AP Physics Test Bank **Name_____ #:__**

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. Calculate the angular speed, in rad/s, of a flywheel turning at 520.0 rpm.

2. Through what angle in degrees does a 33 rpm record turn in 0.25 s?

3. An electrical motor spins at a constant 2857.0 rpm. If the armature radius is 2.685 cm, what is the acceleration of the edge of the rotor?

4. A satellite is in orbit around a planet. The orbital radius is 34.0 km and the gravitational acceleration at that height is 2.3 m/s^2. What is the satellite's orbital speed?

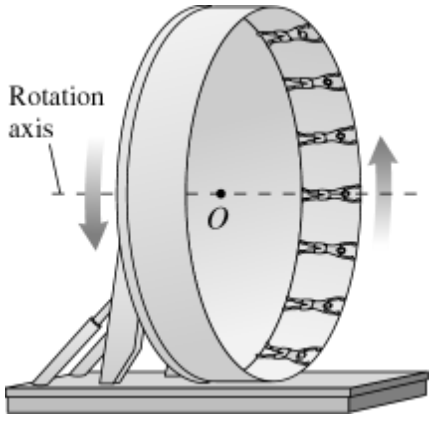
5. A 23 kg mass is connected to a nail on a frictionless table by a (massless) string of length 1.3 m. If the tension in the string is 51 N while the mass moves in a uniform circle on the table, how long does it take for the mass to make one complete revolution?

6. A new roller coaster contains a loop–the–loop in which the car and rider are completely upside down. If the radius of the loop is 13.2 m, with what minimum speed must the car traverse the loop so that the rider does not fall out while upside down at the top? Assume the rider is not strapped to the car.

7. A tetherball is on a 2.1 m string that makes an angle of 44° with the vertical as it moves around the pole in a horizontal plane. If the mass of the ball is 1.3 kg, what is the ball's speed?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. In an amusement park ride, passengers stand inside an 8 m radius cylinder. Initially, the cylinder rotates with its axis oriented along the vertical. After the cylinder has acquired sufficient speed, it tilts into a vertical plane, that is, the axis tilts into the horizontal, as shown in the figure. Suppose that, once the axis has tilted into the horizontal, the ring rotates once every 4.5 s. If a rider's mass is 40 kg, with how much force does the ring push on her at the top of the ride?



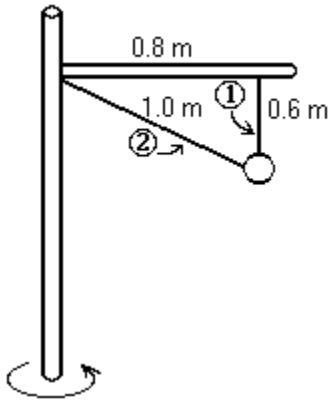
A) 620 N B) 390 N C) 230 N D) 1000 N

2. Future space stations will create an artificial gravity by rotating. Consider a cylindrical space station of 380 m diameter rotating about its axis. Astronauts walk on the inside surface of the space station. What rotation period will provide "normal" gravity?
   A) 6.2 s B) 28 s C) 4.4 s D) 39 s

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. An aerobatic aircraft is to perform a spiral maneuver. If the engine provides a tangential acceleration of 5.41 m/s^2, what is the radial acceleration it will experience at the end of a circle 30.8 m in radius, if the speed at the beginning of the stunt was 55.0 m/s?

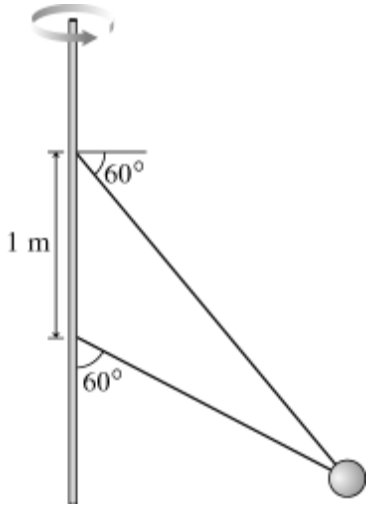
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.



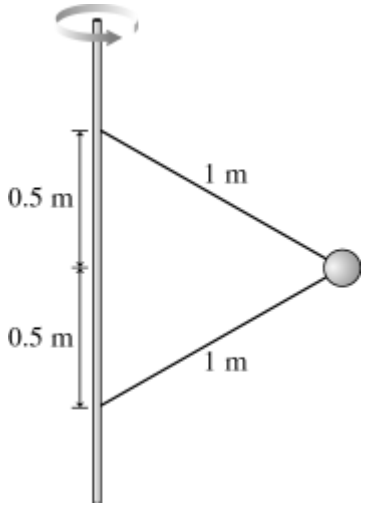
1. A ball of mass 8.0 kg is suspended by two wires from a horizontal arm, which is attached to a vertical shaft, as shown in the figure. The shaft is in uniform rotation about its axis such that the linear speed of the ball equals 2.3 m/s. The tension in wire 1 is closest to:
   A) 49 N B) 39 N C) 29 N D) 9.8 N E) 20 N

SHORT ANSWER. *Write the word or phrase that best completes each statement or answers the question.*

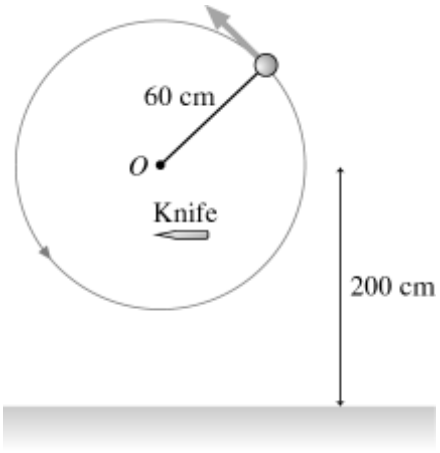
1. The figure shows two wires tied to a 3.3 kg sphere that revolves in a horizontal circle at constant speed. At this particular speed the tension is the same in both wires. What is the tension?



2. The figure shows two wires that are tied to a 710 g mass that revolves in a horizontal circle at a constant speed of 7.5 m/s. What is the tension in the upper wire?

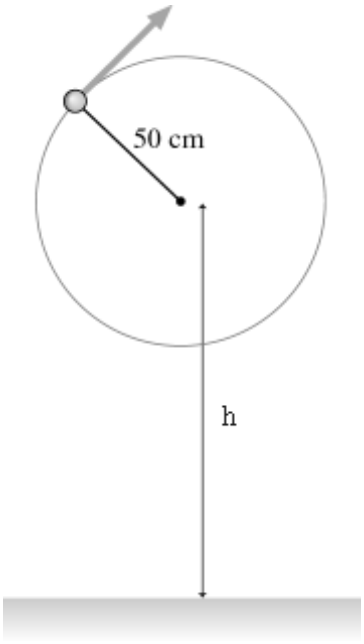


3. A 90 g bead on a 60 cm long string is swung in a vertical circle about a point 200 cm above the floor. The tension in the string when the bead is at the very bottom of the circle is 2.2 N. A very sharp knife is suddenly inserted, as shown in the figure, to cut the string directly below the point of support. How far to the right of the center of the circle does the ball hit the floor?



MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. The figure shows a 3.0 kg ball tied to the end of a 50 cm long string being swung in a circle in a vertical plane at constant speed. The center of the circle is h = 510 cm above the floor. The ball is swung at the minimum speed necessary to make it over the top without the string going slack. If the string is released at the instant the ball is at the top of the loop, how far to the right of the center of the circle does the ball hit the ground?



A) 0.0 cm B) 240 cm C) 210 cm D) 230 cm

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. What is the magnitude of the force exerted by Earth on the Moon?

2. An astronaut is in equilibrium when he is positioned 140 km from planet X and 581 km from planet Y, along the straight line joining the planets' centers. What is the ratio of the masses X/Y?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. At a given point above the surface of Earth, the gravitational acceleration is equal to 7.8 m/s^2. The altitude of this point, above the surface of Earth, in km, is closest to:
   A) 1500 B) 970 C) 770 D) 2400 E) 2000

2. What is the gravitational force acting on a person due to another person standing 2 meters away? Assume each individual has 59 kg mass.
   A) 5.8×10^{-8} N
   B) 8.5×10^{3} N
   C) 9.8×10^{-10} N
   D) 1.2×10^{-7} N
   E) 2.0×10^{-9} N

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. The weight of spaceman Speff, solely due to the gravitational pull of planet X at its surface, is 389 N. If he moves to a distance of 1.86×10^{4} km above the planet's surface, his weight changes to 24.31 N. What is the mass of planet X, if Speff's mass is 75 kg?

2. If we assume that an electron is orbiting a proton just like the moon orbits Earth, find the electron's orbital speed due to the gravitational attraction between itself and the proton. Take the orbital radius as 1.00×10^{-10} m. (This is a very wrong assumption to make.)

3. Spaceman Speff orbits planet X with his spaceship. To remain in orbit at 421 km from the planet's center, he should maintain a speed of 80 m/s. What is the mass of planet X?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. From what height off the surface of Earth should an object be dropped to initially experience an acceleration of 0.5400 g?
   A) 1689 km B) 2930 km C) 5426 km D) 2298 km

2. Suppose we want a satellite to revolve around Earth 5 times a day. What should the radius of its orbit be? (Neglect the presence of the Moon.)
   A) 0.69×10^{7} m B) 2.11×10^{7} m C) 1.44×10^{7} m D) 7.22×10^{7} m

3. A proton moving at 0.999 of the speed of light orbits a black hole 4972 km from the center of the attractor. What is the mass of the black hole?
   A) 6.71×10^{25} kg B) 6.71×10^{36} kg C) 6.71×10^{30} kg D) 6.71×10^{33} kg

4. You are the science officer on a visit to a distant solar system. Prior to landing on a planet you measure its diameter to be 1.8×10^7 m. You have previously determined that the planet orbits 2.9×10^{11} m from its star with a period of 402 Earth days. Once on the surface you find that the acceleration due to gravity is 19.5 m/s^2. What are the masses of (a) the planet and (b) the star?

A) (a) 4.3 kg $\times 10^{25}$ kg
(b) 7.1 kg $\times 10^{30}$ kg

B) (a) 4.3 kg $\times 10^{25}$ kg
(b) 1.2 kg $\times 10^{31}$ kg

C) (a) 2.4 kg $\times 10^{25}$ kg
(b) 1.2 kg $\times 10^{31}$ kg

D) (a) 2.4 kg $\times 10^{25}$ kg
(b) 7.1 kg $\times 10^{30}$ kg

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. Find the orbital speed of an ice cube in the rings of Saturn, if the mass of Saturn is 5.67×10^{26} kg and the rings have an average radius of 100,000 km.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

	Mass	Radius	orbital radius	orbital period
Moon A	4×10^{20}kg		2×10^{8}m	4×10^{6}s
Moon B	1.5×10^{20}kg	2×10^{5}m	3×10^{8}m	

Ekapluto is an unknown planet that has two moons in circular orbits. The table summarizes the hypothetical data about the moons.

1. In the table, the mass of Ekapluto is closest to:

A) 1 $\times 10^{23}$ kg B) 3 $\times 10^{23}$ kg C) 1 $\times 10^{22}$ kg D) 3 $\times 10^{22}$ kg E) 1 $\times 10^{24}$ kg

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A mass on a string is swung in a vertical circle at a constant speed. The string will break if the tension in the string exceeds a critical value. At what part of the circle is the string most likely to break, and why?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. A person ties a rock to a string and whirls it around in a vertical circle such that sometimes the rock is going straight upward and sometimes the rock is going straight down. She whirls the rock at the minimum speed (constant in time) such that the string is always taut (no sag). If she were to use a longer string, she would have to whirl the rock at a

A) lower velocity. B) higher velocity. C) the same velocity.

2. A person ties a rock to a string and whirls it around in a vertical circle such that sometimes the rock is going straight upward and sometimes the rock is going straight down. She whirls the rock at the minimum speed (constant in time) such that the string is always taut (no sag). When is the tension the highest?

A) It is highest when the rock is at the highest elevation.
B) The tension is constant as the rock moves around in a circle.
C) It is highest when the rock is at the lowest elevation.

3. A merry–go–round is spinning at a fixed rate. As a person is walking toward the edge,
   A) the force of static friction such that the person does not slide off remains the same.
   B) the force of static friction must increase in order for the person not to slide off.
   C) the force of static friction must decrease in order for the person not to slide off.

4. You need to make a sharp turn on a flat road, making a radius of curvature of 15 meters. How does the required force of static friction between your tires compare if you make the turn at 30 mph vs. 60 mph?
   A) The force of friction needs to be four times as large.
   B) The force of friction is the same for both speeds since the radius of curvature is the same.
   C) The force of friction needs to be twice as large.
   D) None of the above

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. If there is no such thing as a centrifugal force, why does someone in a car making a turn feel as if he or she is being pulled toward the outside of the curve?

2. Explain, from a force standpoint, why you need to reduce your normal driving speed around curves when it rains.

3. How is it possible for someone to remain in her seat (without any straps) while upside down on a loop–the–loop roller coaster?

4. Astronauts in orbit are weightless, but they are not beyond the pull of Earth's gravity. How can this be?

5. Can a satellite be in an elliptical orbit under uniform circular motion?

6. If I set the car cruise control at a certain speed and take a turn, the speed will remain the same. So, why am I accelerating?

7. In uniform circular motion we have an acceleration and the speed doesn't change. But in projectile motion the speed does change under constant acceleration. Why are they both classified as uniform acceleration phenomena?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. If you stood on a planet having a mass four times higher than Earth's mass, and a radius two times longer than Earth's radius, you would weigh
   A) the same as you do on Earth.
   B) two times less than you do on Earth.
   C) four times more than you do on Earth.
   D) two times more than you do on Earth.

2. A satellite having orbital speed V orbits a planet of mass M. If the planet had half as much mass, the orbital speed of the satellite would be:
   A) $V\sqrt{2}$ B) V C) 2V D) V/2 E) $V/\sqrt{2}$

3. A satellite of mass M takes time T to orbit a planet. If the satellite had twice as much mass, the time for it to orbit the planet would be:
   A) 4T B) T/2 C) 2T D) T/4 E) T

4. If the Moon were twice the distance from Earth than it currently is, the amount of time it would take to go around Earth would be roughly (the current orbital period of the Moon is four weeks)
   A) eight weeks. B) 88 weeks. C) 11 weeks. D) six weeks.

5. If an astronaut were exactly half way between Earth and the Moon, the net gravitational force exerted on the astronaut by these two objects would be
   A) zero. B) directed toward the Moon. C) directed toward Earth.

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. For astronauts in space, there is no atmosphere to slow their orbit. Why don't they just fly away to the moon?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. A child is sitting on the outer edge of a merry–go–round that is 18 m in diameter. If the merry–go–round makes 4.9 rev/min, what is the velocity of the child in m/s?
   A) 0.7 m/s B) 4.6 m/s C) 9.2 m/s D) 3.2 m/s

2. Through what angle in degrees does a 33 rpm record turn in 0.32 s?
   A) 63° B) 35° C) 74° D) 46°

3. An electrical motor spins at a constant 2695.0 rpm. If the armature radius is 7.165 cm, what is the acceleration of the edge of the rotor?
   A) 28.20 m/s^2 B) 5707 m/s^2 C) 572,400 m/s^2 D) 281.6 m/s^2

4. At time t = 0 s, a wheel has an angular displacement of zero radians and an angular velocity of +28 rad/s. The wheel has a constant acceleration of –0.51 rad/s^2. In this situation, the time t, at which the wheel comes to a mandatory halt, is closest to:
   A) 96 s B) 55 s C) 130 s D) 78 s E) 120 s

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A wheel accelerates from rest to 59 rad/s at a rate of 74 rad/s^2. Through what angle (in radians) did the wheel turn while accelerating?

2. A 95 N force exerted at the end of a 0.50 m long torque wrench gives rise to a torque of 15 N • m. What is the angle (assumed to be less than 90°) between the wrench handle and the direction of the applied force?

3. A 0.18 m radius pulley is free to rotate about a horizontal axis. A 4.2 kg mass and a 8.0 kg mass are attached by a massless string, which is hung over the pulley. If the string does not slip, calculate the magnitude of the net torque on the pulley about its rotational axis.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. A machinist turns the power on to a grinding wheel, at rest, at time t = 0 s. The wheel accelerates uniformly for 10 s and reaches the operating angular velocity of 38 rad/s. The wheel is run at that angular velocity for 30 s and then power is shut off. The wheel slows down uniformly at 2.1 rad/s^2 until the wheel stops. In this situation, the angular acceleration of the wheel between t = 0 s and t = 10 s is closest to:
   A) 6.1 rad/s^2 B) 4.6 rad/s^2 C) 5.3 rad/s^2 D) 3.8 rad/s^2 E) 6.8 rad/s^2

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A torque of 12 N • m is applied to a solid, uniform disk of radius 0.50 m. If the disk accelerates at 5.7 rad/s^2, what is the mass of the disk?

2. A particular motor can provide a maximum of 110.0 N • m of torque. Assuming that all of this torque is used to accelerate a solid, uniform flywheel of mass 10.0 kg and radius 3.00 m, how long will it take for the flywheel to accelerate from rest to 6.04 rad/s?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. A machinist turns the power on to a grinding wheel, at rest, at time t = 0 s. The wheel accelerates uniformly for 10 s and reaches the operating angular velocity of 96 rad/s. The wheel is run at that angular velocity for 40 s and then power is shut off. The wheel slows down uniformly at 1.5 rad/s^2 until the wheel stops. In this situation, the time interval of deceleration is closest to:
   A) 64 s B) 70 s C) 62 s D) 68 s E) 66 s

2. A machinist turns the power on to a grinding wheel, at rest, at time t = 0 s. The wheel accelerates uniformly for 10 s and reaches the operating angular velocity of 29 rad/s. The wheel is run at that angular velocity for 27 s and then power is shut off. The wheel slows down uniformly at 2.7 rad/s^2 until the wheel stops. In this situation, the average angular velocity in the time interval from t = 0 s to t = 25 s is closest to:
   A) 11 rad/s B) 8.7 rad/s C) 17 rad/s D) 13 rad/s E) 15 rad/s

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A solid, uniform sphere of mass 2.0 kg and radius 1.7 m rolls without slipping down an inclined plane of height 7.0 m. What is the angular velocity of the sphere at the bottom of the inclined plane?

2. A solid disk of radius 1.60 m and mass 2.30 kg rolls without slipping to the bottom of an inclined plane. If the angular velocity of the disk is 5.35 rad/s at the bottom, what is the height of the inclined plane?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

mass (kg)	x	y
40	0	7
60	5	2
100	7	10

1. The table shows the masses and the coordinates x and y of a set of three point masses in the x–y plane. The masses are interconnected by light struts, forming a rigid body. The moment of inertia of the rigid body, through the center of mass and perpendicular to the x–y plane, is closest to:
   A) 3800 kg • m^2
   B) 3400 kg • m^2
   C) 3000 kg • m^2
   D) 3600 kg • m^2
   E) 3200 kg • m^2

2. A potter's wheel (a solid, uniform disk) of mass 7.0 kg and radius 0.65 m spins about its central axis. A 2.1 kg lump of clay is dropped onto the wheel at a distance 0.41 m from the axis. Calculate the rotational inertia of the system.

A) 1.5 kg • m^2 B) 1.8 kg • m^2 C) 0.40 kg • m^2 D) 2.5 kg • m^2

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A bicycle heading west at 2.0 m/s turns 90.0° to the left in 10.0 s. The final velocity of the bicycle after the turn is 4.2 m/s to the south. Find the direction of the wheel's average angular acceleration. Express your answer as an angle relative to east.

2. A force in the +y direction applied at the point x = 2.3 m, y = 1.4 m gives rise to a torque of 71 N• m about the origin. Find the magnitude of the force.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. A solid disk of radius 1.60 m and mass 2.30 kg rolls without slipping to the bottom of an inclined plane. If the angular velocity of the disk is 4.27 rad/s at the bottom, what is the height of the inclined plane?

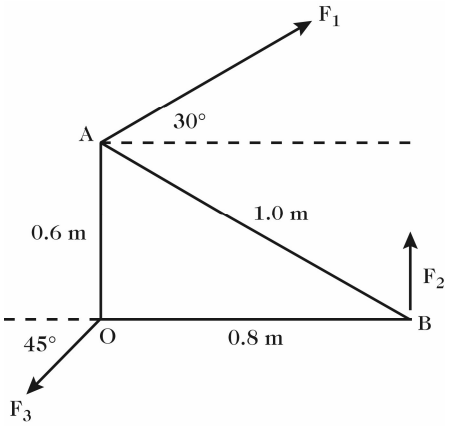
A) 4.28 m B) 3.57 m C) 2.68 m D) 3.14 m

2. A force of 17 N is applied to the end of a 0.63 m long torque wrench at an angle 45° from a line joining the pivot point to the handle. What is the magnitude of the torque generated about the pivot point?

A) 10.7 N•m B) 12.0 N•m C) 9.7 N•m D) 7.6 N•m

3. A force of 16.88 N is applied tangentially to a wheel of radius 0.340 m and gives rise to an angular acceleration of 1.20 rad/s^2. Calculate the rotational inertia of the wheel.

A) 7.17 kg • m^2 B) 4.78 kg • m^2 C) 5.98 kg • m^2 D) 3.59 kg • m^2

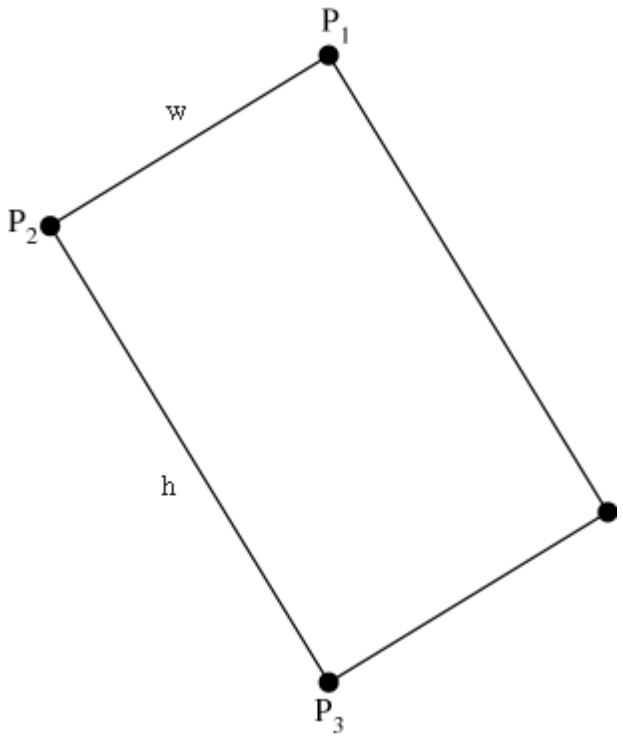


4. A light triangular plate OAB is in a horizontal plane. Three forces, $F_1 = 2$ N, $F_2 = 4$ N, and $F_3 = 7$ N, act on the plate, which is pivoted about a vertical axis through point O. In the figure, consider the counterclockwise sense as positive. The sum of the torques about the vertical axis through point O, acting on the plate due to forces F_1, F_2, and F_3, is closest to:

A) 2.6 N • m B) –2.2 N • m C) zero D) 2.2 N • m E) –2.6 N • m

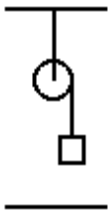
SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A rectangular sign h = 20.0 cm high and w = 11.0 cm wide loses three of its four support bolts and rotates into the position as shown, with P_1 directly over P_3. It is supported by P_2, which is so tight it holds the sign from further rotation. Find the gravitational torque about P_2, if the mass of the sign is 5.0 kg.



MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

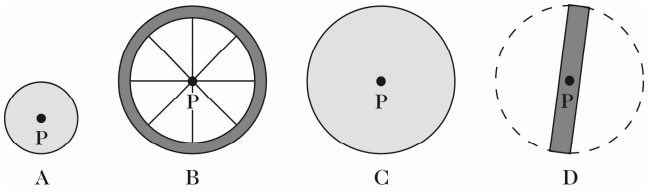
1. A particular motor can provide a maximum of 110.0 N • m of torque. Assuming that all of this torque is used to accelerate a solid, uniform flywheel of mass 10.0 kg and radius 3.00 m, how long will it take for the flywheel to accelerate from rest to 8.13 rad/s?
   A) 3.33 s B) 2.83 s C) 4.36 s D) 4.03 s



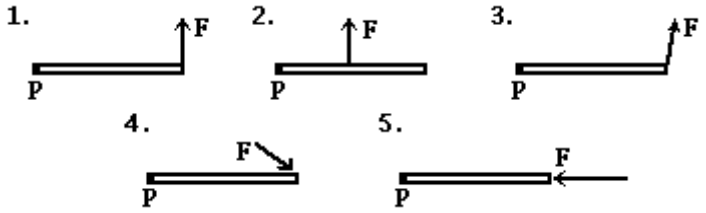
2. In the figure, a mass of 35.30 kg is attached to a light string that is wrapped around a cylindrical spool of radius 10 cm and moment of inertia 4.00 kg • m^2. The spool is suspended from the ceiling, and the mass is then released from rest a distance 3.50 m above the floor. How long does it take to reach the floor?
   A) 2.85 s B) 5.89 s C) 0.892 s D) 4.18 s E) 2.97 s

3. At time t = 0 s, a wheel has an angular displacement of zero radians and an angular velocity of +14 rad/s. The wheel has a constant acceleration of –0.41 rad/s^2. In this situation, the time at which the angular displacement is +88 rad and decreasing is closest to:
   A) 7 s B) 74 s C) 34 s D) 6 s E) 61 s

4. A small mass is placed on a record turntable that is rotating at 45 rpm. The linear acceleration of the mass is
   A) greater the closer the mass is to the center.
   B) independent (in magnitude) of the position of the mass on the turntable.
   C) directed perpendicular to the line joining the mass and the center of rotation.
   D) greater the farther the mass is from the center.
   E) zero.



5. In the figure are scale drawings of four objects, each of the same mass and uniform thickness. Which has the greatest moment of inertia when rotated about an axis perpendicular to the plane of the drawing? In each case the axis passes through point P.
   A) A
   B) C
   C) D
   D) B
   E) The moment of inertia is the same for all of these objects.



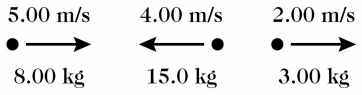
6. In the figure, a given force F is applied to a rod in several different ways. In which case is the torque due to F about the pivot P greatest?
   A) 1 B) 2 C) 3 D) 4 E) 5

7. A disk and a sphere are released simultaneously at the top of an inclined plane. They roll down without slipping. Which will reach the bottom first?
   A) the one of greatest mass
   B) the one of smallest diameter
   C) the sphere
   D) the disk
   E) They will reach the bottom at the same time.

8. A tire is rolling along a road, without slipping, with a velocity v. A piece of tape is attached to the tire. When the tape is opposite the road (at the top of the tire), it's velocity with respect to the road is
   A) 2 v.
   B) 1.5 v.
   C) v.
   D) The velocity depends on the radius of the tire.

9. A tall tree and a short tree (both having the same width and mass density) are cut at the base at the same time, and begin tipping over. Which tree hits the ground first?
   A) the small tree B) the tall tree C) They hit at the same time.

10. Three objects are moving along a straight line as shown in the figure. Taking the positive direction to be to the right, what is the total momentum of this system?



   A) 0 kg m/s
   B) –106 kg m/s
   C) +14 kg m/s
   D) –14 kg m/s
   E) +106 kg m/s

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. Two vehicles approach a right angle intersection and then collide. After the collision, they become entangled. If their mass ratios were 1:4 and their respective speeds as they approached were both 13 m/s, find the magnitude and direction of the final velocity of the wreck.

2. A steel ball is thrown in the air with a speed of 3.6 m/s at an angle of 70° from the horizontal. It drops on another steel ball of 1.4 times its mass resting on a sandy surface. If the original ball comes to a rest after the collision and the resting ball bounces, find the horizontal component of its velocity.

3. A container explodes and breaks into three fragments that fly off 120° apart from each other, with mass ratios 1:4:2. If the first piece flies off with a speed of 6.0 m/s, what is the speed of the other two fragments? (All fragments are in the plane.)

4. A 480 kg car moving at 14.4 m/s hits from behind another car moving at 13.3 m/s in the same direction. If the second car has a mass of 570 kg and a new speed of 17.9 m/s, what is the velocity of the first car after the collision?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. A golf ball of mass 0.050 kg is at rest on the tee and has a velocity of 102 m/s immediately after being struck. If the club and ball were in contact for 0.81 ms, what is the average force exerted on the ball?
   A) 5.5 kN B) 4.9 kN C) 7.1 kN D) 6.3 kN

2. A 1200 kg car moving at 15.6 m/s collides with a stationary car of mass 1500 kg. If the two vehicles lock together, what is their combined velocity immediately after the collision?
   A) 6.9 m/s B) 12.1 m/s C) 5.5 m/s D) 8.6 m/s

3. A 1200 kg cannon fires a 100.0 kg cannonball at 35 m/s. What is the recoil velocity of the cannon? Assume that frictional forces are negligible and the cannon is fired horizontally.
   A) 35 m/s B) 3.2 m/s C) 3.5 m/s D) 2.9 m/s

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A fisherman throws the anchor off her boat at an angle of 3.0°above the horizontal. If the anchor weighs 2.0 times as much as she does and the boat moves with speed 2.7 m/s during the launch, how fast did she throw the anchor? (Solve for her frame of reference. Assume the mass of the boat is negligible.)

2. A 14 cm diameter champagne bottle rests on its side on top of a frictionless table. Suddenly, the cork pops and the bottle slides backward for a distance of 22.0 cm in 0.44 s. If the mass of the bottle is 500 times the mass of the cork, find the distance from the original position the cork will land on the table.

3. A 0.140 kg baseball is thrown with a velocity of 26.2 m/s. It is struck with an average force of 5000.0 N, which results in a velocity of 37.0 m/s in the opposite direction. How long were the bat and ball in contact?

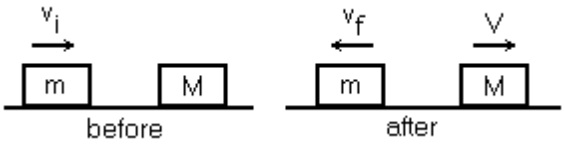
4. A 1120 kg car experiences an impulse of 30,000.0 N• s during a collision with a wall. If the collision takes 0.43 s, what was the velocity of the car just before the collision?

5. Calculate the impulse associated with a force of 4.5 N that lasts for 1.4 s.

6. A 0.24 kg blob of clay is thrown at a wall with an initial velocity of 23 m/s. If the clay comes to a stop in 91 ms, what is the average force experienced by the clay?

7. A 1200 kg ore cart is rolling at 10.8 m/s across a flat surface. A crane dumps 691 kg of ore (vertically) into the cart. How fast does the cart move after being loaded with ore? Assume that frictional forces may be neglected.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.



1. A block of mass m = 4.4 kg, moving on frictionless surface with a speed $v_i = 9.2$ m/s, makes a perfectly elastic collision with a block of mass M at rest. After the collision, the 4.4 kg block recoils with a speed of $v_f = 2.5$ m/s. In the figure, the mass M is closest to:
   A) 21 kg B) 7.7 kg C) 4.4 kg D) 12 kg E) 5.6 kg

2. A block of mass m = 3.6 kg, moving on a frictionless surface with a speed $v_i = 9.3$ m/s, makes a perfectly elastic collision with a block of mass M at rest. After the collision, the 3.6 kg block recoils with a speed of $v_f = 2.7$ m/s. In the figure, the speed of the block of mass M after the collision is closest to:
   A) 9.3 m/s B) 12.0 m/s C) 8.0 m/s D) 10.7 m/s E) 6.6 m/s

3. A block of mass m = 5.6 kg, moving on a frictionless surface with a speed $v_i = 6.5$ m/s, makes a perfectly elastic collision with a block of mass M at rest. After the collision, the 5.6 kg block recoils with a speed of $v_f = 0.7$ m/s. In the figure, the blocks are in contact for 0.20 s. The average force on the 5.6 kg block, while the two blocks are in contact, is closest to:
   A) 34 N B) 162 N C) 192 N D) 182 N E) 202 N

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A car heading north collides at an intersection with a truck heading east. If they lock together and travel at 28 m/s at 46° north of east just after the collision, how fast was the car initially traveling? Assume that the two vehicles have the same mass.

2. A child swings a 0.38 kg ball in a circle on a string that is 1.3 m long. If the ball makes 1.2 rev/s, what is the magnitude of the ball's angular momentum?

3. Two ice skaters of identical mass approach on parallel paths 1.6 m apart. Both are moving at 3.0 m/s. They join hands as they pass, maintaining their 1.6 m separation, and begin rotating about each other. What is their angular speed?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. A 51 g steel ball is released from rest and falls vertically onto a steel plate. The ball strikes the plate and is in contact with it for 0.5 ms. The ball rebounds elastically, and returns to its original height. The time interval for a round trip is 3.00 s. In this situation, the average force exerted on the ball during contact with the plate is closest to:
   A) 3500 N B) 1500 N C) 3000 N D) 2490 N E) 2000 N

2. An 8 g bullet is shot into a 4.0 kg block, at rest on a frictionless horizontal surface. The bullet remains lodged in the block. The block moves into a spring and compresses it by 3.7 cm. The force constant of the spring is 2500 N/m. In the figure, the initial velocity of the bullet is closest to:
   A) 440 m/s B) 460 m/s C) 480 m/s D) 500 m/s E) 520 m/s

3. A girl of mass 55 kg throws a ball of mass 0.8 kg against a wall. The ball strikes the wall horizontally with a speed of 25 m/s, and it bounces back with this same speed. The ball is in contact with the wall 0.05 s. What is the average force exerted on the wall by the ball?
   A) 800 N B) 27,500 N C) 55,000 N D) 400 N E) 13,750 N

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

1. A uniform, solid flywheel of radius 1.4 m and mass 15 kg rotates at 2.4 rad/s. What is the magnitude of the flywheel's angular momentum?

2. A 1.4 kg object at x = 2.00 m, y = 3.10 m moves at 4.62 m/s at an angle 45° north of east. Calculate the magnitude of the object's angular momentum about the origin.

3. Three solid, uniform flywheels, each of mass 65.0 kg and radius 1.47 m, rotate independently around a common axis. Two of the flywheels rotate in one direction at 3.83 rad/s; the other rotates in the opposite direction at 3.42 rad/s. Calculate the magnitude of the net angular momentum of the system.

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

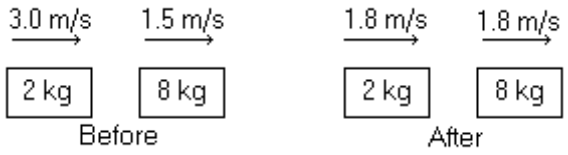
1. A car of mass 1411 kg collides head–on with a parked truck of mass 2000 kg. Spring mounted bumpers ensure that the collision is essentially elastic. If the velocity of the truck is 17 km/h (in the same direction as the car's initial velocity) after the collision, what is the initial speed of the car?
   A) 42 km/h B) 11 km/h C) 21 km/h D) 32 km/h

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

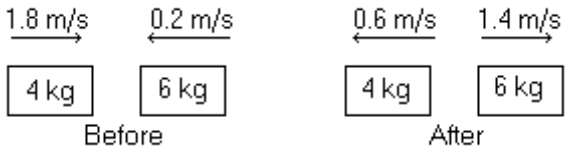
1. Three cars, Car X, Car Y, and Car Z, begin accelerating from rest, at the same time. Car X is more massive than Car Y, which is more massive than Car Z. The net force exerted on each car is identical. After 10 seconds, which car has the most amount of momentum?

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1. You are standing on a skateboard, initially at rest. A friend throws a very heavy ball toward you. You can either catch the object or deflect the object back toward your friend (such that it moves away from you with the same speed as it was originally thrown). What should you do in order to maximize your speed on the skateboard?
   A) deflect the ball back
   B) catch the ball
   C) Your final speed on the skateboard will be the same regardless whether you catch the ball or deflect the ball.



2. In the figure, determine the character of the collision. The masses of the blocks, and the velocities before and after are given. The collision is:
   A) perfectly elastic.
   B) characterized by an increase in kinetic energy.
   C) partially inelastic.
   D) completely inelastic.
   E) not possible because momentum is not conserved.



3. In the figure, determine the character of the collision. The masses of the blocks, and the velocities before and after are given. The collision is:
   A) completely inelastic.
   B) partially inelastic.
   C) perfectly elastic.
   D) not possible because momentum is not conserved.

4. During World War I, Germany used a "Big Bertha" cannon to hurl shells into Paris 30 miles away. This gun also had a long barrel. What is the reason for using a long barrel in these guns?
   A) to increase the force exerted on the bullet due to the expanding gases from the gunpowder
   B) to allow the force of the expanding gases from the gunpowder to act for a longer time
   C) to reduce frictional losses
   D) to reduce the force exerted on the bullet due to the expanding gases from the gunpowder

5. Consider two less–than–desirable options. In the first you are driving 30 mph and crash head–on into an identical car also going 30 mph. In the second option you are driving 30 mph and crash head–on into a stationary brick wall. In neither case does your car bounce off the thing it hits, and the collision time is the same in both cases. Which of these two situations would result in the greatest impact force?
   A) hitting the brick wall
   B) hitting the other car
   C) The force would be the same in both cases.
   D) We cannot answer this question without more information.
   E) None of these is true.

6. A 5 kg ball collides head–on with a 10 kg ball, which is initially stationary. The collision is inelastic. Which statement is true?
   A) The magnitude of the change of the momentum of the 5 kg ball is equal to the magnitude of the change of momentum of the 10 kg ball.
   B) The magnitude of the change of velocity the 5 kg ball experiences is less than that of the 10 kg ball.
   C) The magnitude of the change of velocity the 5 kg ball experiences is equal to that of the 10 kg ball.
   D) The magnitude of the change of velocity the 5 kg ball experiences is greater than that of the 10 kg ball.
   E) Two of the above statements are true.

7. Two friends are standing on opposite ends of a canoe. The canoe is initially at rest with respect to the lake. The person on the right throws a very massive ball to the left, and the person on the left catches it. After the ball is caught (ignoring friction between the canoe and the water), the canoe is
   A) moving to the left. B) moving to the right. C) stationary.

1. 54.44 rad/s
2. 50°
3. 2403 m/s^2
4. 280 m/s
5. 4.8 s
6. 11.4 m/s
7. 3.7 m/s

1. C
2. B

1. 166 m/s^2

1. B

1. 24 N
2. 34 N
3. 160 cm

1. B

1. 2.01×10^{20} N
2. 0.0581

1. C
2. A

1. 2.96×10^{24} kg
2. 3.33×10^{-14} m/s
3. 4.0×10^{19} kg

1. D
2. C
3. D
4. C

1. 19.5 km/s

1. B

1. The string is most likely to break at the lowest point in the circular path, because the tension in the string is greatest at this point. This follows from Newton's Second Law:

   $\frac{mV^2}{r} = T - mg$ at the lowest point $\Rightarrow T = \frac{mV^2}{r} + mg$ at the bottom of the arc.

1. B
2. C
3. B
4. A

1. The car is making a turn, but the person in the car is <u>not</u> part of the car. According to Newton's First Law, you will move in a straight line until acted on by an outside force – thus, you move in a straight line while the car turns (at least until you run into the door. At this time, the car exerts a force on you, causing your direction of motion to change.).
2. In order to safely negotiate a curve at a given velocity, frictional forces between the tires and the road must be large enough to provide the necessary centripetal force.
   $\left(\frac{mV^2}{r} = \mu F_n = \mu mg \right)$
   The coefficient of friction μ decreases when it rains, so the frictional force decreases.

3. If the velocity of the roller coaster car is sufficiently large at the top of the loop, the person (and car) will remain on the track. For lower speeds, the normal force on the person goes to 0 before she reaches the top, meaning that she comes out of the seat.
   (This follows from $N = \frac{mV^2}{r} - mg$.)
4. Astronauts in orbit are moving in uniform circular orbits; the centripetal force is provided by gravitational attraction. The net force experienced by an astronaut is 0, thus the astronaut is weightless. (The astronaut is in a continual state of free fall while in orbit.)
5. No. A satellite in an elliptical orbit would experience tangential acceleration. By definition, a satellite under uniform circular motion can have no tangential acceleration component. Therefore, its orbit can only be a circle.
6. If you observe a car actually performing this maneuver, you will notice that the tires will skid at high speeds, or the car will bank in one side. This means that the car is actually accelerating, it is changing the one–dimensional speed to a two–dimensional velocity. But the speedometer cannot detect it. If you had a gyroscope on board, as airplanes do, it would register an acceleration.
7. Acceleration is defined as the rate of change of velocity. Respecting this definition means that we observe the entire velocity vector's behavior. Speed is only a constituent of velocity, therefore observing only the speed gives a partial and sometimes misleading picture of the physical phenomena. The fact is that in both cases the acceleration vector is uniform in a particular framework (coordinate system).

1. A
2. E
3. E
4. C
5. C

1. The astronauts were initially placed there by a capsule or shuttle. Therefore they have the same speed as the craft. If the craft was launched with enough energy to make a certain orbit, the extra energy must be gotten elsewhere. If the astronaut pushes hard enough on the craft, he will convert part of the work into kinetic energy and fly away. The problem is that to cover the distance in some kind of realistic time travel, he would have to push harder than a Titan.

1. B
2. A
3. B
4. C

1. 24 rad
2. 18°
3. 6.7 N • m

1. D

1. 17 kg
2. 2.47 s

1. A
2. C

1. 5.8 rad/s
2. 5.61 m

1. A
2. B

1. 25° south of east
2. 31 N

1. B
2. D

3. B
4. D

1. 4.7 Nm

1. A
2. E
3. E
4. D
5. D
6. A
7. C
8. A
9. A
10. D

1. 13.1 m/s at 79°
2. 0.88 m/s
3. 1.5 and 3.0 m/s
4. 8.94 m/s

1. D
2. A
3. D

1. 1.4 m/s
2. 3000 cm
3. 1.77×10^{-3} s
4. 27 m/s
5. 6.3 kg• m/s
6. 61 N
7. 6.8 m/s

1. B
2. E
3. E

1. 40 m/s
2. 4.8 kg•m^2/s
3. 3.7 rad/s

1. C
2. B
3. A

1. 35 kg•m^2/s
2. 5.0 kg• m^2/s
3. 298 kg• m^2/s

1. C

1. They all have the same amount of momentum.

1. A
2. D
3. C
4. B
5. C
6. D
7. C