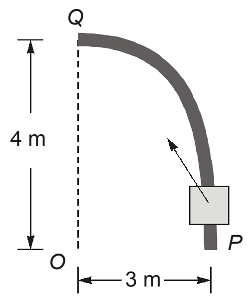
Q.21 A moment *M* is applied to a uniform disc *I* of mass 20 kg and radius 0.2 m which drives another uniform disc *II* of mass 40 kg and radius 0.3 m, without slip occurring between them. If the angular acceleration of disc *I* is 8.33 rad/s^2 the value of *M* is (in Nm)

(a) 10 (b) 8.7
(c) 11.3 (d) 12

Q.22 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) 30 mm (b) 5 mm
(c) 7.5 mm (d) 15 mm

Q.23 Consider an elliptical shaped rail *PQ* in the vertical plane as shown. A block of mass 1 kg is pulled along the rail from *P* to *Q* with a force of 18 N which is always parallel to line *PQ*. The increase in kinetic energy of the block when it reaches *Q* will be
[Assume no friction and g = 10 m/s^2]

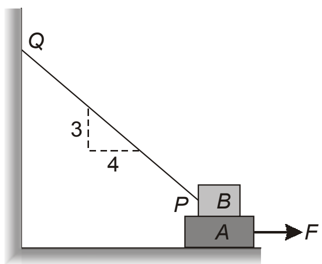


(a) 45 (b) 50
(c) 69 (d) 99

Q.24 A thin circular ring of mass 5 kg and radius 20 cm is rotating about its axis with an angular speed 10 rad/s. Two particles having mass 0.5 kg each are now attached at diametrically opposite points. The angular speed of the ring will be (in rad s^{-1})

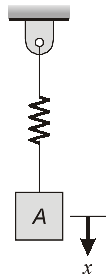
(a) 8.33 (b) 14.92
(c) 7.89 (d) 10

Q.25 Block '*A*' of weight 900 N rests on a horizontal surface and supports on top of it another block '*B*' of weight 225 N. The block '*B*' is attached to a vertical wall by an inclined string *PQ*. The magnitude of the horizontal force *F* applied to the lower block as shown below, that will be necessary to cause slipping to impend, is [Take coefficient of static friction for all the surfaces = 0.3]



(a) 380.2 N (b) 392.5 N
(c) 400.1 N (d) 405.6 N

Q.26 The vertical motion of mass *A* is defined by the relation x = 10 sin 2t + 15 cos 2t + 100, where x and t are expressed in mm and seconds, respectively. The magnitude of maximum acceleration of mass *A* will be

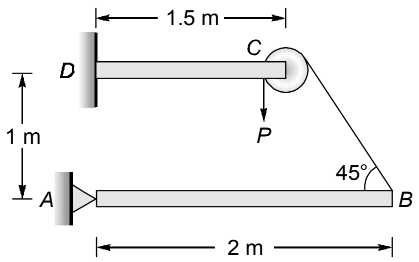


(a) 72.11 mm/sec^2 (b) 63.26 mm/sec^2
(c) 54.33 mm/sec^2 (d) 48.67 mm/sec^2

Q.27 At a certain instant, the linear momentum of a particle is given by
$I = -2\hat{i} - \hat{j} + \hat{k}$ kg m/s and its position vector is
$r = 2\hat{i} - 3\hat{j} + \hat{k}$ m.
The magnitude of angular momentum of the particle about the origin of coordinate axes is nearly (in kgm^2/s)

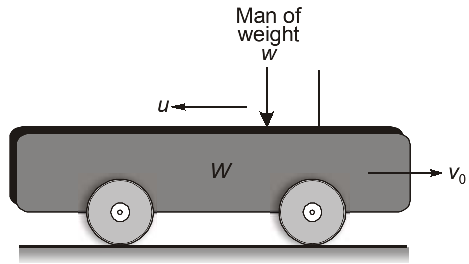
(a) 7 (b) 8
(c) 9 (d) 10

Q.28 A beam *AB*, 2 m long, uniform in cross-section is held in equilibrium by the application of a force '*P*' as shown below. If the self weight of beam *AB* is 100 kN then the magnitude of force '*P*' is



(a) 35.35 kN (b) 45.56 kN
(c) 70.71 kN (d) 91.12 kN

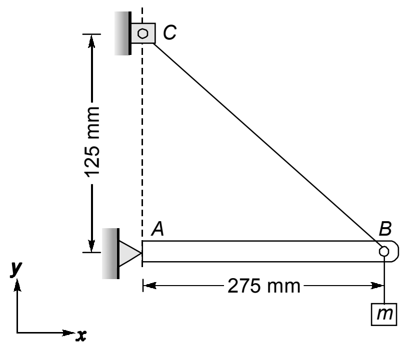
Q.29 A flat car of weight *W* roll without resistance along a horizontal track as shown in the figure. Initially, the car together with a man of weight *w* is moving to the right with speed v_0. What increment of velocity Δv will the car obtain if the man runs with speed *u* relative to the floor of the car and jumps off at the left?



(a) $\frac{wu}{W+w}$ (b) $\frac{Wu}{W+w}$

(c) $\frac{(W+w)u}{W}$ (d) $\frac{(W+w)u}{w}$

Q.30 A mass of 35 kg is suspended from a weightless bar *AB* which is supported by a cable *CB* and a pin at *A* as shown in figure. The tension in cable *CB* will be



(a) 755.5 N (b) 801.6 N
(c) 829.8 N (d) 840.3 N

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CLASS TEST 2019-2020

CIVIL ENGINEERING

Date of Test : 11/06/2019

ANSWER KEY ➤ Engineering Mechanics

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

DETAILED EXPLANATIONS

1. (b)

$$e = \frac{\text{Velocity of separation}}{\text{Velocity of approach}}$$

For perfectly elastic body, $e = 1$ and no dissipation of energy occurs.

2. (c)

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

$$\omega_0 = 0$$

$$\theta = \frac{1}{2}\times 2\times 10^2 = 100\,\text{rad}$$

$$\therefore \quad \text{Number of revolutions} = \frac{100}{2\pi} = 15.92$$

3. (a)

During inelatic collision, only linear momentum is conserved.

4. (a)

Change in the stored energy of rubber band = $F\,dx$

$$\Rightarrow \quad dE = 300x^2 dx$$

$$\text{Integrating,} \quad \int_0^E dE = \int_0^{0.1} 300x^2\,dx$$

$$\Rightarrow \quad E = 300\times \left.\frac{x^3}{3}\right|_0^{0.1} = 0.1\text{ Joule}$$

5. (c)

$$I = mk^2 = 50(0.180)^2 = 1.62\text{ kg.m}^2$$

$$M = I\alpha$$

$$3.5 = (1.62)\,\alpha$$

$$\Rightarrow \quad \alpha = 2.1605\text{ rad/s}^2\text{ (deceleration)}$$

$$\omega_0 = \frac{2\pi N}{60} = \frac{2\pi(3600)}{60} = 120\pi\text{ rad/s}$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta \quad \text{or} \quad 0 = (120\pi)^2 - 2\times 2.1605\times\theta$$

$$\therefore \quad \theta = 32.891\times 10^3\text{ rad}$$

$$\text{Number of revolutions} = \frac{\theta}{2\pi} = \frac{32.891\times 10^3}{2\times 3.14} = 5234.77$$

6. (c)

$$\text{Kinetic energy, } KE = \frac{1}{2}I\omega^2$$

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

$$\omega = \frac{2\pi N}{60} = \frac{2\times\pi\times 600}{60} = 62.83 \text{ rad/sec}$$

$$\therefore \quad KE = \frac{1}{2}\times 0.4\times(62.83)^2 \simeq 790 \text{ Joules}$$

7. (c)

$$F = 100\sqrt{2^2+3^2+(3.464)^2} \simeq 500 \text{ N}$$

$$\cos\alpha = \frac{200}{500} = 0.4$$

$$\alpha = \cos^{-1} 0.4 = 66.42°$$

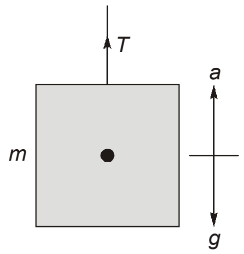
8. (a)

$$P = \frac{W}{R}\cdot\mu$$

where, P = Rolling resistance, R = Radius of wheel, W = Weight of freight car
Coefficient of rolling resistance,

$$\mu = \frac{PR}{W} = \frac{30\times 750}{1000000} = 0.0225 \text{ mm} = 22.5\times 10^{-3} \text{ mm}$$

9. (d)



$T = m(a + g) = 400(3 + 10) = 5200$ N

10. (c)
Let, S be the distance by which a pile will move under a single blow of hammer.
Work done by hammer = Work done by the ground resistance

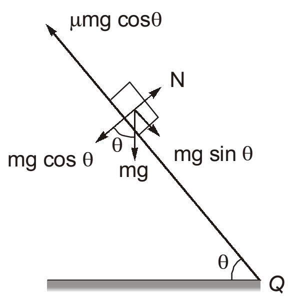
$$\frac{1}{2}(12+4)V^2 = 200\times S$$

$$\Rightarrow \quad 8\times 4^2 = 200\times S$$

$$\Rightarrow \quad 128 = 200\times S$$

$$\Rightarrow \quad S = 0.64 \text{ m}$$

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

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

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

13. (c)

$$\omega = 12 + 9t - 3t^2$$

$$\frac{d\omega}{dt} = 9 - 6t = 0$$

$\Rightarrow \quad t = 1.5\text{s}$

$$\frac{d^2\omega}{dt^2} = -6 < 0$$

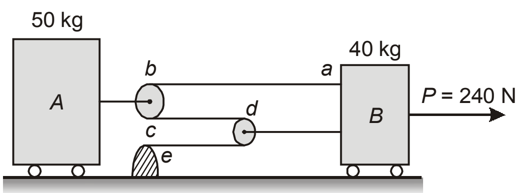
Hence, at t = 1.5 sec maximum value of angular velocity will occur

$\therefore \quad \omega_{max} = 12 + 9 \times 1.5 - 3 \times 1.5^2$

$= 12 + 13.5 - 6.75$

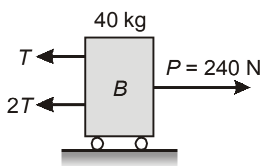
$= 18.75$ rad/s

14. (c)



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

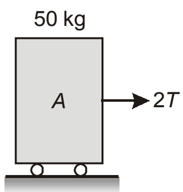
For block B:



ΣF = Mass × Acceleration

$240 - 3T = 40\, a_B$ ...(i)

For block A:



$\Rightarrow \quad \Sigma F$ = Mass × Acceleration

$\Rightarrow \quad 2T = 50\, a_A$ ...(ii)

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

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

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

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

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

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

15. (c)

Let the shortest distance between ships will occur at time thereafter the ship A passes point O.

The distance of ship A from O = 20 t

The distance of ship B from O = 20 (2 – t)

The distance between ships

$$D = \sqrt{(20t)^2 + \{20(2-t)\}^2}$$

For shortest distance

$$\frac{dD}{dt} = 0 \quad \text{or} \quad \frac{d(D^2)}{dt} = 0$$

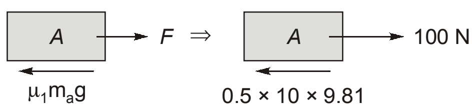
$$2 \times 20t - 20(2-t) \times 2 = 0$$

$$t = 1 \text{ hrs}$$

Shortest distance = $20\sqrt{2}$ km

16. (b)

Free body diagram of A:

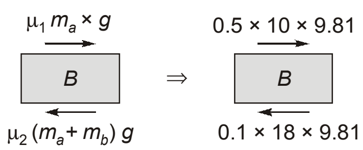


Writing equation of motion for A.

$$100 - 0.5 \times 10 \times 9.81 = 10a$$

$\Rightarrow$ $$a = 5.095 \text{ m/s}^2$$

Free body diagram of B:



Writing equation of motion for B.

$$49.05 - 17.658 = 8\,a$$

$\Rightarrow$ $$a = 3.924 \text{ m/s}^2$$

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 = $V_A - V_B$

$$= 0.5095 - 0.3924 \simeq 0.12 \text{ m/s}$$

17. (c)

$$5g(2.1) = \frac{1}{2} \times 5 \times V^2 + \frac{1}{2} k\delta^2$$

[$\because$ $k = 10000$ N/m]

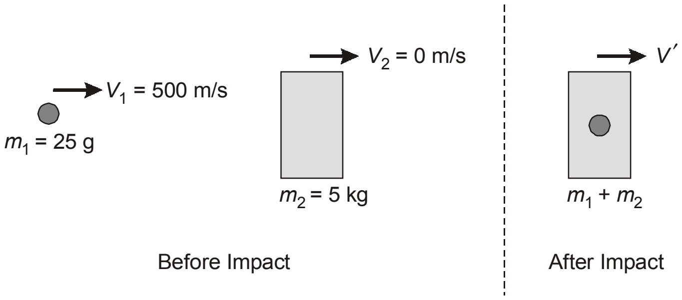
$$\Rightarrow \quad 10.5g = 2.5V^2 + \frac{1}{2}\times 10000\times (0.1)^2$$

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

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

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

18. (d)



$$V' = \frac{0.025\times 500}{5+0.025} = \frac{12.5}{5.025} = 2.488 \text{m/s}$$

Change in kinetic energy,

$$\Delta KE = \frac{1}{2}\times 0.025\times 500^2 - \frac{1}{2}\times 5.025\times 2.488^2$$

$$= 3125 - 15.55 = 3109.45 \text{ J}$$

$$\text{Percentage of energy lost} = \frac{3109.45}{3125}\times 100 = 99.5\%$$

19. (c)

Coefficient of restitution,

$$e = -\frac{\Delta V}{\Delta u} = -\frac{v_2 - v_1}{u_2 - u_1}$$

here, $u_2 = 0,$

$$v_2 = 0$$

$$e = \frac{v_1}{u_1}$$

$$v^2 - u^2 = 2\ ah$$

when ball is dropped from height,

$$u = 0$$

Let final velocity is u_1

$$u_1^2 = 2ah_1$$

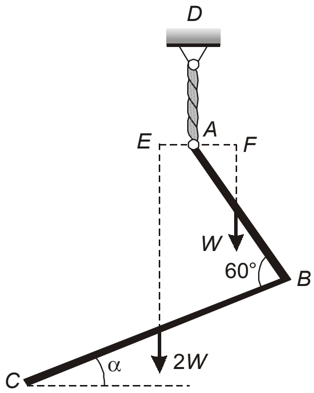
$$v_1^2 = 2ah_2$$

$$e^2 = \left(\frac{v_1}{u_1}\right)^2 = \frac{h_2}{h_1}$$

$$\therefore \quad h_2 = h_1\times e^2 = 0.36 \text{ m}$$

20. (d)

Considering both bars together as a free body, we see that they are in equilibrium under the action of three parallel forces i.e. weights W and $2W$ and the vertical reaction exerted by the string AD.



For equilibrium condition,

$$\Sigma M_A = 0$$

$$\Rightarrow \quad 2W \times AE - W \times AF = 0$$

$$\therefore \quad AF = 2AE \quad \text{...(i)}$$

Now, from the geometry of the system,

$$AF = \frac{L}{2}\cos(60° - \alpha) \quad \text{...(ii)}$$

and

$$AE = (L\cos\alpha - L\cos(60° - \alpha)) \quad \text{...(iii)}$$

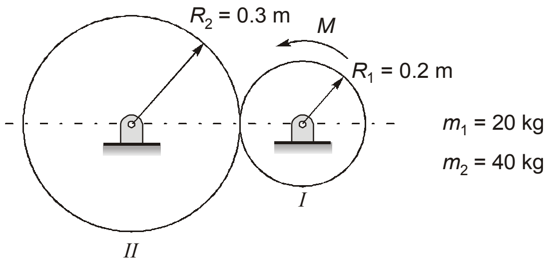
From equations (i), (ii) and (iii), we get

$$\frac{L}{2}\cos(60° - \alpha) = 2(L\cos\alpha - L\cos(60° - \alpha))$$

$$\tan\alpha = \frac{\sqrt{3}}{5}$$

$$\alpha = 19.11°$$

21. (a)



$$\text{Moment of inertia, } I_2 = \frac{m_1R_1^2}{2} = \frac{20 \times 0.2^2}{2} = 0.4 \text{ kgm}^2$$

$$I_2 = \frac{m_2R_2^2}{2} = \frac{40 \times 0.3^2}{2} = 1.8 \text{ kgm}^2$$

A force of friction F acts between disc I and II which drives disc II.

$$F \times R_2 = I_2\alpha_2 \quad \text{...(1)}$$

$$R_1\alpha_1 = R_2\alpha_2$$

$$\Rightarrow \quad 0.2 \times 8.33 = 0.3 \times \alpha_2$$

$$\alpha_2 = 5.55 \text{ m/s}^2$$

Put α_2 value in (1)

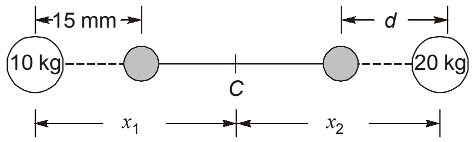
We get $F = 33.32$ N

$$M - FR_1 = I_1\alpha_1$$

$$\Rightarrow \quad M - 33.32 \times 0.2 = 0.4 \times 8.33$$

$$M = 9.996 \simeq 10 \text{ Nm}$$

22. (c)



To keep centre of mass at C

$$m_1x_1 = m_2x_2$$

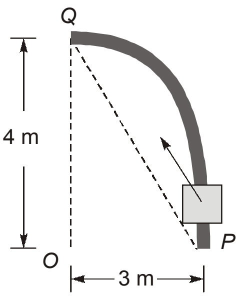
$\rightarrow$ (Let 10 kg = m_1, 20 kg = m_2)

and $$m_1(x_1 - 15) = m_2(x_2 - d)$$

$$15\, m_1 = m_2 d$$

$$d = \frac{15 \times 10}{20} = 7.5 \text{ mm}$$

23. (b)



$$\text{Change in Kinetic Energy} = \text{Total work done} = W_{18} + W_{mg}$$

$$= F.S. - mg \times s'$$

$$= 18 \times PQ - 1 \times 10 \times OQ$$

$$= 18 \times 5 - 10 \times 4 \qquad \left[PQ = \sqrt{4^2 + 3^2} = 5\text{m}\right]$$

$$= 50 \text{ J}$$

Change in kinetic energy is positive hence increase in kinetic energy is 50 J.

24. (a)

Since no external torque has acted, angular momentum will be conserved.

Applying conservation of angular momentum,

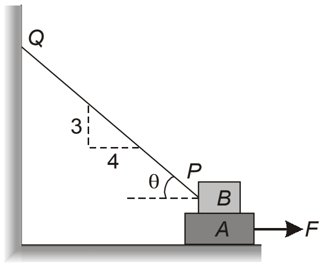
$$\therefore \quad I\omega = I'\omega'$$

$$MR^2 \times \omega = (MR^2 + 2mR^2)\omega'$$

$$5 \times (0.2)^2 \times 10 = [5 \times (0.2)^2 + 2 \times 0.5 \times (0.2)^2]\omega'$$

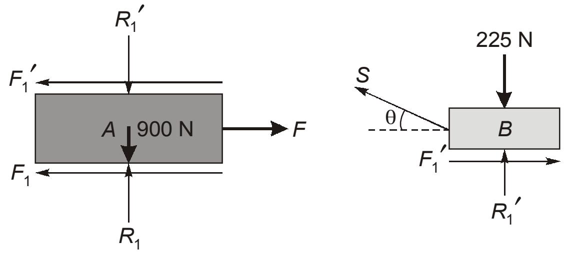
$$\Rightarrow \quad \omega' = 8.333 \text{ rad s}^{-1}$$

25. (a)



$$\tan\theta = \frac{3}{4}$$

The free body diagrams of the blocks are shown below.



$$F_1 = \mu R_1 \text{ and } F_1' = \mu R_1' \quad \text{...(i)}$$

From equilibrium of block *A*,

$$F - F_1 - F_1' = 0 \quad \text{...(ii)}$$

and

$$R_1 - W_1 - R_1' = 0 \quad \text{...(iii)}$$

$\Rightarrow$

$$R_1 = \frac{F_1}{\mu} = W_1 + \frac{F_1'}{\mu} \quad \text{...(iv)}$$

From the equilibrium of block *B*,

$$F_1' - S\cos\theta = 0 \quad \text{...(v)}$$

and

$$R_1' + S\sin\theta - W_2 = 0$$

...(vi)

$\Rightarrow$

$$F_1' = \frac{W_2}{1/\mu + \tan\theta} \quad \text{...(vii)}$$

From equations (ii), (iv) and (vii), we get

$$F = \mu W_1 + \frac{2W_2}{\frac{1}{\mu} + \tan\theta} = 0.3 \times 900 + \frac{2 \times 225}{\frac{1}{0.3} + \frac{3}{4}} = 380.2\text{N}$$

26. (a)

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

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

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

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

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

27. (d)

$$I = -2\hat{i} - \hat{j} + \hat{k}$$

$$r = 2\hat{i} - 3\hat{j} + \hat{k}$$

$$\text{Angular momentum} = H = r \times I$$

$$= \left(2\hat{i} - 3\hat{j} + \hat{k}\right) \times \left(-2\hat{i} - \hat{j} + \hat{k}\right) = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & 2 \\ -2 & -1 & 1 \end{vmatrix}$$

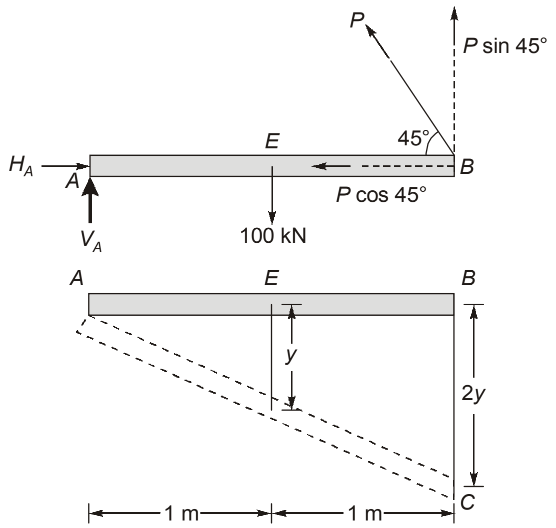
$$= \hat{i}(-3+2) - \hat{j}(2+4) + \hat{k}(-2-6)$$

$$= \hat{i}(-1) - 6\hat{j} - 8\hat{k} = -\hat{i} - 6\hat{j} - 8\hat{k}$$

$$|H| = \sqrt{1^2 + 6^2 + 8^2} = 10.01 \text{ kg m}^2/\text{s} \simeq 10 \text{ kg m}^2/\text{s}$$

28. (c)

Free body diagram of beam *AB*,



Now using the principle of virtual work done, if C.G. of beam *AB* shifts by an amount '*y*' then end *B* must shift by '2*y*' (using similar triangles).

$$\therefore \quad 100 \times y - P \sin 45^\circ \times 2y = 0$$

$$\Rightarrow \quad P = 70.71 \text{ kN}$$

29. (a)

Considering velocities to the right as positive,

The initial momentum of the system = $\frac{W+w}{g}v_0$

The final momentum of the car = $\frac{W}{g}(v_0+\Delta v)$

The final momentum of the man = $\frac{w}{g}(v_0+\Delta v-u)$

Since no external forces act on the system, the law of conservation of momentum gives,

$$\frac{W+w}{g}v_0 = \frac{W}{g}(v_0+\Delta v)+\frac{w}{g}(v_0+\Delta v-u)$$

$$\Rightarrow \quad W\Delta v - wu + w\Delta v = 0$$

$$\therefore \quad \Delta v = \frac{wu}{W+w}$$

30. (c)

$$T\sin\theta + R_y = mg$$

$$T\cos\theta = R_x$$

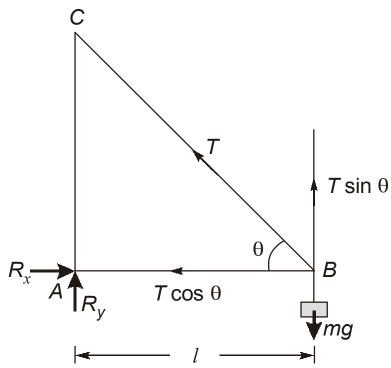
Now, $\tan\theta = \frac{125}{275}$

$$\theta = 24.44°$$

Taking moments about *A*,

$$l \times T\sin\theta = l \times mg$$

$$\Rightarrow \quad T = \frac{35\times 9.81}{\sin 24.44°} = 829.87 \text{ N}$$



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