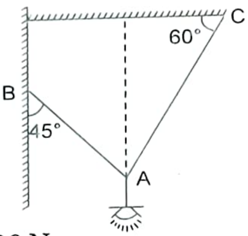
Contents

1 CHAPTER ENGINEERING MECHANICS

EXERCISE - I

1. An electric light fixture weighing 150 N hangs from a point A by two hinges AB and AC. The tension is string AB would be approximately



(a) 78 N (b) 86 N
(c) 99 N (d) 98 N

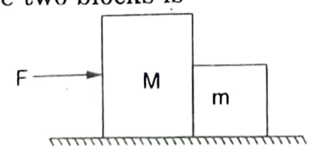
2. A string 2 m long is tied to the ends of a uniform rod that weighs 60 N and is 1.6 m long. The string passes over a nail so that the rod hangs vertically. The tension in the string will be
(a) 24 N (b) 30 N
(c) 42 N (d) 50 N

3. A mass of 1 kg is attached to the middle of a rope, which is being pulled from both ends in the opposite directions. Taking $g = 10$ m/sec², the minimum pull required to completely straighten the rope will be
(a) 5 N (b) 20 N
(c) 25 N (d) ∞

4. Two cars are moving in the same direction with a speed of 45 km/hr and a distance of 10 km separates them. If a car coming from the opposite direction meets these two cars at an interval of 6 minutes, its speed would be
(a) 45 km/hr (b) 55 km/hr
(c) 65 km/hr (d) 75 km/hr

5. A body of mass 10 kg moving with a velocity of 1 m/s is acted upon by a force of 50 N for two seconds. The final velocity will be
(a) 22 m/sec (b) 10 m/sec
(c) $\sqrt{21}$ m/sec (d) 11 m/sec

6. Two blocks with masses M and m are in contact with each other and are resting on a horizontal frictionless floor. When horizontal force is applied to the heavier, the blocks accelerate to the right. The force between the two blocks is
(a) (M + m) F/m
(b) MF/m
(c) mF/M
(d) mF/(M + m)



7. A particle starts from rest with a constant acceleration α m/sec² and after some time it deaccelerates at a uniform rate of β m/sec² till it comes to rest. If the total time taken between two rests positions is t, then maximum velocity acquired by the particle would be
(a) $\frac{\alpha+\beta}{2}t$ (b) $\frac{\alpha-\beta}{2}t$
(c) $\left(\frac{\alpha\beta}{\alpha+\beta}\right)t$ (d) $\left(\frac{\alpha+\beta}{\alpha-\beta}\right)t$

8. A train travels between two stations 15 km apart in 18 minutes. If the train accelerates for a part of journey uniformly followed by uniform retardation, the maximum speed attained by the train during the journey will be
(a) 60 km/hr (b) 80 km/hr
(c) 100 km/hr (d) 125 km/hr.

9. A particle starts with a velocity 2 m/sec and moves on a straight line track with retardation 0.1 m/sec². The time at which the particle is 1.5 m from the starting point would be
(a) 10 sec (b) 20 sec
(c) 50 sec (d) 40 sec

10. A car moving with speed u can be stopped in minimum distance x when brakes are applied. If the speed becomes n times, the minimum distance over which the car can be stopped would take the value
(a) $\frac{x}{n}$ (b) nx
(c) $\frac{x}{n^2}$ (d) n^2x

11. A train accelerates from rest at a constant rate α for some time and then it retards to rest at constant rate β. If total distance covered by the train during the course of its motion would be
(a) $\left[\frac{\alpha+\beta}{2\alpha\beta}x\right]^{1/2}$ (b) $\left[\frac{2\alpha\beta}{\alpha+\beta}x\right]^{1/2}$
(c) $\left[\frac{\alpha+\beta}{\alpha-\beta}x\right]^{1/2}$ (d) $\left[\frac{2\alpha\beta}{\alpha-\beta}x\right]^{1/2}$

12. A particle moves with uniform acceleration along a straight line ABC. The speeds of the particle at positions A and C are 5 cm/sec and 15 cm/sec respectively. If point B lies midway between A and C, the ratio of times taken by the particle to travel distances AB and BC is

(a) 2 : 1 (b) 1 : 1
(c) 1 : 2 (d) 1 : 5

13. Two balls are dropped from the same point after an interval of one second. If acceleration due to gravity is 10 m/sec², their separation 3 seconds after the release of first ball would be

(a) 15 m (b) 20 m
(c) 25 m (d) 30 m

14. Two bodies of mass m_1 and m_2 are dropped from different heights h_1 and h_2 respectively. Neglecting the effect of friction, the ratio of times taken to drop through the given heights would be

(a) $\frac{m_1}{m_2}$ (b) $\frac{m_2 h_2}{m_1 h_1}$

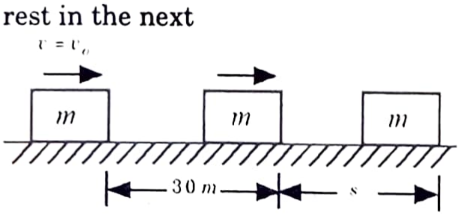
(c) $\left(\frac{h_1}{h_2}\right)^{1/2}$ (d) $\left(\frac{h_1}{h_2}\right)^2$

15. A stone falls freely from rest and the distance covered by it in the last second of its motion equals the distance covered by it in the first four seconds of its motion. The stone then remains in air for a total period of (Take g = 10 m/sec²)

(a) 6 sec (b) 8.5 sec
(c) 10.5 sec (d) 12.5 sec

16. A small block of mass m is sliding on a rough horizontal plane at velocity v_0. If the velocity is reduced to $v_0/2$ in 30 meters, the block will be brought to rest in the next

(a) 10m
(b) 20m
(c) 25m
(d) 30m



17. A block slides down a smooth inclined plane in time t after having been released from its top. An identical block on being released from the same point and falling freely will reach the ground in time

(a) $\frac{t}{3}$ (b) $\frac{t}{\sqrt{3}}$

(c) $\frac{t}{2}$ (d) $\frac{t}{3}$

(Take inclination of plane = 30°)

18. A motorbike starts from rest and accelerates at a rate of 4 m/sec² for 10 seconds and then decelerates at 8 m/sec² until it stops. The total distance covered is

(a) 100 m (b) 200 m
(c) 300 m (d) 500 m

19. A person standing on a moving elevator feels 20% heavier than when at rest. The elevator is accelerating upward at

(a) 2 m/sec² (b) 12 m/sec²
(c) 2 m/sec² (d) 6 m/sec²

20. Two metallic blocks having masses in the ratio 2 : 3 are made to slide down a friction less inclined plane starting initially from rest position. When these blocks reach the bottom of the inclined plane, they will have their kinetic energies in the ratio

(a) 2 : 3 (b) 3 : 5
(c) 3 : 2 (d) 7 : 4

21. AB is the vertical diameter of a circle in a vertical plane. Another diameter CD makes an angle of 60° with AB. Then the ratio of time taken by a particle to slide along AB to the time taken by it to slide along CD is

(a) $1 : \sqrt{3}$ (b) $\sqrt{2} : 1$
(c) $1 : \sqrt{2}$ (d) $\sqrt{3} : \sqrt{2}$

22. The displacement-time graph for two particles A and B are straight lines inclined at angles of 30° and 45° with the time axis. The ratio of velocities $V_a : V_b$ will be

(a) 0.33 (b) 0.52
(c) 0.577 (d) 0.877

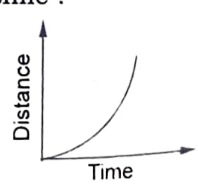
23. The velocity-time graph of a body is a straight line passing through the origin. If the slope of the graph is m, the distance travelled by the body in time t would be

(a) $2mu^2$ (b) $\frac{mu^2}{2t}$

(c) $\frac{u^2}{2m}$ (d) none of these

24. Which of the following graphs represents the motion of an objects moving with a linearly increasing acceleration against time ?

(a)


(b)


(c)


(d)


EXERCISE - II

1. The power of an engine has been specified without the unit as 50. If the magnitude is correct in MKS system, the unit to be specified for this power will be
   (*a*) joule
   (*b*) watt
   (*c*) hertz
   (*d*) newton-meter **[Civil Services]**

2. For three vectors to produce zero resultant
   (*a*) they should in the same plane
   (*b*) the resultant of any two vectors should be equal and opposite to the third vector
   (*c*) it should be possible to represent the vectors by three sides of a triangle taken in order
   (*d*) the vector should act along the sides of a parallelogram **[IES]**

3. Two forces of equal magnitude P act at an angle θ to each other. Their resultant is equal to
   (*a*) $2\,P \sin \dfrac{\theta}{2}$ (*b*) $2\,P \cos \dfrac{\theta}{2}$
   (*c*) $2\,P \cos \theta$ (*d*) $2\,P \cos 2\,\theta$ **[IES]**

4. If resultant of two equal forces is equal to either of them, then angle between the forces is
   (*a*) 30° (*b*) 60°
   (*c*) 90° (*d*) 120° **[IES]**

5. If resultant of two forces (P + Q) and (P – Q) is equal to $\sqrt{3\,P^2 + Q^2}$, then forces are inclined to each other at the angle of
   (*a*) 30° (*b*) 60°
   (*c*) 90° (*d*) 120° **[Gate]**

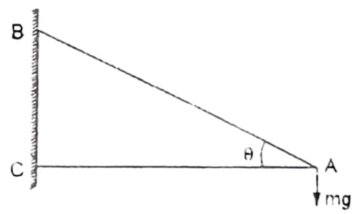
6. Magnitude of two forces is such that when acting at right angles produces a resultant force of $\sqrt{20}$ and when acting at 60 degree produce a resultant equal to $\sqrt{28}$. The force have a magnitudes of
   (*a*) $\sqrt{10}$ and $\sqrt{10}$ (*b*) 2 and $\sqrt{7}$
   (*c*) 2 and 4 (*d*) 2 and $\sqrt{5}$ **[Gate]**

7. Two ships A and B leave a port at the same time, the ship A moving north at 30 km/h. The speed of ship B relative to A is
   (*a*) 70 km/h
   (*b*) 35 km/h
   (*c*) 10 km/h
   (*d*) 50 km/h **[Civil Services]**

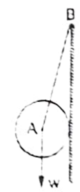
8. The resultant of two forces P and Q is R. If one of the forces is reversed in direction, the resultant is S. Then for the identity $R^2 + S^2 = 2\,(P^2 + Q^2)$ to hold good,
   (*a*) forces are collinear
   (*b*) forces act at right angles to each other
   (*c*) forces are inclined at to 60° to each other
   (*d*) forces can have any angle of inclination between them **[Civil Services]**

9. Four forces, P, 2P, 3P, and 4P act along the sides taken in order, of a square. The resultant force is
   (*a*) zero (*b*) $2\sqrt{2}\,P$
   (*c*) 2P (*d*) $\sqrt{5}\,P$ **[IES]**

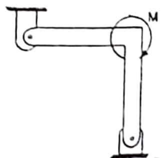
10. For the loaded system depicted in figure, the force induced in the string AB would be
    (*a*) $mg \tan \theta$
    (*b*) $mg \sec \theta$
    (*c*) $mg \sin \theta$
    (*d*) $mg \operatorname{cosec} \theta$



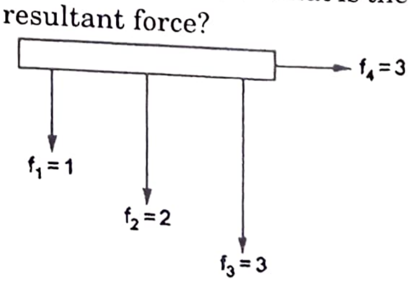
11. A circular roller of weight W hangs by a tie rod and rests against a smooth vertical wall. The tension in the tie rod AB will be
    (*a*) less than weight W
    (*b*) greater than W
    (*c*) equal to W
    (*d*) none of above **[Gate]**



12. For the member shown, degree of indeterminacy is
    (*a*) 3
    (*b*) 2
    (*c*) 1
    (*d*) 0 **[Civil Services]**



13. Three weights are hung from a level surface and a force parrallel with the surface is applied as shown in the figure below. What is the magnitude of the resultant force?



    (*a*) 3 (*b*) $\sqrt{18}$
    (*c*) 6 (*d*) $\sqrt{45}$
    [Civil Services]

14. When two bodies move uniformly towards each other, the distance between them decreases by 6 m/s. If both bodies move in the same direction with the same speeds, the distance between them increases by 4 m/s. Then speeds of the two bodies are:

[Civil Services]

(*a*) 3 m/s and 3 m/s. (*b*) 4 m/s and 2 m/s.
(*c*) 5 m/s and 1 m/s. (*d*) none of these

15. The drive of a train moving at 25 m/s sights another train moving at 5 m/s on the same track and in the same direction. He immediately applies brakes and the train begins to retard at 2.5 m/s². For no collision, the minimum distance between the two trains at the instant of first sight should be

(*a*) 80 m (*b*) 128 m
(*c*) 240 m (*d*) None **[Gate]**

16. A body of mass 10 kg. moving with a velocity of 1 m/s is acted upon by a force of 50 N for two seconds. The final velocity is

(*a*) 22 m/s (*b*) 1 m/s
(*c*) $\sqrt{21}$ m/s (*d*) 11 m/s **[GATE]**

17. A slides down a smooth inclined plane and takes 4 seconds to reach the bottom. If it starts from rest at the top, the time taken to cover $\frac{1}{4}$th of distance from top is

(*a*) 1 sec (*b*) 1.4 sec
(*c*) 1.8 sec (*d*) 2.0 sec **[GATE]**

18. A particle undergoing rectilinear motion has a displacement prescribed by the relation :

$$s = (t^3 - 3.5\,t^2 - 6t + 5) \text{ metre}$$

where t represents the time.

The acceleration of the particle, when its velocity is zero, will be

(*a*) –8 m/s² (*b*) 11 m/s²
(*c*) 18 m/s² (*d*) 25 m/s² **[GATE]**

19. At any time t, the position of a particle moving along a straight line is prescribed by the relation

$$x = 2\,t^3 - 24t + 6$$

From its initial position at t = 0, the particle will attain a velocity of 72 m/s after

(*a*) 2 sec (*b*) 4 sec
(*c*) 8 sec (*d*) 12 sec

[Civil Services]

20. A 6.0 kg. box sledge is travelling across the ice at a speed of 9.0 m/s when a 12 kg package is dropped into it vertically. As a result **[GATE]**

(*a*) stop moving
(*b*) continue to move at the same speed
(*c*) continue to move at half the initial speed
(*d*) continue to move at one-third the initial speed.

21. The displacement of a particle undergoing rectilinear motion along the X-axis is given by

$$x = 2t^3 - 21t^2 + 60t + 6 \text{ metres}$$

The acceleration of the particle, when its velocity is zero, will be

(*a*) + 36 m/s² (*b*) – 18 m/s²
(*c*) 9 m/s² (*d*) –9 m/s⁻² **[GATE]**

22. A particle moves in the x–y plane with velocity

$$\bar{v} = t^3 i + 3t^2 j$$

The acceleration in the x-direction will be

(*a*) t^4 (*b*) $\frac{t^4}{4}$
(*c*) $\frac{3t^2}{2}$ (*d*) $3t^2$ **[IES]**

23. The velocity of a particle moving along the x-axis varies with distance x as $v = 2x-5$. At the instant of zero acceleration, its velocity will be

(*a*) 0 (*b*) 2.4 m/s
(*c*) 4.2 m/s (*d*) none of these **[IES]**

24. The position of a particle is expressed as

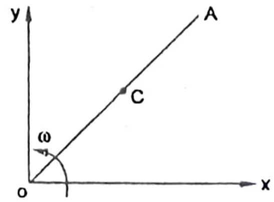
$$x = 2t^3; \quad y = t^2 + 4t; \quad z = 3t - 5$$

in terms of time parameter t.

At $t = 1$, acceleration of the particle would be

(*a*) 7.8 units (*b*) 9.02 units
(*c*) 10.28 units (*d*) 12.16 units **[IES]**

25. A point of C on a straight link OA moves with a velocity u from O to A. OA itself turns with a velocity ω rad/s with plane Oxy. The velocity of the point in the Oxy when it is at a distance r from O is



(*a*) $u + \omega r$
(*b*) $\sqrt{u^2 + \omega^2 r^2}$
(*c*) $\sqrt{u^2 - \omega^2 r^2}$
(*d*) $\sqrt{u^2 - \omega^2 r}$ **[Civil Services]**

26. The velocity in m/s of a particle moving in a straight line is given by $v = t^3 - t^2$. Civil Services

Its acceleration after three seconds is

(*a*) 10.25 m/s² (*b*) 15.25 m/s²
(*c*) 18 m/s² (*d*) 21 m/s² **[GATE]**

27. For first half of time a car travels with velocity v_1 and for the second half of time it travels with velocity v_2. The average velocity of the car is

(*a*) $\frac{v_1 + v_2}{2}$ (*b*) $\frac{2v_1 v_2}{v_1 + v_2}$
(*c*) $\sqrt{v_1 v_2}$ (*d*) $\frac{v_1 v_2}{2(v_1 + v_2)}$ **[IES]**

28. Two cars A and B move at 15 m/s in the same direction and the car B is 300 m ahead of car A. If car A is accelerated at 6 m/s^2 while car B continues to move with the same velocity, the car A will overtake car B at time

(*a*) 7.5s (*b*) 12s

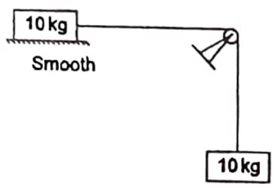
(*c*) 10s (*d*) 15s **[IES]**

29. A body is allowed to fall from the top of a tower. It falls through half the height in 2 seconds. The total time taken to reach the ground is approximately

(*a*) 4.5 sec (*b*) 4.8 sec

(*c*) 4.2 sec (*d*) 2.8 sec **[Gate]**

30. Two 10 kg blocks are connected by cable in the arrangement shown. If the system is released from rest, the tension in Newtons in the cable is



(*a*) 5 g N

(*b*) 6 g N

(*c*) 8 g N

(*d*) 9 g N **[Civil Services]**

31. Two trains having average speeds of 25 km/hr and 15 km/hr respectively, are moving towards each other on straight parallel tracks. A bird that can fly with an average speed of 80 km/hr flies off the first train when the trains are separated by a distance of 40 km. upon touching the second train, the bird immediately files back and continues this process until trains pass each other. The total distance covered by the bird is

(*a*) 25 km

(*b*) 15 km

(*c*) 80 km

(*d*) 40 km **[JEE, Civil Services]**

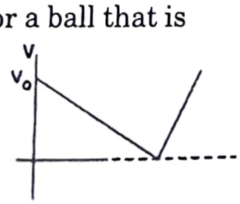
32. A ball of mass 2 kg was thrown vertically upwards and a height of 5 m above the ground, its kinetic energy was equal to its potential energy. The total time balls take to reach the highest point will be

(*a*) $\sqrt{7}$ s (*b*) $\sqrt{5}$ s

(*c*) $\sqrt{3}$ s (*d*) $\sqrt{2}$ s

Take $g = 10$ m/s^2 **[JEE]**

33. The graph below represents the speed-time variation for a ball that is



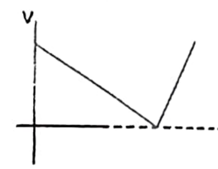
(*a*) dropped from an initial height and bounces elastically off the ground back to that initial height

(*b*) thrown straight up in the air from an initial height and falls back to that height

(*c*) thrown from an initial height in a parabolic path until it returns to that initial height

(*d*) thrown from an initial height horizontally and bounces elastically off the groundback to that initial height **[IES]**

34. A metalic chain of length L and mass M is vertically hung above a surface with one end in contact with it. The chain is then released to fall freely. If X is the distance covered by the end of the chain, how much force (exerted by the surface) will the chain experience at any instance during the process?



(*a*) $N = Mg - M\ddot{X}$

(*b*) $N = 3\ Mg$

(*c*) $N = Mg - 2M\ \ddot{X}$

(*d*) $N = \dfrac{3M}{L} g\ X$ **[Civil Services]**

35. A particle in simple harmonic motion while passing through mean position will have

(*a*) maximum kinetic energy and maximum potential energy

(*b*) maximum kinetic energy and minimum potential energy

(*c*) minimum kinetic energy and minimum potential energy

(*d*) average kinetic energy and average potential energy **[GATE]**

36. An object moves along x-axis from $x = 0$ to $x = 16$ cm under the action of a force $F_x = 24 - 3x$ (x in cm). Then

(*a*) work done on the object will be 384 J

(*b*) work done on the object will be zero

(*c*) potential energy of the object will be maximum at $x = 8$ cm

(*d*) object will oscillate about its mean position **[Civil Services]**

37. A 100 kg flywheel having a radius of gyration of 1 m is rotating at 1000 rpm. The angular momentum of the flywheel about its axis of rotation in kg-m^2/s is

(*a*) 10,000 (*b*) 10,470

(*c*) 1,000 (*d*) 5,235 **[GATE]**

38. For a particle moving under the action of a central force field

(*a*) its angular momentum is conserved

(*b*) its angular momentum increases

(*c*) its angular momentum decreases

(*d*) the path is always linear **[GATE]**

86. For a mass connected to a spring and oscillating in simple harmonic motion, to double the period of oscillation, which of the following must be done?

(*a*) Increase mass by a factor of 2

(*b*) Increase mass by a factor of 4

(*c*) Increase displacement by a factor of 2π

(*d*) Increase spring constant by a factor of 2

[Civil Services]

87. A particle executes simple harmonic motion with an amplitude of 3 cm and time period of 6 seconds. Its maximum velocity will be

(*a*) $\frac{\pi}{2}$ cm/s (*b*) π cm/s

(c) 2π cm/s (*d*) 3π cm/s **[Gate]**

88. A particle executes simple harmonic motion and when its displacement from the mean position is 2.5 cm, its kinetic and potential energies are of equal magnitude. The amplitude of the motion of the particle is approximately

(*a*) 2.5 cm (*b*) 3.5 cm

(*c*) 5.0 cm (*d*) 7.5 cm **[IES]**

89. Speed of a particle executing simple harmonic motion with amplitude a is half of the maximum speed. At that instant, displacement of the particle is

(*a*) $\frac{a}{2}$ (*b*) $\frac{\sqrt{3}}{2}a$

(*c*) $\frac{2a}{\sqrt{3}}$ (*d*) $3\sqrt{2}\,a$ **[IES]**

90. A particle executes simple harmonic motion with displacement at any time t prescribed by the relation

$$y = r \sin \omega t$$

where r is amplitude and ω is angular velocity.

The velocity of the particle is

(*a*) $\omega\sqrt{(r^2 - y^2)}$ (*b*) $\omega\,(r^2 - y^2)^{1/4}$

(*c*) $\frac{\omega}{\sqrt{(r^2 - y^2)}}$ (*d*) $\omega\,(r^2 - y^2)$ **[IES]**

91. A particle is moving with simple harmonic motion in a straight line. When distance of the particle from equilibrium position has values x_1 and x_2, the corresponding values of velocities are v_1 and v_2. Then time period of the oscillation of the particle is **[Civil Services]**

(*a*) $2\pi\left[\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}\right]^{1/2}$ (*b*) $\frac{1}{2\pi}\left[\frac{x_2^2 - x_1^2}{v_1^2 - v_2^2}\right]^{1/2}$

(*c*) $2\pi\left[\frac{v_2^2 - v_2^2}{x_1^2 - x_2^2}\right]^{1/2}$ (*d*) none of these

92. The period of a simple pendulum (for very small amplitude motion) may be increased by

(*a*) increasing mass of the hanging object

(*b*) decreasing mass of the hanging object

(*c*) increasing initial displacement from equilibrium

(*d*) lengthening the string **[JEE]**

93. Starting from rest, a particle travels on a circular path and the distance covered is prescribed by the relation

$$s = kt^2$$

where, k is constant and t is the time.

Then the particle has a tangential acceleration of

(*a*) $\frac{k}{t}$ (*b*) k

(*c*) $2k$ (*d*) $4k$ **[IES]**

94. The pending torque exerted by a bicycle rider is transmitted to the ground by the spokes of a wheel through

(*a*) tension only

(*b*) compression only

(*c*) both tension and compression

(*d*) torsion **[GATE]**

95. Then equitorial radius of earth is stated to be 6408 km. The angular velocity of rotation of earth about its axis is about

(*a*) $2.3 \times 10^{-5}\,\pi$ rad/s

(*b*) $1.5 \times 10^{-5}\,\pi$ rad/s

(*c*) $0.75 \times 10^{-5}\,\pi$ rad/s

(*d*) $4.6 \times 10^{-5}\,\pi$ rad/s **[Civil Services]**

96. Velocity of a satellite in an orbit close to earths surface depends upon

(*a*) radius of the orbit only

(*b*) product of radius and acceleration due to gravity

(*c*) product of radius and universal gravitational constant

(*d*) $\frac{\text{universal gravitational constant}}{\text{radius of orbit} \times \text{acceleration due to gravity}}$

[IES]

97. A particle in a plane curvilinear motion may have acceleration

(*a*) only normal to the path in the plane

(*b*) only tangential to the path in the plane

(*c*) both normal and tangential to the path in the plane

(*d*) only normal to the plane **[GATE]**

ANSWERS

EXERCISE – I

1. (*a*)	**2.** (*d*)	**3.** (*d*)	**4.** (*b*)	**5.** (*d*)	**6.** (*d*)	**7.** (*c*)	**8.** (*c*)	**9.** (*a*)	**10.** (*d*)
11. (*b*)	**12.** (*b*)	**13.** (*c*)	**14.** (*c*)	**15.** (*b*)	**16.** (*a*)	**17.** (*c*)	**18.** (*c*)	**19.** (*a*)	**20.** (*a*)
21. (*c*)	**22.** (*c*)	**23.** (*c*)	**24.** (*c*)	**25.** (*d*)	**26.** (*b*)	**27.** (*b*)	**28.** (*b*)	**29.** (*d*)	**30.** (*a*)
31. (*c*)	**32.** (*c*)	**33.** (*a*)	**34.** (*d*)	**35.** (*a*)	**36.** (*c*)	**37.** (*d*)	**38.** (*c*)	**39.** (*d*)	**40.** (*b*)
41. (*d*)	**42.** (*d*)	**43.** (*d*)	**44.** (*b*)	**45.** (*d*)	**46.** (*a*)	**47.** (*a*)	**48.** (*a*)	**49.** (*b*)	**50.** (*a*)
51. (*d*)	**52.** (*c*)	**53.** (*d*)	**54.** (*b*)	**55.** (*a*)	**56.** (*a*)	**57.** (*b*)	**58.** (*c*)	**59.** (*a*)	**60.** (*b*)
61. (*a*)	**62.** (*b*)	**63.** (*c*)	**64.** (*b*)	**65.** (*a*)	**66.** (*b*)	**67.** (*d*)	**68.** (*b*)	**69.** (*c*)	**70.** (*d*)
71. (*b*)	**72.** (*a*)	**73.** (*c*)	**74.** (*b*)	**75.** (*a*)	**76.** (*b*)	**77.** (*c*)	**78.** (*c*)	**79.** (*a*)	**80.** (*c*)
81. (*d*)	**82.** (*b*)	**83.** (*c*)	**84.** (*c*)	**85.** (*c*)	**86.** (*a*)	**87.** (*c*)			

EXERCISE – II

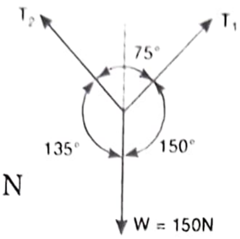
1. (*b*)	**2.** (*b*)	**3.** (*b*)	**4.** (*d*)	**5.** (*b*)	**6.** (*c*)	**7.** (*d*)	**8.** (*d*)	**9.** (*b*)	**10.** (*d*)
11. (*b*)	**12.** (*c*)	**13.** (*d*)	**14.** (*c*)	**15.** (*b*)	**16.** (*d*)	**17.** (*d*)	**18.** (*b*)	**19.** (*b*)	**20.** (*d*)
21. (*b*)	**22.** (*d*)	**23.** (*a*)	**24.** (*d*)	**25.** (*b*)	**26.** (*d*)	**27.** (*a*)	**28.** (*c*)	**29.** (*d*)	**30.** (*d*)
31. (*c*)	**32.** (*d*)	**33.** (*b*)	**34.** (*d*)	**35.** (*b*)	**36.** (*b*)	**37.** (*b*)	**38.** (*d*)	**39.** (*a*)	**40.** (*a*)
41. (*a*)	**42.** (*b*)	**43.** (*c*)	**44.** (*b*)	**45.** (*a*)	**46.** (*d*)	**47.** (*c*)	**48.** (*a*)	**49.** (*a*)	**50.** (*b*)
51. (*b*)	**52.** (*c*)	**53.** (*c*)	**54.** (*b*)	**55.** (*d*)	**56.** (*b*)	**57.** (*b*)	**58.** (*d*)	**59.** (*a*)	**60.** (*c*)
61. (*b*)	**62.** (*b*)	**63.** (*b*)	**64.** (*b*)	**65.** (*b*)	**66.** (*b*)	**67.** (*d*)	**68.** (*d*)	**69.** (*b*)	**70.** (*d*)
71. (*b*)	**72.** (*c*)	**73.** (*b*)	**74.** (*b*)	**75.** (*a*)	**76.** (*b*)	**77.** (*d*)	**78.** (*a*)	**79.** (*d*)	**80.** (*d*)
81. (*c*)	**82.** (*c*)	**83.** (*c*)	**84.** (*c*)	**85.** (*a*)	**86.** (*b*)	**87.** (*b*)	**88.** (*b*)	**89.** (*b*)	**90.** (*a*)
91. (*c*)	**92.** (*d*)	**93.** (*c*)	**94.** (*b*)	**95.** (*a*)	**96.** (*d*)	**97.** (*b*)	**98.** (*c*)	**99.** (*d*)	**100.** (*b*)
101. (*b*)	**102.** (*b*)	**103.** (*b*)	**104.** (*c*)	**105.** (*a*)	**106.** (*b*)	**107.** (*b*)			

EXPLANATIONS

EXERCISE - I

1. From the geometry of the system

$$\frac{W}{\sin 75^0} = \frac{T_2}{\sin 150^0}$$



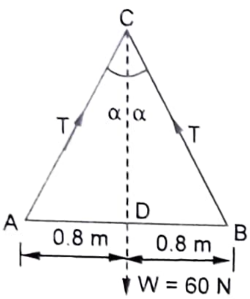
$$\therefore \quad T_2 = W\frac{\sin 150^0}{\sin 75^0}$$

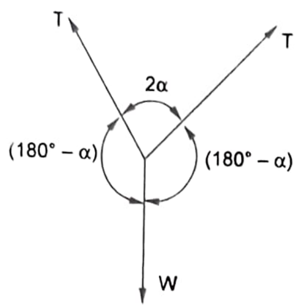
$$= \frac{150 \times 0.5}{0.966} \approx 78 \text{ N}$$

2. AC = BC = 1 m;

$$CD = \sqrt{1^2-(0.8)^2} = 0.6 \text{ m}$$

$\sin\alpha = 0.8$, and $\cos\alpha = 0.6$





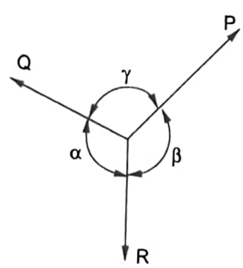
Since three forces W, T and T are in equilibrium,

$$\therefore \quad \frac{W}{\sin 2\alpha} = \frac{T}{\sin(180-\alpha)}$$

$$\Rightarrow \quad \frac{W}{2\sin\alpha\cos\alpha} = \frac{T}{\sin\alpha}$$

$$\Rightarrow \quad T = \frac{W}{2\cos\alpha} = \frac{60}{2\times 0.6} = 50 \text{ N}$$

3. By Lami's theorem, if P, Q and R are three vectors acting at a point, and their resulatant is zero (*i.e.* system is in equilibrium), then



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

To completely straighten the rope,

$$\gamma = 180^0 \text{ and } \alpha = \beta = 90^0$$

$$\therefore \quad P = Q = R\frac{\sin 90^0}{\sin 180^0} = (1\times 10)\times\frac{1}{0} = \infty$$

4. Let v be speed of the car coming from the opposite direction.
Then velocity of this car relative to either of the other two cars $= v - (-45) = (v + 45)$ km/hr
From $s = vt$

$$10 = (v + 45) \times \frac{6}{60}$$

$$\Rightarrow \quad v = 55 \text{ km/hr.}$$

5. Velocity = mass × acceleration

$$\therefore \quad 50 = 10 \times a$$

$$\Rightarrow \quad a = 5 \text{ m/sec}^2$$

Velocity after 2 seconds,

$$v = u + at$$

$$= 1 + 5 \times 2 = 11 \text{ m/sec}$$

6. From free body diagram

$$F - N = Ma \quad ...(i)$$

and

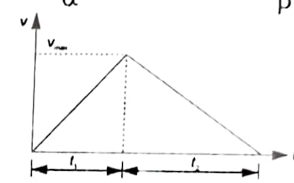
$$N = ma \quad ...(ii)$$

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

$$N = \frac{mF}{(m + M)}$$

7. From $v = u + at$

$$t_1 = \frac{v_{max}}{\alpha} \text{ and } t_2 = \frac{v_{max}}{\beta}$$

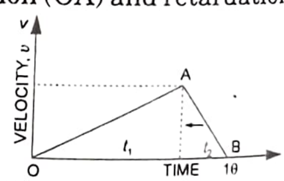


$$\therefore \quad t = t_1 + t_2$$

$$= \frac{v_{max}}{\alpha} + \frac{v_{max}}{\beta} = v_{max}\left(\frac{\alpha+\beta}{\alpha\beta}\right)$$

$$\therefore \quad v_{max} = \frac{\alpha\beta}{\alpha+\beta}t$$

8. Total distance between stations = 15 km
Figure shows acceleration (OA) and retardation (AB) of the train.
Let S be the area of triangle and V be the maximum velocity



$$\therefore \quad S = \frac{1}{2} \times 18 \times 60 \times V = 15 \text{ km}$$

$$\therefore \quad V = 100 \text{ km/hr.}$$

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

$$1.5 = 2t + \frac{1}{2}(-0.1)t^2$$

$$\Rightarrow \quad t = 10 \text{ sec and } 30 \text{ sec}$$

The particle will be 1.5 m from the starting point at t = 10 sec when moving in the forward direction and at t = 30 sec when moving in the backward direction.

10. From

$$v^2 - u^2 = 2as$$

$$0 - u^2 = 2ax$$

$$\therefore \quad \text{Retardation, } a = \frac{u^2}{2x}$$

$$\therefore \quad 0 - (nu)^2 = 2\left(\frac{-u^2}{2x}\right)s$$

$$\Rightarrow \quad s = (nu)^2 \times \frac{x}{u^2} = n^2x$$

11. $v^2 - u^2 = 2as$

where, a is the uniform acceleration

$$\therefore \quad x_1 = \frac{v^2}{2\alpha} \text{ and } x_2 = \frac{v^2}{2\beta}$$

$$\therefore \quad x = x_1 + x_2 = \frac{v^2}{2\alpha} + \frac{v^2}{2\beta} = \frac{v^2}{2}\left(\frac{\alpha+\beta}{\alpha\beta}\right)$$

Maximum velocity attained by the train during the course of its motion would be

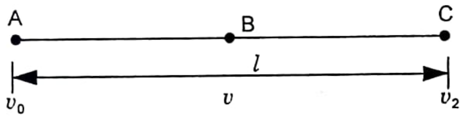
$$v = \left[\frac{2\alpha\beta}{\alpha+\beta}x\right]^{1/2}$$

12. $v^2 - u^2 = 2as$

$$\therefore \quad v_2^2 - v_0^2 = 2al$$

$$\Rightarrow \quad 15^2 - 5^2 = 2\,al$$

$$\Rightarrow \quad a = \frac{100}{l}\text{ m}$$



Again $\quad v_1^2 - v_0^2 = 2a\dfrac{l}{2}$

$$\Rightarrow \quad v_1 = 10 \text{ m/sec}$$

The times t_1 and t_2 to cover distance AB and BC are given by :

$$t_1 = \frac{v_1 - v_0}{a} = \frac{10-5}{a} = \frac{5}{a};$$

$$t_2 = \frac{v_2 - v_1}{a} = \frac{15-10}{a} = \frac{5}{a}$$

$\therefore$ Required ratio $= \dfrac{t_1}{t_2} = 1 : 1$

13. Distance covered by the first ball in 3 sec

$$= \frac{1}{2} \times 10 \times (3)^2 = 45 \text{ m}$$

Distance covered by second ball in 2 sec

$$= \frac{1}{2} \times 10 \times (2)^2 = 20 \text{ m}$$

$\therefore$ Separation $= 45 - 20 = 25$ m

14. We know, $\quad s = ut + \dfrac{1}{2}gt^2$

and $\quad u = 0$

$$\therefore \quad h_1 = \frac{1}{2}g{t_1}^2, \quad \text{and } h_2 = \frac{1}{2}g{t^2}_2$$

Hence $\quad \dfrac{t_1}{t_2} = \left(\dfrac{h_1}{h_2}\right)^{1/2}$

Apparently ratio of times taken is indepedent of the mass of bodies.

15. Here, $u = 0$

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

$$= 0 + \frac{1}{2} \times (10) \times (4)^2 = 80 \text{ m}$$

Now $\quad s_n = \dfrac{g}{2}(2n-1);$

$$\therefore \quad 80 = \frac{10}{2}(2n-1)$$

$$\Rightarrow \quad n = 8.5 \text{ sec}$$

16. Since acceleration is constant,

$$\therefore \quad \left(\frac{v_0}{2}\right)^2 = v_0^2 + 2a(30)$$

$$\Rightarrow \quad a = -\frac{v_0^2}{80}$$

Now $\quad v^2 = u^2 + 2as$

$$\therefore \quad 0 = \frac{v_0^2}{4} - 2 \times \frac{v_0^2}{80}s$$

$$\Rightarrow \quad s = \frac{v_0^2}{4} \times \frac{40}{v_0^2} = 10 \text{ m}$$

17. For motion along the plane

$$a = g\sin\theta \quad \text{and} \quad l = \frac{h}{\sin\theta}$$

$$\therefore \quad \frac{h}{\sin\theta} = \frac{1}{2}(g\sin\theta)t^2$$

$$\Rightarrow \quad t^2 = \frac{2h}{g}\frac{1}{\sin^2\theta} \quad \ldots (i)$$

For vertical motion :

$$h = \frac{1}{2}gT^2$$

$$\Rightarrow \quad T^2 = \frac{2h}{g} \quad \ldots (ii)$$

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

$$T = t\sin\theta = t\sin 30° = \frac{t}{2}$$

18. Total distance

S = distance covered during acceleration, s_a
+ distance covered during deceleration, s_d

Now $\quad s_a = v_i t + \dfrac{1}{2}at^2$

where v_i = initial velocity = 0, since the body is initially at rest.

$$\therefore \quad s_a = \frac{1}{2}at^2 = \frac{1}{2} \times 4 \times (10)^2 = 200 \text{ m}$$

Also $\quad v_f = v_i + at = 0 + (4)(10) = 40$ m/s

Now, $\quad v_f^2 - v_i^2 = 2aS_d$

Here, $\quad v_f = 0$ and $(v_i)_{dec} = (v_f)_{acc} = 40$ m/s

$$\therefore \quad -(40)^2 = 2(-8)S_d$$

$$\Rightarrow \quad s_d = \frac{1600}{16} = 100 \text{ m}$$

$$\therefore \quad s = s_a + s_d = 200 + 100 = 300 \text{ m}$$

85. In the absence of an external torque, the angular momentum is conserved,

i.e. $I\omega = \text{constant}$

An increase in the value of moment of inertia (due to stretching of arms) will bring about a decrease in the value of speed of rotation of the turn table.

86. Initial moment of inertia = Mr^2

Final moment of inertia = $(M + 2m)r^2$.

By law of conservation of angular momentum,

$$I_1\omega_1 = I_2\omega_2$$

$$\Rightarrow \quad \omega_2 = \frac{I_1}{I_2}\omega = \frac{Mr^2}{(M+2m)r^2}\omega$$

$$= \frac{\mathbf{M}}{\mathbf{M+2m}}\omega$$

87. Displacement $x = A\cos\omega t$

It describes a simple harmonic motion with maximum acceleration, $a_{max} = A\omega^2$.

Since there is no slipping between cylinder and platform, the maximum linear acceleration a_{max} and maximum angular acceleration α_{max} are related as

$$\alpha_{max} = \frac{a_{max}}{r} = \frac{A\omega^2}{r}$$

Maximum torque acting on the cylinder during its motion

$$= I\alpha_{max} = \left(\frac{1}{2}mr^2\right)\left(\frac{A\omega^2}{r}\right) = \frac{1}{2}A\omega^2 mr$$

EXERCISE – II

1. 1 Watt = 1 Joule per second
= 0.00134 h.p
= 0.001 kilowatt
= 3.42 BTU per hour
= 44.22 foot-pounds per minute
= 0.74 foot-pounds per second
= 0.0035 pound of water evaporated per hour at 212° F

2. A parallelogram has four sides. As such if three vectors act along its sides, their resultant can not be zero

3. From parallelogram law of forces

$$R^2 = P^2 + Q^2 + 2PQ\cos\theta$$
$$= P^2 + P^2 + 2P^2\cos\theta$$
$$= 4P^2\left(\frac{1+\cos\theta}{2}\right) = 4P^2\cos^2\frac{\theta}{2}$$
$$R = 2P\cos\frac{\theta}{2}$$

4. If resultant of two equal forces is equal to either to them, then

$$R = P = 2P\cos\frac{\theta}{2}$$
$$\Rightarrow \quad \cos\frac{\theta}{2} = \frac{1}{2}$$
$$\Rightarrow \quad \theta = 120° \text{ or } \frac{2\pi}{3}$$

5.
$$3P^2 + Q^2 = (P+Q)^2 + (P-Q)^2 + 2(P+Q)(P-Q)\cos\theta$$
$$= 2P^2 + 2Q^2 + 2(P^2 - Q^2)\cos\theta$$

Solving, we get

$$\cos\theta = \frac{1}{2}$$
$$\Rightarrow \quad \theta = 60°$$

6.
$$20 = P^2 + Q^2 + 2PQ\cos 90° = P^2 + Q^2 \quad ...(i)$$

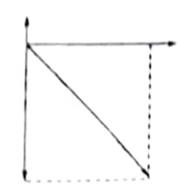
and
$$28 = P^2 + Q^2 + 2PQ\cos 60° = P^2 + Q^2 + PQ \quad ...(ii)$$

Solving equations (*i*) and (*ii*), we get

$$PQ = 8$$

and
$$20 = P^2 + \frac{64}{P^2}$$
$$\Rightarrow \quad P^4 - 20P^2 + 64 = 0$$
$$\Rightarrow \quad (P^2 - 16)(P^2 - 4) = 0$$
$$\therefore \quad P = 2 \text{ or } 4$$

7. Speed of B relative to A



$$= \sqrt{30^2 + 50^2}$$
$$= 50 \text{ km/h}$$

8.
$$R^2 = P^2 + Q^2 + 2PQ\cos\theta \quad ...(i)$$
$$S^2 = P^2 + (-Q) + 2P(-Q)\cos\theta$$
$$= P^2 + Q^2 - 2PQ\cos\theta \quad ...(ii)$$

Adding (*i*) and (*ii*), we get

$$R^2 + S^2 = 2(P^2 + Q^2)$$

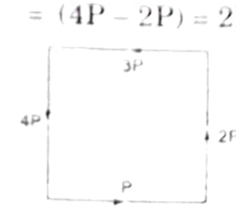
Hence for adding we get a given identity to hold good, the forces can have any angle of inclination between them.

9. Resultant forces in horizontal direction

= (3P – P) = 2P towards left

Resultant forces in vertical direction

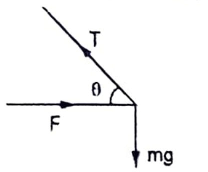
= (4P – 2P) = 2P downwards

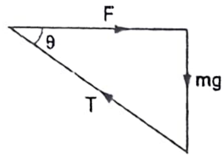


Overall resultant force = $\sqrt{(2P)^2 + (2P)^2} = 2\sqrt{2}P$

10. The given system is in equilibrium and as the lines of action of all external forces must be concurrent i.e., meet. The solution is then obtained by drawing the free body diagram for the system and the corresponding force polygon.

$T \sin\theta = mg$; $\quad T = mg \operatorname{cosec}\theta$



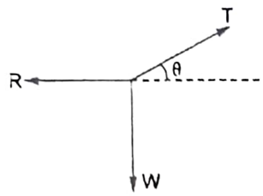


11. $T \sin\theta = W$

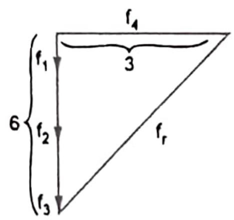
$\Rightarrow \quad T = \dfrac{W}{\sin\theta}$

Since $\sin\theta < 1$

$\therefore \quad T > W$



13. Resultant force is the result of adding the forces, which can be done using their vector representations as shown.



$\therefore \quad f_r^2 = 6^2 + 3^2$

$\Rightarrow \quad f_r = \sqrt{45}$

14. Let u and v be uniform velocities of the two bodies.
Then $\quad u + v = 6 \quad$ ...(i)
and $\quad u - v = 4 \quad$ ...(ii)
Solving (i) and (ii) we get
$u = 5$ m/s and $v = 1$ m/s.

15. Let s be the distance between of the two trains. There will be no collision the relative velocity between the trains is reduced to zero within this distance.
Relative velocity of approaching train
$= 20 - 4 = 16$ m/s
From the relation,
$$v^2 - 4^2 = 2as$$
$$0 - (16)^2 = 2 \times 1 \times s$$
$$s = 128 \text{ m}$$

16. Velocity = mass × acceleration
$\therefore \; 50 = 10 \times a$
$\Rightarrow a = 5$ m/s^2
Hence velocity after 2 seconds,
$$v = u + at$$
$$= 1 + 5 \times 2 = 11 \text{ m/s}$$

17. As the body starts sliding from the rest position,
$$u = 0$$
Now $\quad s = ut + \dfrac{1}{2}at^2 = \dfrac{1}{2}a \times (4)^2 = 8a$

Also $\quad \dfrac{s}{4} = \dfrac{1}{2}at^2$

$\therefore \quad \dfrac{8a}{4} = \dfrac{1}{2}at^2$

$\Rightarrow \quad t = 2$ sec.

18. Given : $s = t^3 - 3.5t^2 - 6t + 5$

$\therefore \quad v = \dfrac{ds}{dt} = 3t^2 - 7t - 6.$

The particle will have zero velocity at
$$t = \frac{-2}{3} \text{ and } 3$$

Acceleration, $a = \dfrac{dv}{dt} = 6t - 7$
$$= 6 \times 3 - 7 = 11 \text{ m/s}^2$$

19. Given : $\quad x = 2t3 - 24t + 6$

$\therefore \quad v = \dfrac{dx}{dt} = 6\,t^2 - 24$

$\Rightarrow \quad 6\,t^2 - 24 = 72$

$\Rightarrow \quad t = 4$ sec.

20. Mass of box of sledge, $m = 6$ kg.
$\therefore$ Initial velocity, $v_1 = 6 \times 9 = 54$ m/s
Mass of box sledge + package = 6 + 12 = 18 kg
Let V_1 be the final velocity. Then according to law of conservation of momentum,
$$MV_1 = Mv_1$$
$$\Rightarrow \quad V_1 = \frac{54}{18} = 3 \text{ m/s}$$

21. Given, $\quad x = 2t^3 - 21t^2 + 60\,t + 6$

$\therefore$ Velocity $= \dfrac{dx}{dt} = 6t^2 - 42t + 60$

For velocity to be zero,
$$6t^2 - 42t + 60 = 0$$
$\Rightarrow \quad t = -\,18$ m/s^2

22. Since $\quad \vec{a} = \dfrac{\overline{dv}}{dt}$

$\therefore \quad a = \dfrac{d}{dt}(t^3 i + 3t^2 \vec{j})$
$$= 3t^2\,\vec{i} + 6t\,\vec{j}$$

Hence x component of $\vec{a}$ is $3t^2$.

23. Given : $\quad v = \dfrac{dx}{dt} = 2x - 5$

Acceleration, $a = \dfrac{dx}{dt} = \dfrac{dv}{dx}\dfrac{dx}{dt}$
$$= v\frac{dv}{dx} = (2x - 5)^2$$
Apparently when $a = 0$, v is also zero.

24. At $t = 1$, $\quad a_x = \dfrac{d^2x}{dt^2} = 12\,t = 12$ units,

$a_y = \dfrac{d^2y}{dt^2} = 2$ units

and $\quad a_z = \dfrac{d^2z}{dt^2} = 0$

$\therefore \quad a = \sqrt{a_x^{\,2} + a_y^{\,2} + a_z^{\,2}}$
$$= \sqrt{48} = 12.16 \text{ units}$$