1. A rod of length L has a linear mass density, λ, that varies according to the equation, $\lambda(x) = ax$, where a is a constant, x is in meters, and λ is in kg/m. What is the rotational inertia (moment of inertia), I, of this rod about an axis that is perpendicular to the rod and passes through the left end of the rod (at x = 0)?
   A) $aL^2/4$
   B) aL^2
   C) $aL^2/3$
   D) $2aL^2/3$
   E) None of these

2. A disk has a rotational inertia of $6.0\ kg \cdot m^2$ and a constant angular acceleration of 2.0 rad/s^2. If it starts from rest the work done during the first 5.0 s by the net torque acting on it is:

   A) 0
   B) 30 J
   C) 60 J
   D) 300 J
   E) None of these

3. A disk starts from rest and rotates around a fixed axis, subject to a constant net torque. The work done by the torque during the second 5 s is what multiple of the work done during the first 5 s?

   A) the same
   B) twice as much
   C) half as much
   D) four times as much
   E) None of these

4. A wheel initially has an angular velocity of 18 rad/s but it is slowing at a rate of 2.0 rad/s^2. By the time it stops it will have turned through:

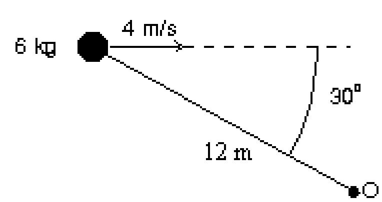
   A) 81 rad
   B) 160 rad
   C) 245 rad
   D) 330 rad
   E) None of these

5. A wheel initially at rest begins to angularly accelerate at the rate given by α (t) = 6 t^2. How much time (in seconds) will it take to rotate through 50 radians? (Two integrations will be required.)
   A) 2.8
   B) 3.2
   C) 4.0
   D) 4.7
   E) None of these

6. The torque acting on an object initially rotating at 3 rad/s at $\theta = 0$ is given by the equation, $\tau(\theta) = 2\theta$, where θ is in radians, and τ is in m-N. The object's rotational inertia is 0.64 kg-m^2. What will be the object's rotational kinetic energy (in joules) after it has completed one-half of a rotation?

   A) 17.25
   B) 11.46
   C) 16.66
   D) 10.08
   E) None of these

7. A 6.0-kg particle moves to the right at 4.0 m/s as shown. The magnitude of its angular momentum (in kg-m^2/s) about the point O is:



   A) zero
   B) 288
   C) 144
   D) 24
   E) 249

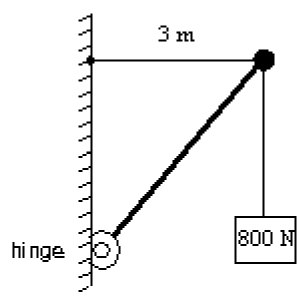
8. A uniform sphere of radius R rotates about a diameter with angular momentum of magnitude L. Under the action of internal forces the sphere collapses to a uniform sphere of radius $R/2$. The magnitude of its new angular momentum is:

   A) $L/4$
   B) $L/2$
   C) L
   D) $2L$
   E) $4L$

9. The position vector **r** of a 3-kg particle, relative to the origin, and measured in meters, is given by **r =** < $2t^2$, 3t, 0>, where the terms inside the angle brackets represent the time-varying x, y, and z components of the position vector. What is the magnitude of the torque (in m-N) acting on the particle at time t = 2 seconds?

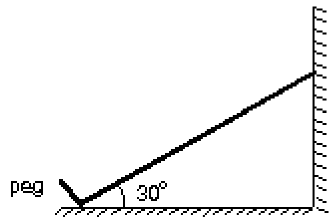
   A) 24
   B) 36
   C) 44
   D) 72
   E) None of these

10. A 5.0 m weightless strut, hinged to a wall, is used to support a 800-N block as shown. The horizontal and vertical components (H, and V) of the force (in N) of the hinge on the strut are:



   A) H =800, V = 800
   B) H = 600, V = 800
   C) H = 800, V = 600
   D) H = 1200, V = 600
   E) None of these

11. A uniform ladder is 10 m long and weighs 400 N. It rests with its upper end against a frictionless vertical wall. Its lower end rests on the ground and is prevented from slipping by a peg driven into the ground. The ladder makes a 30° angle with the horizontal. The force (in N) exerted on the wall by the ladder is:



A) 48
B) 74
C) 120
D) 350
E) None of these

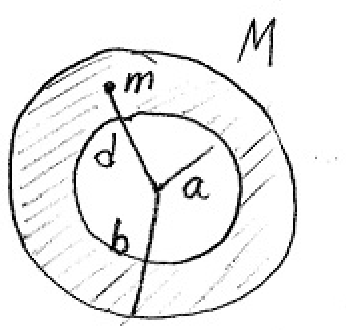
12. A playground merry-go-round has a radius of 3.0 m and a rotational inertia of 600 kg · m^2. It is initially spinning at 0.80 rad/s when a 20-kg child crawls from the center to the rim. When the child reaches the rim the angular velocity (in rad/s) of the merry-go-round is:

A) 0.62
B) 0.73
C) 0.80
D) 0.89
E) None of these

13. A machine exerts a torque of 0.80 N · m on an object that is rotating with a constant angular velocity of 20 rad/s. What is the work done (in joules) on the object by the machine in 1.0 min? (The angular velocity remains constant at 20 rad/s during this period. The concept of power is the key to this problem.)

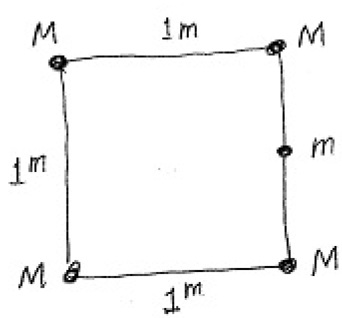
A) 0
B) 480
C) 960
D) 1400
E) 1800

14. A spherical shell has inner radius ***a***, outer radius ***b***, and mass **M**, distributed uniformly throughout the shell. The magnitude of the gravitational force exerted by the shell on a point mass particle of mass **m** a distance d from the center, outside the inner radius, and inside the outer radius, is:



A) zero
B) $(GMm/d^2)(d^3-a^3)/(b^3-a^3)$
C) $(GMm/d^2)(b^3-a^3)/(d^3-a^3)$
D) $(GMm/d^2)(b^3-a^3)/(d^3-b^3)$
E) $GMm/(d-a)^2$

15. Four point particles, each of mass M = 1.50×10^{10} kg, are at the four vertices of a square. Each side of the square is one meter long. What is the total force (in N) on a fifth particle of mass m = 1.0 kg located at the middle of one of the sides?

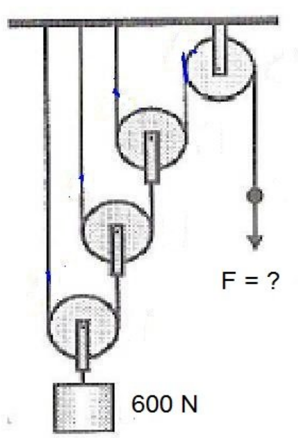


A) 0 .65
B) 1.54
C) 5.67
D) 8.33
E) None of these

16. A rocket leaving Earth exhausts its fuel and begins coasting away from Earth when it is 9.0×10^6 m from the center of Earth. At that time its speed is 5000 m/s. How far (in millions of meters) from the center of Earth will the rocket be when it starts to fall back to Earth? Note: $G = 6.67 \times 10^{-11}$ N-m^2/kg^2, and the mass of Earth is $M = 5.98 \times 10^{24}$ m.
    A) 15.4
    B) 10.3
    C) 12.5
    D) 34.3
    E)

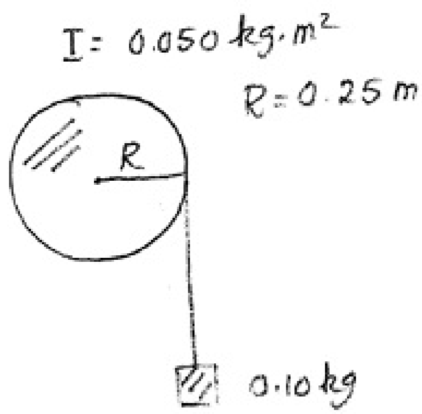
17. If the gravitational force law were $F = GMm/r^4$, and this law applied to the circular orbits of satellites about Earth, what fraction of its original orbital speed would the satellite have to have if it were to be moved to an orbit four times farther from the center of Earth?
    A) 1/2
    B) 1/3
    C) 1/4
    D) 1/8
    E) 1/16

18. What pull F (in newtons) will support the 600 N hanging weight? (The pulleys have zero masses and rotational inertias.)



    A) 150
    B) 75
    C) 100
    D) 125
    E) 200

19. A disk with a rotational inertia of 0.050 kg · m^2 and a radius of 0.25 m is initially at rest on an axis perpendicular to the disk and through its center. Wrapped around this disk is a string and at the end of the string a 0.10 kg mass is placed, as shown in the figure. What will be angular acceleration of the disk (in rad/s^2) once the hanging mass begins to fall?



A) 4.4
B) 2.5
C) 6.3
D) 10.3
E) 6.8

20. A solid uniform sphere of radius *R* and mass *M* has a rotational inertia about a diameter that is given by (2/5)MR^2. A light string of length 3*R* is attached to the surface and used to suspend the sphere from the ceiling. Its rotational inertia about an axis parallel to the ceiling at the point of attachment at the ceiling is:

A) (2/5) MR^2
B) 9 MR^2
C) 16 MR^2
D) (47/5) MR^2
E) (82/5) MR^2

Answer Key

1. A
2. D
3. D
4. A
5. B
6. A
7. C
8. C
9. D
10. B
11. D
12. A
13. C
14. B
15. A
16. C
17. C
18. *(No Answer Provided)*
19. A
20. E