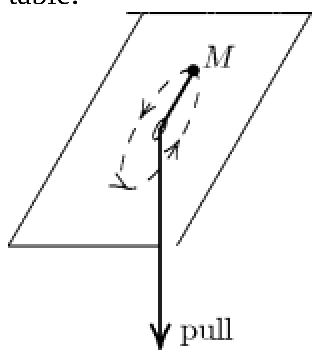
Name: ___________________________ Date: _____________

1. A sphere and a cylinder of equal mass and radius are simultaneously released from rest on the same inclined plane and roll without sliding down the incline. Then:

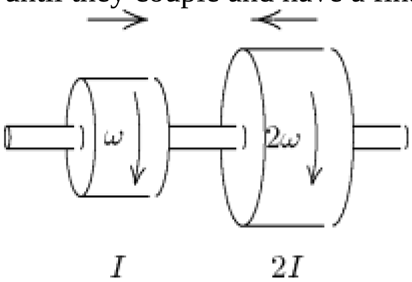
A) the sphere reaches the bottom first because it has the greater inertia
B) the cylinder reaches the bottom first because it picks up more rotational energy
C) the sphere reaches the bottom first because it picks up more rotational energy
D) they reach the bottom together
E) none of the above are true

2. A block with mass *M*, on the end of a string, moves in a circle on a horizontal frictionless table as shown. As the string is slowly pulled through a small hole in the table:



A) the rotational momentum of the block remains constant
B) the rotational momentum of the block decreases
C) the kinetic energy of the block remains constant
D) the kinetic energy of the block decreases
E) none of the above

3. Two disks are mounted on low-friction bearings on a common shaft. The first disc has rotational inertia I and is spinning with rotational speed ω. The second disc has rotational inertia $2I$ and is spinning in the same direction as the first disc with rotational speed 2ω as shown. The two disks are slowly forced toward each other along the shaft until they couple and have a final common rotational speed of:



A) $5\omega/3$
B) $\omega\sqrt{3}$
C) $\omega\sqrt{7/3}$
D) ω
E) 3ω

4. When the speed of a rear-drive car is increasing on a horizontal road the direction of the frictional force on the tires is:

A) forward for all tires
B) backward for all tires
C) forward for the front tires and backward for the rear tires
D) backward for the front tires and forward for the rear tires
E) zero

5. A forward force on the axle accelerates a rolling wheel on a horizontal surface. If the wheel does not slide the frictional force of the surface on the wheel is:

A) zero
B) in the forward direction
C) in the backward direction
D) in the upward direction
E) in the downward direction

6. A solid wheel with mass M, radius R, and rotational inertia $MR^2/2$, rolls without sliding on a horizontal surface. A horizontal force $\vec{F}$ is applied to the axle and the center of mass has an acceleration $\vec{a}$. The magnitudes of the applied force $\vec{F}$ and the frictional force $\vec{f}$ of the surface, respectively, are:

A) $F = Ma$, $f = 0$
B) $F = Ma$, $f = Ma/2$
C) $F = 2Ma$, $f = Ma$
D) $F = 2Ma$, $f = Ma/2$
E) $F = 3Ma/2$, $f = Ma/2$

7. A playground merry-go-round has a radius R and a rotational inertia I. When the merry-go-round is at rest, a child with mass m runs with speed v along a line tangent to the rim and jumps on. The rotational speed of the merry-go-round is then:

A) mv/I
B) v/R
C) mRv/I
D) $2mRv/I$
E) $mRv/(mR^2 + I)$

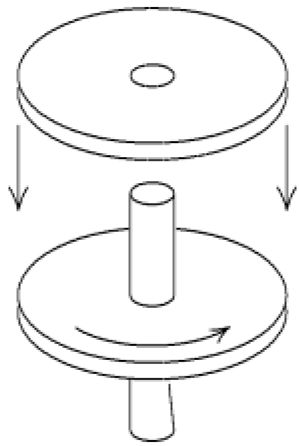
8. Two identical disks, with rotational inertia I ($=\frac{1}{2}MR^2$), roll without sliding across a horizontal floor with the same speed and then up inclines. Disk A rolls up its incline without sliding. On the other hand, disk B rolls up a frictionless incline. Otherwise the inclines are identical. Disk A reaches a height 12 cm above the floor before rolling down again. Disk B reaches a height above the floor of:

A) 24 cm
B) 18 cm
C) 12 cm
D) 8 cm
E) 6 cm

9. A phonograph record is dropped onto a freely spinning turntable. Then:

A) neither rotational momentum nor mechanical energy is conserved because of the frictional forces between record and turntable
B) the frictional force between record and turntable increases the total rotational momentum
C) the frictional force between record and turntable decreases the total rotational momentum
D) the total rotational momentum remains constant
E) the sum of the rotational momentum and rotational kinetic energy remains constant

10. A wheel with rotational inertia I, mounted on a vertical shaft with negligible rotational inertia, is rotating with rotational speed ω_0. A nonrotating wheel with rotational inertia $2I$ is suddenly dropped onto the same shaft as shown. The resultant combination of the two wheels and shaft will rotate at:



A) $\omega_0/2$
B) $2\omega_0$
C) $\omega_0/3$
D) $3\omega_0$
E) $\omega_0/4$

11. A uniform sphere of radius R rotates about a diameter with a rotational 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 rotational momentum is:

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

12. A 2.0-kg block travels around a 0.50-m radius circle with an rotational speed of 12 rad/s. The circle is parallel to the *xy* plane and is centered on the *z* axis, 0.75 m from the origin. The magnitude of its rotational momentum around the origin is:

A) 6.0 kg · m^2/s
B) 9.0 kg · m^2/s
C) 11 kg · m^2/s
D) 14 kg · m^2/s
E) 20 kg · m^2/s

13. As a 2.0-kg block travels around a 0.50-m radius circle it has a rotational speed of 12 rad/s. The circle is parallel to the *xy* plane and is centered on the *z* axis, a distance of 0.75 m from the origin. The *z* component of the rotational momentum around the origin is:

A) 6.0 kg · m^2/s
B) 9.0 kg · m^2/s
C) 11 kg · m^2/s
D) 14 kg · m^2/s
E) 20 kg · m^2/s

14. As a 2.0-kg block travels around a 0.50-m radius circle it has a rotational speed of 12 rad/s. The circle is parallel to the *xy* plane and is centered on the *z* axis, 0.75 m from the origin. The component in the *xy* plane of the rotational momentum around the origin has a magnitude of:

A) 0
B) 6.0 kg · m^2/s
C) 9.0 kg · m^2/s
D) 11 kg · m^2/s
E) 14 kg · m^2/s

15. A 2.0-kg stone is tied to a 0.50-m long string and swung around a circle at a constant rotational speed of 12 rad/s. The magnitude of the net torque on the stone about the center of the circle is:

A) 0
B) 6.0 N · m
C) 12 N · m
D) 72 N · m
E) 140 N · m

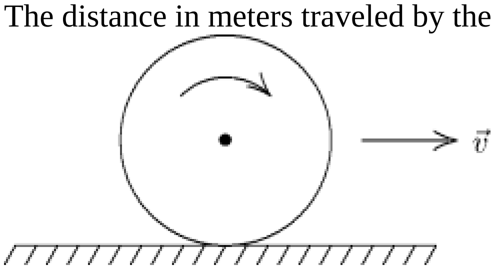
16. A 2.0-kg block starts from rest on the positive *x* axis 3.0 m from the origin and thereafter has a translational acceleration given by $\vec{a} = (4.0\,\text{m/s}^2)\,\hat{\text{i}} - (3.0\,\text{m/s}^2)\,\hat{\text{j}}$. At the end of 2.0 s its rotational momentum about the origin is:

A) 0
B) $(-36\,\text{kg}\cdot\text{m}^2/\text{s})\,\hat{\text{k}}$
C) $(+48\,\text{kg}\cdot\text{m}^2/\text{s})\,\hat{\text{k}}$
D) $(-96\,\text{kg}\cdot\text{m}^2/\text{s})\,\hat{\text{k}}$
E) $(+96\,\text{kg}\cdot\text{m}^2/\text{s})\,\hat{\text{k}}$

17. The newton · second is a unit of:

A) work
B) rotational momentum
C) power
D) translational momentum
E) none of these

18. A wheel of radius 0.5 m rolls without sliding on a horizontal surface as shown. Starting from rest at time $t_1 = 0$, the wheel moves with constant rotational acceleration 6 rad/s^2. The distance in meters traveled by the center of the wheel from time t_1 to time $t_2 = 3$ s is:



A) zero
B) 27
C) 13.5
D) 18
E) none of these

19. An ice skater with rotational inertia I_1 is spinning with rotational speed ω_1. She pulls her arms in, thereby increasing her rotational speed to $4\omega_1$. Her rotational inertia is then:

A) I_1
B) $I_1/2$
C) $2I_1$
D) $I_1/4$
E) $4I_1$

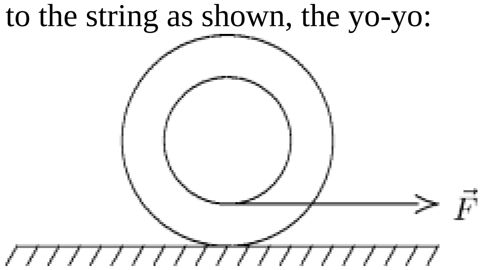
20. The fundamental dimensions of rotational momentum are:

A) mass · length · time^{-1}
B) mass · length^{-2} · time^{-2}
C) mass · length^{2} · time^{-1}
D) mass · length^{2} · time^{-2}
E) none of these

21. When a man on a frictionless rotating stool extends his arms horizontally, his rotational kinetic energy:

A) must increase
B) must decrease
C) must remain the same
D) may increase or decrease depending on his initial rotational speed
E) may increase or decrease depending on his rotational acceleration

22. A yo-yo, arranged as shown, rests on a frictionless surface. When a force $\vec{F}$ is applied to the string as shown, the yo-yo:



A) moves to the left and rotates counterclockwise
B) moves to the right and rotates counterclockwise
C) moves to the left and rotates clockwise
D) moves to the right and rotates clockwise
E) moves to the right and does not rotate

23. A man, with his arms at his sides, is spinning on a light frictionless turntable. When he extends his arms:

A) his rotational speed increases
B) his rotational speed remains the same
C) his rotational inertia decreases
D) his rotational kinetic energy increases
E) his rotational momentum remains the same

24. A 15-g paper clip is attached to the rim of a phonograph record with a radius of 30 cm, spinning at 3.5 rad/s. The magnitude of its rotational momentum is:

A) 1.4×10^{-3} kg · m^2/s
B) 4.7×10^{-3} kg · m^2/s
C) 1.6×10^{-2} kg · m^2/s
D) 3.2×10^{-1} kg · m^2/s
E) 1.1 kg · m^2/s

25. A man, holding a weight in each hand, stands at the center of a horizontal frictionless rotating turntable. The effect of the weights is to double the rotational inertia of the system. As he is rotating, the man opens his hands and drops the two weights. They fall outside the turntable. Then:

A) his rotational speed doubles
B) his rotational speed remains about the same
C) his rotational speed is halved
D) the direction of his rotational momentum vector changes
E) his rotational kinetic energy increases

Answer Key

1. E
2. A
3. A
4. D
5. D
6. E
7. E
8. D
9. D
10. C
11. C
12. C
13. A
14. C
15. A
16. B
17. D
18. C
19. D
20. C
21. B
22. B
23. E
24. B
25. B