Last names	Section	Date	Score
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Phys 20.01 Group homework 4

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2025 W45

Instructions: For comprehension and conceptual questions, choose the best answer. For problem-solving questions, choose the best answer and show your solution and reasoning. Comprehension is 1 pt each, conceptual is 2 pt each, and problem-solving is 3 pt each.

1. Comprehension

1. The rotational inertia of a rigid body is
   a. dependent on the location of the axis of rotation
   b. large if most of the mass is far from axis of rotation
   c. a measure of its resistance to changes in rotational motion
   d. all of the above
   e. none of the above

2. The angular momentum of a particle is
   a. independent of the specific origin of coordinates
   b. zero when its position and momentum vectors are parallel
   c. zero when its position and momentum vectors are perpendicular
   d. all of the above
   e. none of the above

3. Angular velocity is expressed in units of
   a. meters per second
   b. radians per second
   c. omegas per second
   d. arcs per second

4. What is the quantity used to measure an object's resistance to changes in rotation?
   a. inertia
   b. moment of inertia
   c. linear momentum
   d. angular momentum

5. An object is rotated about a vertical axis by 90° and then about a horizontal axis by 180°. If we start over and perform the rotations in the reverse order, the orientation of the object
   a. will be the same as before
   b. will be different than before
   c. depends on the shape of the object

6. When a disk rotates counterclockwise at a constant rate about a vertical axis through its center, the tangential acceleration of a point on the rim is
   a. positive
   b. zero
   c. negative
   d. impossible to determine without more information

7. The moment of inertia of a rigid body about a fixed axis through its center of mass is I. The moment of inertia of this same body about a parallel axis through some other point is always
   a. smaller than I
   b. the same as I
   c. larger than I
   d. whether it's larger or smaller depends on the choice of axis

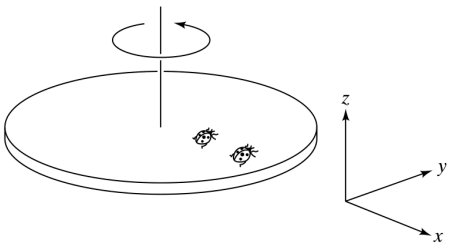
8. Consider a rigid body that is rotating. Which of the following is an accurate statement?
   a. Its center of rotation is its center of gravity
   b. All points on the body are moving with the same angular velocity
   c. All points on the body are moving with the same linear velocity
   d. Its center of rotation is at rest, that is, not moving

9. A wheel rolls without slipping along a horizontal surface. The center of the wheel has a translational speed v. The lowermost point on the wheel has a net forward velocity of
   a. $2v$
   b. v
   c. zero
   d. need more information

10. An ice-skater spins about a vertical axis through her body with her arms held out. As she draws her arms in, her angular velocity
    a. increases
    b. decreases
    c. remains the same
    d. need more information

2. Conceptual

1. A ladybug sits at the outer edge of a merry-go-round, and a gentleman bug sits halfway between her and the axis of rotation. The merry-go-round makes a complete revolution once each second. The gentleman bug's angular speed is
   a. half the ladybug's
   b. the same as the ladybug's
   c. twice the ladybug's
   d. impossible to determine

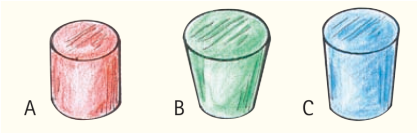


2. If the merry-go-round is turning and slowing down, then at the instant shown in the figure, the radial component of the ladybug's (cartesian) acceleration is
   a. in the $+x$ direction
   b. in the $-x$ direction
   c. in the $+y$ direction
   d. in the $-y$ direction
   e. in the $+z$ direction
   f. in the $-z$ direction
   g. zero

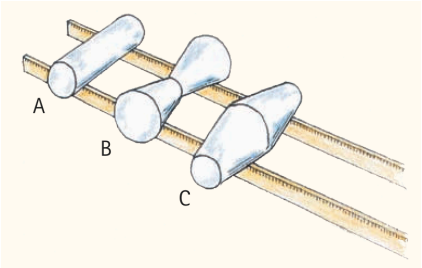
3. If the merry-go-round is turning and slowing down, then the vector expressing her angular velocity is
   a. in the $+x$ direction
   b. in the $-x$ direction
   c. in the $+y$ direction
   d. in the $-y$ direction
   e. in the $+z$ direction
   f. in the $-z$ direction
   g. zero

4. A wheel starts at rest, and has an angular acceleration of 4 rad/s^2. Through what angle does it turn in 3 s?
   a. 36 rad
   b. 18 rad
   c. 12 rad
   d. 9 rad

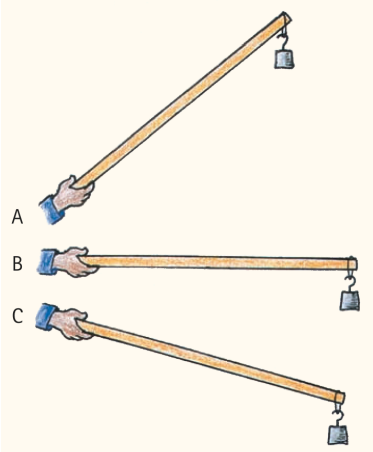
5. The three cups are rolled on a level surface. Rank the cups by how far they depart from a straight-line path (most curved to least curved).
   a. test
   b. test
   c. test
   d. test



6. Three types of rollers are placed on slightly inclined parallel meterstick tracks as shown. From greatest to least, rank the rollers in terms of their ability to remain stable as they roll.
   a. test
   b. test
   c. test
   d. test



7. You hold a meterstick at one end with the same mass suspended at opposite end. Rank the torque needed to keep the stick steady, from largest to smallest.
   a. test
   b. test
   c. test
   d. test



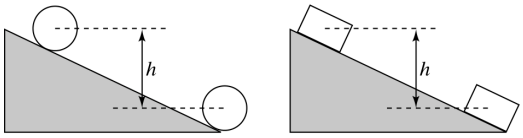
3. Problem solving

Human moment of inertia. The moment of inertia of the human body about an axis through its center of mass is important in the application of biomechanics to sports such as diving and gymnastics. We can measure the body's moment of inertia in a particular position while a person remains in that position on a horizontal turntable, with the body's center of mass on the turntable's rotational axis. The turntable with the person on it is then accelerated from rest by a torque that is produced by using a rope wound around a pulley on the shaft of the turntable. From the measured tension in the rope and the angular acceleration, we can calculate the body's moment of inertia about an axis through its center of mass.

Overhead view of a female gymnast lying in somersault position atop a turntable

1. The moment of inertia of the empty turntable is 1.5 kg m^2. With a constant torque of 2.5 N m, the turntable-person system takes 3.0 s to spin from rest to an angular speed of 1.0 rad/s. What is the person's moment of inertia about an axis through her center of mass? Ignore friction in the turntable axle.
   a. 2.5 kg m^2
   b. 6.0 kg m^2
   c. 7.5 kg m^2
   d. 9.0 kg m^2
2. While the turntable is being accelerated, the person suddenly extends her legs. What happens to the turntable? Why? Write down your reasoning
   a. It suddenly speeds up
   b. it rotates with constant speed
   c. its acceleration decreases
   d. it suddenly stops rotating

Rollin' vs. slidin'. A ball initially at rest rolls without slipping down an inclined plane, as shown below.



1. Make a diagram of the ball on the incline showing all forces acting on the ball. Describe each force in words. Which force causes the ball to roll by creating a torque about its center?
2. Now consider a block sliding down an identical inclined plane. The block travels the same vertical distance as the ball before arriving at the bottom. Which arrives at the bottom with more total kinetic energy? Why? Write down your reasoning.
   a. rolling ball
   b. sliding block
   c. it is the same for both at the bottom
   d. cannot be determined

Bucket logic. Why is it easier to carry the same amount of water in two buckets, one in each hand, than in a single bucket? Write your reasoning.