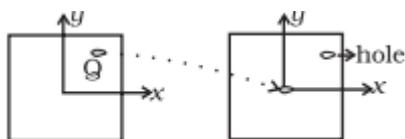


1. When a disc rotates with uniform angular velocity, which of the following is not true?

- (a) The sense of rotation remains same.
- (b) The orientation of the axis of rotation remains same.
- (c) The speed of rotation is non-zero and remains same.
- (d) The angular acceleration is non-zero and remains same.

2. A uniform square plate has a small piece Q of an irregular shape removed and glued to the centre of the plate leaving a hole behind (Fig below). . The moment of inertia about the z-axis is then



- (a) increased
- (b) decreased
- (c) the same
- (d) changed in unpredicted manner.

3. The density of a non-uniform rod of length 1m is given by

$$\rho(x) = a(1+bx^2)$$

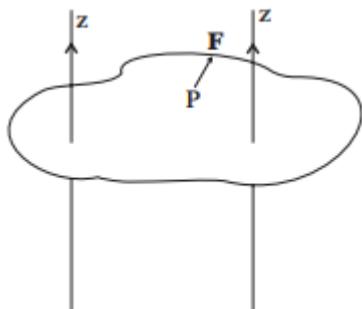
where a and b are constants and $0 \leq x \leq 1$. The centre of mass of the rod will be at

- (a) $\frac{3(2+b)}{4(3+b)}$
- (b) $\frac{4(2+b)}{3(3+b)}$
- (c) $\frac{3(3+b)}{4(2+b)}$
- (d) $\frac{4(3+b)}{3(2+b)}$

4. A Merry-go-round, made of a ring-like platform of radius R and mass M, is revolving with angular speed ω . A person of mass M is standing on it. At one instant, the person jumps off the round, radially away from the centre of the round (as seen from the round). The speed of the round afterwards is

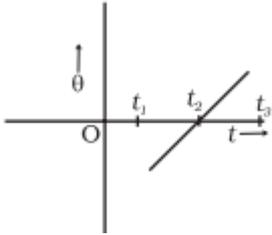
- (a) 2ω
- (b) ω
- (c) $\omega/2$
- (d) 0

5. Figure shows a lamina in x-y plane. Two axes z and z' pass perpendicular to its plane. A force F acts in the plane of lamina at point P as shown. Which of the following are true? (The point P is closer to z'-axis than the z-axis.)



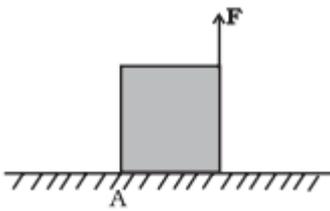
- (a) Torque τ caused by F about z axis is along $-\mathbf{k}$.
- (b) Torque τ' caused by F about z' axis is along $-\mathbf{k}$.
- (c) Torque τ caused by F about z axis is greater in magnitude than that about z' axis.
- (d) Total torque is given by $\tau = \tau + \tau'$.

6. The variation of angular position θ , of a point on a rotating rigid body, with time t is shown in Fig.



Is the body rotating clock-wise or anti-clockwise?

7. A uniform cube of mass m and side a is placed on a frictionless horizontal surface. A vertical force F is applied to the edge as shown in Fig. Match the following (most appropriate choice):



- (a) $mg/4 < F < mg/2$ (i) Cube will move up.
- (b) $F > mg/2$ (ii) Cube will not exhibit motion.
- (c) $F > mg$ (iii) Cube will begin to rotate and slip at A.
- (d) $F = mg/4$ (iv) Normal reaction effectively at $a/3$ from A, no motion.

8. The vector sum of a system of non-collinear forces acting on a rigid body is given to be non-zero. If the vector sum of all the torques due to the system of forces about a certain point is found to be zero, does this mean that it is necessarily zero about any arbitrary point?

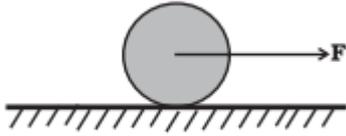
9. Find the centre of mass of a uniform (a) half-disc, (b) quarter-disc.

10. Two discs of moments of inertia I_1 and I_2 about their respective axes (normal to the disc and passing through the centre), and rotating with angular speed ω_1 and ω_2 are brought into contact face to face with their axes of rotation coincident.

- (a) Does the law of conservation of angular momentum apply to the situation? why?
- (b) Find the angular speed of the two-disc system.
- (c) Calculate the loss in kinetic energy of the system in the process.

(d) Account for this loss.

11. A uniform disc of radius R , is resting on a table on its rim. The coefficient of friction between disc and table is μ .



Now the disc is pulled with a force F as shown in the figure. What is the maximum value of F for which the disc rolls without slipping ?

12. If the law of gravitation, instead of being inverse-square law, becomes an inverse-cube law-

(a) planets will not have elliptic orbits.

(b) circular orbits of planets is not possible.

(c) projectile motion of a stone thrown by hand on the surface of the earth will be approximately parabolic.

(d) there will be no gravitational force inside a spherical shell of uniform density.

13. If the mass of sun were ten times smaller and gravitational constant G were ten times larger in magnitudes-

(a) walking on ground would become more difficult.

(b) the acceleration due to gravity on earth will not change.

(c) raindrops will fall much faster.

(d) airplanes will have to travel much faster.

14. If the sun and the planets carried huge amounts of opposite charges,

(a) all three of Kepler's laws would still be valid.

(b) only the third law will be valid.

(c) the second law will not change.

(d) the first law will still be valid.

15. There have been suggestions that the value of the gravitational constant G becomes smaller when considered over very large time period (in billions of years) in the future. If that happens, for our earth,

(a) nothing will change.

(b) we will become hotter after billions of years.

(c) we will be going around but not strictly in closed orbits.

(d) after sufficiently long time we will leave the solar system.

16. Which of the following are true?

(a) A polar satellite goes around the earth's pole in north- south direction.

(b) A geostationary satellite goes around the earth in east-west direction.

(c) A geostationary satellite goes around the earth in west-east direction.

(d) A polar satellite goes around the earth in east-west direction.

17. Give one example each of central force and non-central force.

18. Draw areal velocity versus time graph for mars.

19. Is it possible for a body to have inertia but no weight?

20. Out of aphelion and perihelion, where is the speed of the earth more and why ?

21. Two identical heavy spheres are separated by a distance 10 times their radius. Will an object placed at the mid point of the line joining their centres be in stable equilibrium or unstable equilibrium? Give reason for your answer.

22. Show the nature of the following graph for a satellite orbiting the earth.

(a) KE vs orbital radius R (b) PE vs orbital radius R (c) TE vs orbital radius R.

23. Six point masses of mass m each are at the vertices of a regular hexagon of side l . Calculate the force on any of the masses.

24. A satellite is in an elliptic orbit around the earth with aphelion of $6R$ and perihelion of $2R$ where $R = 6400$ km is the radius of the earth. Find eccentricity of the orbit. Find the velocity of the satellite at apogee and perigee. What should be done if this satellite has to be transferred to a circular orbit of radius $6R$? [$G = 6.67 \times 10^{-11}$ SI units and $M = 6 \times 10^{24}$ kg]

25. The Young's modulus for steel is much more than that for rubber. For the same longitudinal strain, which one will have greater tensile stress?

26. For an ideal liquid

(a) the bulk modulus is infinite.

(b) the bulk modulus is zero.

(c) the shear modulus is infinite.

(d) the shear modulus is zero.

27. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force f , its length increases by l . Another wire of the same material of length $2L$ and radius $2r$, is pulled by a force $2f$. Find the increase in length of this wire.

28. To what depth must a rubber ball be taken in deep sea so that its volume is decreased by 0.1%. (The bulk modulus of rubber is $9.8 \times 10^8 \text{ N m}^{-2}$; and the density of sea water is 103 kg m^{-3} .)
29. Two identical solid balls, one of ivory and the other of wet-clay, are dropped from the same height on the floor. Which one will rise to a greater height after striking the floor and why?
30. A steel rod of length $2l$, cross sectional area A and mass M is set rotating in a horizontal plane about an axis passing through the centre. If Y is the Young's modulus for steel, find the extension in the length of the rod. (Assume the rod is uniform.)
31. An ideal fluid flows through a pipe of circular cross-section made of two sections with diameters 2.5 cm and 3.75 cm. The ratio of the velocities in the two pipes is
- (a) 9:4 (b) 3:2 (c) $\sqrt{3} : \sqrt{2}$ (d) $\sqrt{2} : \sqrt{3}$
32. The angle of contact at the interface of water-glass is 0° , Ethylalcohol-glass is 0° , Mercury-glass is 140° and Methyl iodide-glass is 30° . A glass capillary is put in a trough containing one of these four liquids. It is observed that the meniscus is convex. The liquid in the trough is
- (a) water (b) ethylalcohol (c) mercury (d) methyl iodide.
33. With increase in temperature, the viscosity of
- (a) gases decreases. (b) liquids increases. (c) gases increases. (d) liquids decreases.
34. Iceberg floats in water with part of it submerged. What is the fraction of the volume of iceberg submerged if the density of ice is $\rho_{\text{ice}} = 0.917 \text{ g cm}^{-3}$?
35. A cubical block of density ρ is floating on the surface of water. Out of its height L , fraction x is submerged in water. The vessel is in an elevator accelerating upward with acceleration a . What is the fraction immersed?
36. The sap in trees, which consists mainly of water in summer, rises in a system of capillaries of radius $r = 2.5 \times 10^{-5} \text{ m}$. The surface tension of sap is $T = 7.28 \times 10^{-2} \text{ Nm}^{-1}$ and the angle of contact is 0° . Does surface tension alone account for the supply of water to the top of all trees?
37. The free surface of oil in a tanker, at rest, is horizontal. If the tanker starts accelerating the free surface will be tilted by an angle θ . If the acceleration is $a \text{ m s}^{-2}$, what will be the slope of the free surface?
38. Two mercury droplets of radii 0.1 cm. and 0.2 cm. collapse into one single drop. What amount of energy is released? The surface tension of mercury $T = 435.5 \times 10^{-3} \text{ N m}^{-1}$.
39. If a drop of liquid breaks into smaller droplets, it results in lowering of temperature of the droplets. Let a drop of radius R , break into N small droplets each of radius r . Estimate the drop in temperature.
40. A hot air balloon is a sphere of radius 8 m. The air inside is at a temperature of 60°C . How large a mass can the balloon lift when the outside temperature is 20°C ? (Assume air is an ideal gas, $R = 8.314 \text{ J mole}^{-1}\text{K}^{-1}$, $1 \text{ atm.} = 1.013 \times 10^5 \text{ Pa}$; the membrane tension is 5 N m^{-1} .)

41. A bimetallic strip is made of aluminium and steel ($\alpha_{Al} > \alpha_{steel}$). On heating, the strip will

(a) remain straight.

(b) get twisted.

(c) will bend with aluminium on concave side.

(d) will bend with steel on concave side.

42. Why does a metal bar appear hotter than a wooden bar at the same temperature? Equivalently it also appears cooler than wooden bar if they are both colder than room temperature.

43. Calculate the stress developed inside a tooth cavity filled with copper when hot tea at temperature of 57°C is drunk. You can take body (tooth) temperature to be 37°C and

$\alpha = 1.7 \times 10^{-5}/^\circ\text{C}$, bulk modulus for copper = $140 \times 10^9\text{ N/m}^2$.

44. Find out the increase in moment of inertia I of a uniform rod (coefficient of linear expansion α) about its perpendicular bisector when its temperature is slightly increased by ΔT .