Name: ____ **Date:** ____________________ **Period:** ________

AP Physics C
Rotational Motion HO19

1.) A wheel turns with constant acceleration 0.450 rad/s^2. (9-9)

a.) How much time does it take to reach an angular velocity of 8.00 rad/s, starting from rest?

b.) Through how many revolutions does the wheel turn in this time interval?

2.) A bicycle wheel has an initial angular velocity of 1.50 rad/s. If its angular acceleration is constant and equal to 0.300 rad/s^2, what is its angular velocity after it has turned through 3.50 revolutions? (9-10)

3.) The angle θ through which a wheel turns is given by $\theta(t) = a + bt^2 + ct^3$, where a, b, and c are constants that for t in seconds, θ will be in radians. Find the angular acceleration of the wheel as a function of time. (9-7)

4.) A flywheel whose angular acceleration is constant and equal to 2.50 rad/s^2 rotates through an angle of 80.0 rad in 5.00 s. What was the angular velocity of the flywheel at the beginning of the 5.00 s interval? (9-13)

5.) A circular saw blade 0.200 m in diameter starts from rest and accelerates with constant angular acceleration to an angular velocity of 140 rad/s in 8.00 s. Find the angular acceleration and the angle through which the blade has turned. (9-12)

6.) A wheel requires 3.00 s to rotate through 162 rad. Its angular velocity at the end of this time is 108 rad/s. (9-14)

a.) Find the angular velocity at the beginning of the 3.00 s interval.

b.) Find the constant angular acceleration.

7.) Derive a constant-angular-acceleration equation that gives $\theta - \theta_0$ in terms of ω, α, and t (no ω_0 in the equation). (9-16)

8.) At $t = 0$ a grinding wheel has an angular velocity of 24.0 rad/s. It has a constant angular acceleration of 60.0 rad/s^2 until a circuit breaker trips at $t = 2.00$ s. From then on, it turns through 432 rad as it coasts to a stop at constant angular acceleration. (9-17)

a.) Through what total angle did the wheel turn between $t = 0$ and the time it stopped?

b.) At what time did it stop?

c.) What was its acceleration as it slowed down?

9.) A safety device brings the blade of a power mower from an initial angular velocity of ω_1 to rest in 1 revolution. At the same constant acceleration, how many revolutions would it take the blade to come to rest from an initial angular velocity ω_2 that was twice as great, $\omega_2 = 2\omega_1$? (9-15)

10.) The tires of a car make 65 revolutions as the car reduces its speed uniformly from 100 km/h to 50 km/h. The tires have a diameter of 0.80 m.

a.) What was the angular acceleration?

b.) If the car continues to decelerate at this rate, how much more time is required for it to stop?

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AP Physics C
Rotational Motion HO20

1.) A machine part has a disk of radius 4.50 cm fixed to the end of a shaft that has radius 0.25 cm. If the tangential speed of a point on the surface of the shaft is 2.00 m/s, what is the tangential speed of a point on the rim of the disk? (9-24)

2.) At t = 3.00 s a point on the rim of a 0.200 m radius wheel has a tangential speed of 40.0 m/s as the wheel slows down with a tangential acceleration of constant magnitude 10.0 m/s^2. (9-30)

a.) Calculate the wheel's constant angular acceleration.

b.) Calculate the angular velocities a t = 3.00 s and t = 0.

c.) Through what angle did the wheel turn between t = 0 and t = 3.00 s?

d.) At what time will the radial acceleration equal 9.8 m/s^2?

3.) An electric fan blade 0.850 m in diameter is rotating about a fixed axis with an initial angular velocity of 3.00 rev/s. The angular acceleration is 1.50 rev/s^2. (9-26)

a.) Compute the angular velocity after 1.00 s.

b.) Through how many revolutions has the blade turned in this time interval?

c.) What is the tangential speed of a point on the tip of the blade at t = 1.00 s?

d.) What is the magnitude of the resultant acceleration of a point on the tip of the blade at t = 1.0 s?

4.) Small blocks, each with mass m, are clamped at the ends and at the center of light rod of length L. Compute the moment of inertia of the system about an axis perpendicular to the rod and passing through a point one third of the length from one end. (9-32)

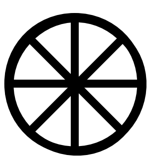
5.) Four small spheres, each with a mass of 0.200 kg, are arranged in a square 0.400 m on a side and connected by light rods. Find the moment of inertia of the system about an axis (9-35)

a.) through the center of the square, perpendicular to its plane.

b.) bisecting two opposite sides of the square.

6.) Four identical particles (mass of each = 0.24 kg) are placed at the vertices of a rectangle (2.0 m x 3.0 m) and held in those positions by four light rods which form the sides of the rectangle. What is the moment of inertia of this rigid body about an axis that passes through the center of mass of the body and is parallel to the shorter sides of the rectangle?

7.)



A wagon wheel is constructed as shown. The radius of the wheel is 0.300 m, and the rim has a mass of 1.60 kg. Each of the eight spokes, which lie along a diameter and are 0.300 m long, has a mass of 0.320 kg. What is the moment of inertia of the wheel about an axis through its center and perpendicular to the plane of the wheel? (9-37)

8.) Find the moment of inertia for the following.

a.) A solid sphere of mass 5.0 kg and radius 0.20 m about a central axis.

b.) A hoop of mass 10.0 kg and radius 2.5 m a about a central axis perpendicular to its diameter.

c.) A hollow sphere of mass 15.0 kg and radius 3.00 m about a central axis.

d.) A solid cylinder of mass 150 kg and radius 1.5 m about a central axis perpendicular to its diameter.

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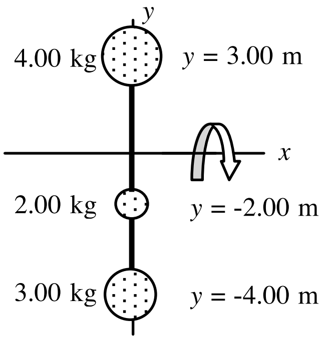
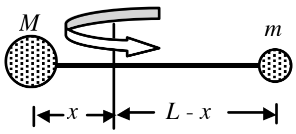
AP Physics C
Rotational Motion HO21

1.) 

Three particles are connected by rigid rods of negligible mass lying along the y-axis as shown in the figure . If the system rotates about the *x*-axis with an angular speed of 2.00 rad/s, find

a.) the moment of inertia about the *x*-axis and the total rotational energy evaluated from $\frac{1}{2}I\omega^2$.

b.) the linear speed of each particle and the total energy evaluated from $\sum \frac{1}{2} m_i v_i^2$.

2.) 

Two masses *M* and *m* are connected by a rigid rod of length *L* and negligible mass as shown .

a.) For an axis perpendicular to the rod, show that the system has the minimum moment of inertia when the axis passes through the center of mass.

b.) Show that the minimum moment of inertia is $I = \dfrac{MmL^2}{M + m}$.

3.) A solid cylinder of mass *M* and radius *R* rolls (without slipping) down an inclined plane (of height *h* and length *L*) whose incline angle with the horizontal is *θ*. Determine the linear speed of the cylinder's center of mass when it reaches the bottom.

4.) Repeat problem (3.) for a solid sphere.

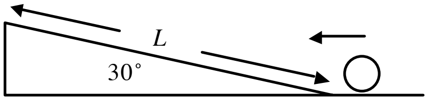
5.) Use the parallel-axis theorem and known formulas to find the moments of inertia of

a.) a solid cylinder about an axis parallel to the center of mass axis and passing through the edge of the cylinder

b.) a hollow sphere about an axis tangent to its surface

6.) A merry-go-round has a mass of 1640 kg and a radius of 8.20 m. How much work is required to accelerate it from rest to a rotation rate of one revolution in 8.00 s? (Assume it is a solid cylinder.)

7.) Calculate the transitional and rotational speeds of a hollow sphere (radius 20.0 cm and mass 1.20 kg), that rolls without slipping down a 30.0˚ incline that is 10.0 m long, when it reaches the bottom.

8.) 

A hollow cylinder (mass 1.0 kg and radius 0.4 m) is rolling towards a 30˚ incline. If its linear speed is 4.00 m/s at the bottom of the incline, how far (*L*) does the cylinder travel along (without slipping) the incline before it stops?

9.) About what axis will a uniform sphere have the same moment of inertia as for a thin-walled hollow sphere of the same mass and radius with the axis along a diameter? (9-49)

10.) A thin hoop of radius *R* is hung over a nail at the rim of the hoop. It is displaced to its side through an angle *β* from its equilibrium position and let go. What is its angular speed when it returns to its equilibrium position? (9-75)

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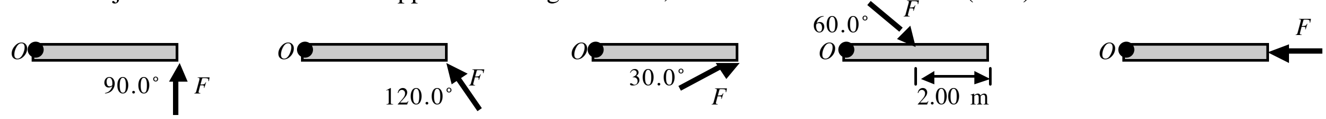
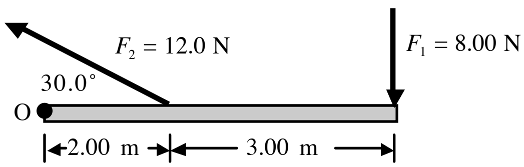
AP Physics C
Rotational Motion HO22

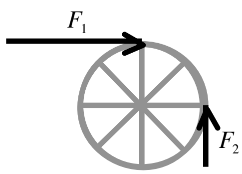
1.) Calculate the torque (magnitude and direction) about point O due to the force F in each of the situations shown below. In each case the object to which the force is applied has length 4.00 m, and the force F is 15.0 N. (10-1)



2.) Find the net torque about point O for the two forces applied as in the figure to the left. (10-2)



3.) Forces F_1 = 8.60 N and F_2 = 4.30 N are applied tangentially to a wheel with radius 0.330 m, as shown. What is the net torque on the wheel due to these two forces for an axis perpendicular to the wheel and passing through its center? (10-4)



4.) The flywheel of an engine has a moment of inertia 3.50 kg·m^2 about its rotation axis. (10-6)

a.) What constant torque is required to bring it up to an angular velocity of 600 rev/min in 8.00 s, starting from rest?

b.) What is its final kinetic energy?

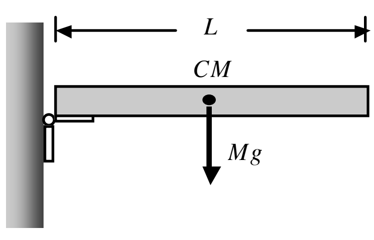
5.) A cord is wrapped around the rim of a flywheel 0.300m in radius, and a steady pull of 50.0 N is exerted on the cord. The wheel is mounted on frictionless bearings on a horizontal shaft through its center. The moment of inertia of the wheel about this shaft is 4.00 kg·m^2. Compute the angular acceleration of the wheel. (10-10)

6.) A yo-yo is made of two solid cylindrical disks, each of mass 0.050 kg and diameter 0.075 m, joined by a (concentric) a thin cylindrical hub of mass 0.0050 kg and diameter 0.010 m. (???)

a.) Use conservation of energy to calculate the linear speed of the yo-yo when it reaches the end of its 1.0 m long string, if it is released from rest.

b.) What fraction of its kinetic energy is rotational?

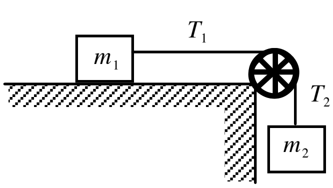
7.) A uniform rod of mass M and length L can pivot freely about a hinge attached to a wall as shown. The rod is held horizontally and then released. At the moment of release, determine (???)



a.) the angular acceleration of the rod.

b.) the linear acceleration of the tip of the rod.

8.) A box of mass m_1 = 2.0 kg slides without friction on a horizontal surface. It is attached to a hanging mass m_2 = 1.5 kg by a string of negligible mass. The pulley is a thin cylindrical shell (with massless spokes) with a mass of 1.0 kg and radius of 0.15 m, and the string turns the pulley without stretching or slipping. Find the acceleration of each body, the angular acceleration of the pulley, and the tension in each part of the string. (???)



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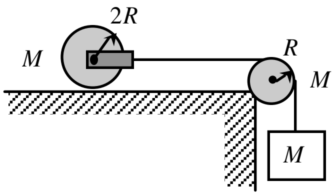
AP Physics C
Rotational Motion HO23

1.) 

A uniform solid cylinder of mass M and radius $2R$ rests on a horizontal table top. A string is attached by a yoke to a frictionless axle through the center of the cylinder so that the cylinder can rotate about the axle. The string runs over a pulley in the shape of a disk of mass M and radius R that is mounted on a frictionless axle through its center. A block of mass M is suspended from the free end of the string. The string doesn't slip over the pulley surface, and the cylinder rolls without slipping on the table top. After the system is released from rest, what is the magnitude of the downward acceleration of the block? (10-71)

2.) A flywheel 0.500 m in diameter is pivoted on a horizontal axis. A rope is wrapped around the outside of the flywheel, and a steady pull of 60.0 N is exerted on the rope. The flywheel starts from rest, and 3.00 m of rope are unwound in 4.00 s. (10-48)

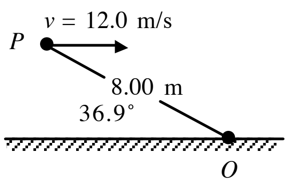
a.) What is the angular acceleration of the flywheel?

b.) What is its final angular velocity?

c.) What is its final kinetic energy?

d.) What is its moment of inertia about the rotation axis?

3.) What is the angular momentum of the second hand on a clock about an axis through the center of the clock face if the clock hand has a length of 25.0 cm and a mass of 15.0 g? Take the second hand to be a slender rod rotating with constant angular velocity about one end. (10-29)

4.) 

A 3.00 kg rock has a horizontal velocity of magnitude 12.0 m/s when it is at point P as shown . At this instant, what is its angular momentum relative to point O? (10-48)

5.) The outstretched hands and arms of a figure skater preparing for a spin can be considered, a slender rod pivoting about an axis through its center. When his hands and arms are brought in and wrapped around his body to execute the spin, the hands and arms can be considered a thin-walled hollow cylinder. His hands and arms have a combined mass of 8.0 kg. When outstretched, they span 1.8 m; when wrapped, they form a cylinder of radius 25 cm. The moment of inertia about the rotation axis of the remainder of his body is constant and equal to 0.40 $kg \cdot m^2$. If his original angular velocity is 0.60 rev/s, what is his final angular velocity? (10-34)

6.) A merry-go-round rotates about a fixed vertical axis, making one revolution in 6.00 s. Its moment of inertia is 1200 $kg \cdot m^2$. A man of mass 80.0 kg, initially standing at the center of the merry-go-round, runs out along a radius. What is the angular velocity of the merry-go-round when the man is 2.00 m from the center? (10-40)

7.) A uniform disk turns at 7.0 rev/s around a frictionless spindle. A nonrotating rod, of the same mass as the disk and length equal to the disk's diameter, is dropped on the freely spinning disk. They both turn around the spindle with their centers superimposed. What is the angular velocity of the combination?

8.) A nonrotating cylindrical disk of moment of inertia I is dropped onto an identical disk rotating at angular speed ω. Assuming no external torques, what is the final common angular speed of the two disks?

9.) A 4.2 m diameter merry-go-round is rotating freely with an angular velocity of 0.80 rad/s. Its total moment of inertia is 1760 $kg \cdot m^2$. Four people standing on the ground, each of mass 65 kg, suddenly step onto the edge of the merry-go-round. What is the angular velocity of the merry-go-round now?

10.) Larry decides to shoot a bullet into a 10.0 kg solid disk of wood with radius 0.300 m mounted on a frictionless axle through its center and perpendicular to its face. The axle is vertical, so the disk lies in a horizontal plane. The bullet has a mass of 1.88 g and a velocity of 360 m/s before its strikes the wood and becomes embedded along a line 0.250 m to the right of its center. How much time will it take the disk to make one revolution after the bullet has stopped relative to the disk? (10-38)