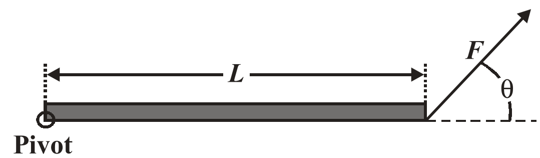
TRY YOURSELF - III   ANGULAR ACCELERATION PRODUCED BY A TORQUE

1. State Newton's three laws of motion in words suitable for rotating bodies.

2. Can an object rotate if there is no torque acting?

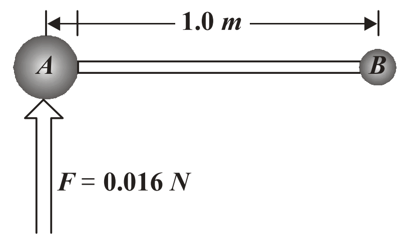
3. If the angular velocity of a body is zero at some instant, does this mean that the resultant torque on the body must be zero?

4. A uniform rod of mass $M = 1.2$ kg and lengt $h = 0.80$ m is free to rotate about one end as shown. The moment of inertia of the rod about an axis perpendicular to the rod an through the centre of mass is given by $ML^2/12.$ If a force ($F = 5.0$ N, $\theta = 40°$) acts as shown, what is the resulting angular acceleration about the pivot point?



(a) 16 rad/s²
(b) 12 rad/s²
(c) 14 rad/s²
(d) 10 rad/s²
(e) 33 rad/s².

5. Two small masses, $m_A = 4.0 \times 10^{-3}$ kg and $m_B = 2.0 \times 10^{-3}$ kg, are connected by a 1.0 m rod of negligible mass. The angular acceleration about B produced by a force of 0.016 N applied at A is is approximately

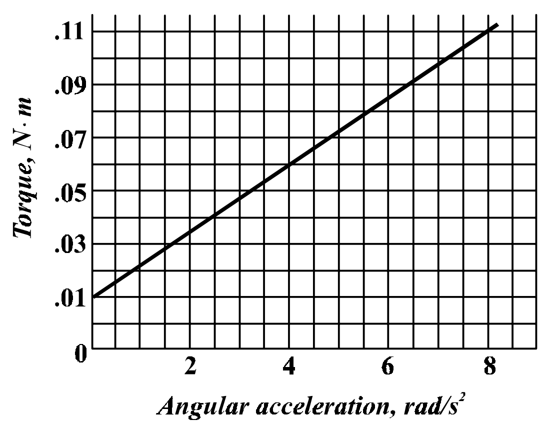


(a) 4.0 rad/s^2
(b) 2.7 rad/s^2
(c) 11 rad/s^2
(d) 12 rad/s^2
(e) 4.0×10^2 rad/s^2

6. A solid cylinder has a moment of inertia of 2 kg . m^2. It is at rest at time zero when a net torque given by $\tau = 6t^2 + 6$ (SI units) is applied. After 2 s, the angular velocity of the cylinder will be

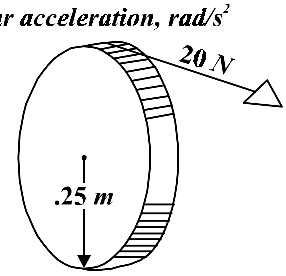
(a) 3.0 rad/s   (b) 12 rad/s
(c) 14 rad/s   (d) 24 rad/s
(e) 28 rad/s

7. In a laboratory experiment, various torques are applied to a rotor and the angular acceleration is measured. The results are plotted on the graph above. From the graph, the moment of inertia of the rotor is



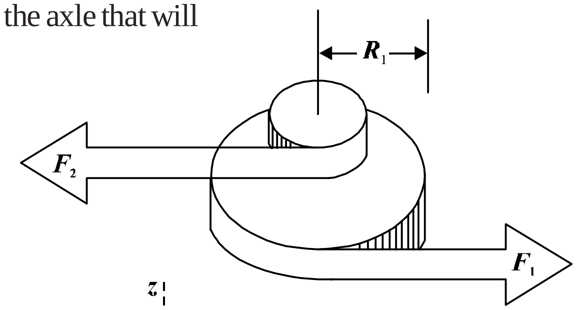
(a) $0.010\ kg \cdot m^2$
(b) $0.011\ kg \cdot m^2$
(c) $0.0125\ kg \cdot m^2$
(d) $0.0138\ kg \cdot m^2$
(e) $0.0225\ kg \cdot m^2$

8. A thin, massless string is wrapped around a 0.25-m radius grindstone supported by bearings that produce negligible frictional torque. A steady tension of 20 N in the string causes the grindstone to move from rest to a speed of 60 rad/s in 12 s. The moment of inertia of the grindstone is



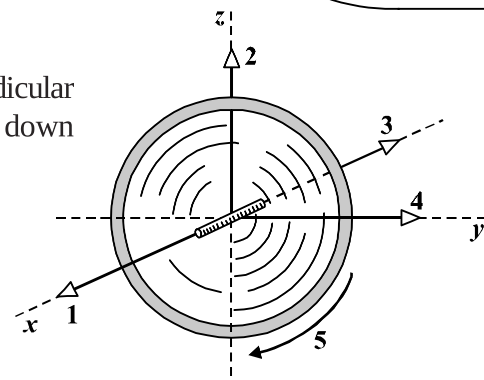
(a) $1.0\ kg \cdot m^2$ (b) $2.0\ kg \cdot m^2$
(c) $3.0\ kg \cdot m^2$ (d) $4.0\ kg \cdot m^2$
(e) $5.0\ kg \cdot m^2$

9. A wheel of radius R_1 has an axle of radius $R_2 = \frac{1}{4}R_1$. If a force F_1 is applied tangent to the wheel, a force F_2, applied tangent to the axle that will keep the wheel from turning, is equal to



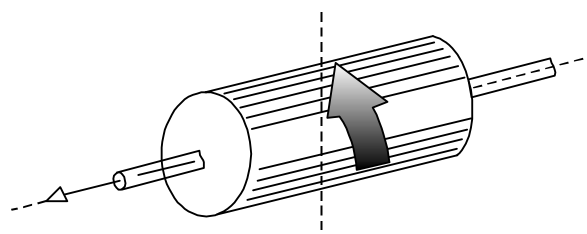
(a) $F_1/4$
(b) F_1
(c) $4F_1$
(d) $16F_1$
(e) $F_1/16$

10. A wheel is rotating clockwise on a fixed axis perpendicular to the page. A torque that causes the wheel to slow down is best represented by the vector



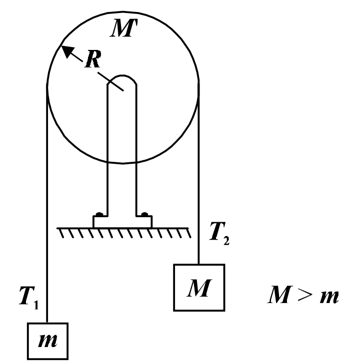
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

11. A solid cylinder is spinning counterclockwise about a longitudinal axis when a net torque τ is applied, as shown. The cylinder



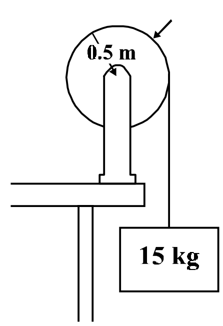
(a) speeds up
(b) slows down
(c) precesses about a vertical axis
(d) precesses about a horizontal axis
(e) does none of these

12. Two masses M and m ($M > m$) are hung over a disk $(I_{\text{disk}} = \frac{1}{2}M'R^2)$ and are released so that they acclerate. If T_1 is the tension in the cord on the left and T_2 is the tension in the cord on the right, then



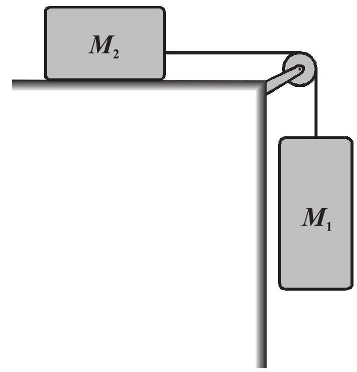
(a) $T_1 = T_2$
(b) $T_2 > T_1$
(c) $T_2 < T_1$
(d) $T_2 = Mg$
(e) $T_2 = Mg/m$

13. The moment of inertia of the wheel in the figure is 0.50 kg. m^2, and the bearing is frictionless. The acceleration of the 15-kg mass is approximately



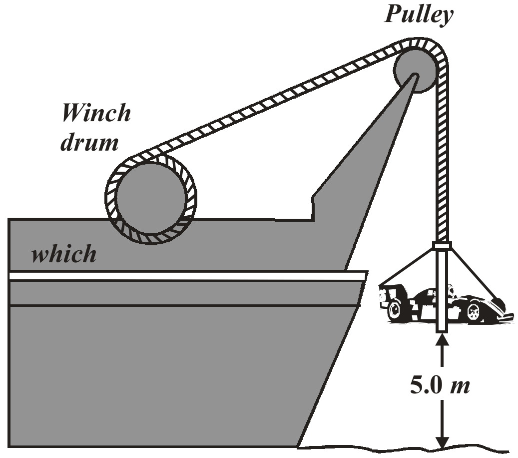
(a) 9.8 m/s^2
(b) 8.7 m/s^2
(c) 74 m/s^2
(d) 16 m/s^2

14. A mass $(m_1 = 5.0 \text{ kg})$ is connected by a light cord to a mass $(m_2 = 4.0 \text{ kg})$ which slides on a smooth surface, as shown in the figure. The pulley (radius = 0.20 m) rotates about a frictionless axle. The acceleration of m_2 is 3.5 m/s². What is the moment of inertia of the pulley?



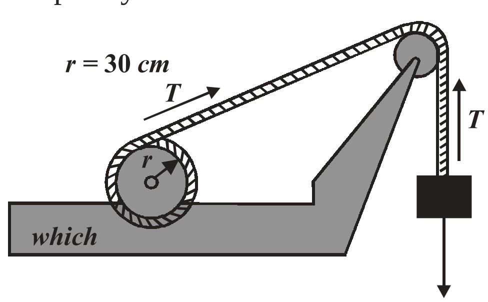
(a) 0.29 kg · m²
(b) 0.42 kg · m²
(c) 0.20 kg · m²
(d) 0.62 kg · m²
(e) 0.60 kg · m².

15. A 1 Mg car is being unloaded by a winch, as shown in figure. At this moment , the winch gearbox shaft breaks, and the car falls from rest. The moment of inertia of the winch drum is 320 kg. m² and that of the pulley is 4 kg.m²; the radius of the winch drum is 0.80 m and that of the pulley 0.30m. Find the speed of the car as it hits the water.

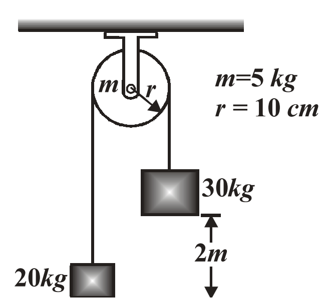


16. A 2000 kg block is lifted by a steel cable which passes over a pulley to a motor-driven winch (see fig 9.22). The radius of the which drum is 30 cm, and the moment of inertia of the pulley is negligible.

(a) What force must be exerted by the cable to lift the block at a constant velocity of 8 cm/s?
(b) What torque does the cable exert on the winch drum?
(c) What is the angular velocity of the winch drum ?
(d) What power must be developed by the motor to drive the winch drum?

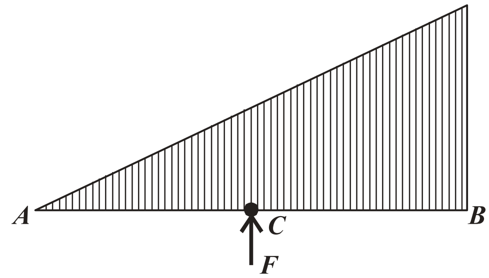


17. The system in figure is released from rest. The 30 kg body is 2 m above the floor. The pulley is a uniform disk with a radius of 10 cm and mass 5kg. Find



(a) the speed of the 30 kg body just before it hits the floor and the angular speed of the pulley at that time,
(b) the tensions in the strings and

18. A triangular plate of uniform thickness and density is made to rotate about an axis perpendicular to the plane of the paper and (a) passing through A, (b) passing through B, by the application of the same force, F, at C(mid-point of AB) as shown in the figure. The angular acceleration in both the cases will be the same. (True/false).

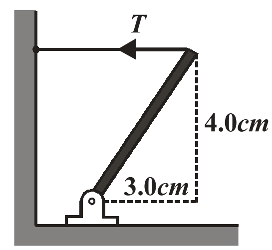


19. A uniform disk of mass M and radius R is pivoted so that it can rotate freely about an axis through its center and perpendicular to the plane of the disk. A small particle of mass m is attached to the rim of the disk at the top directly above the pivot. The system is given a gentle start and the disk begins to rotate.

(a) What is the angular velocity of the disk when the particle is at its lowest point ?
(b) At this point, what force must be exerted on the particle by the disk to keep it one the disk ?

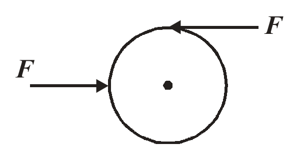
20. A uniform boom 5.0 m long and having a total mass of 150 kg is connected to the ground by a hinge at the bottom and is supported by a horizontal cable, as shown in figure.

(a) What is the tension in the cable ?
(b) What is the angular acceleration of the boom the instant the cable is cut?
(c) It the cable is cut, what is the angular velocity of the boom when it is horizontal?
(e) 0.53 m/s^2



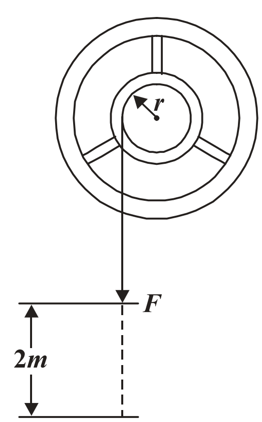
21. two forces of magnitude of 50 N, as shown in the figure below, act on a cylinder of radius 4 m and mass 6.25 kg. The cylinder sits on a frictionless surface. After 1 second, the velocity and angular velocity of the cylinder in m/s and rad/s are respectively:

(a) $v = 0$; $\omega = 0$
(b) $v = 0$; $\omega = 4$
(c) $v = 0$; $\omega = 8$
(d) $v = 8$; $\omega = 8$
(e) $v = 16$; $\omega = 9$.



22. In the figure, the rotational inertia of the wheel and axle about the center is 12.0 kg. m^2, the constant force F is 39.2 N, and the radius r is 0.800 m. The wheel starts from rest. When the force has acted through 2.00 m, the rotational velocity ω acquired by the wheel due to this force will be

(a) 1.26 rad/s
(b) 3.33 rad/s
(c) 3.61 rad/s
(d) 6.24 rad/s
(e) 10.3 rad/s

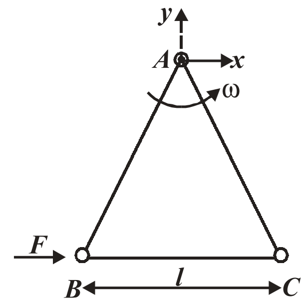


23. A uniform disc of radius R is spinned to the angular velocity ω and then carefully placed on a horizontal surface. How long will the disc be rotating on the surface if the friction coefficient is equal to μ? The pressure exerted by the disc on the surface can be regarded as uniform.

24. A cubical block of mass M and edge a slides down a rough inclined plane of inclination θ with a uniform velocity. The torque of the normal force on the block about its centre has a magnitude

(a) zero (b) Mga
(c) Mga sinθ (d) $\frac{1}{2}$ Mga sinθ.

25. Three particles A, B and C, each of mass m, are connected to each other by three massless rigid rods to form a rigid, equilateral triangular body of side l. This body is placed on a horizontal frictionless table (x-y plane) and is hinged to it at the point A so that it can move without friction about the vertical axis through A (see figure). The body is set into rotational motion on the table about A with a constant angular velocity ω.



(a) Find the magnitude of the horizontal force exerted by the hinge on the body.

(b) At time T, when the side BC is parallel to the x-axis, a force F is applied on B along BC (as shown). Obtain the x-component and the y-component of the force exerted by the hinge on the body, immediately after time T.

26. One-fourth length of a uniform rod of mass m and length l is placed on a rough horizontal surface and it is held stationary in horizontal position by means of a light thread as shown in the figure. The thread is then burnt and the rod starts rotating about the edge. Find the angle between the rod and the horizontal when it is about to slide on the edge. The coefficient of friction between the rod and the surface is μ.