

Figure 1:

1. A comet orbits the Sun as shown in Figure 1. What is the direction of the angular momentum of the comet at the instant shown if the $+z$ direction is defined as out of the page?
 - (a) into the page ($-z$ direction)
 - (b) out of the page ($+z$ direction)
 - (c) neither because the angular momentum is zero
2. An ice skater is rotating with one leg outward and her arms outward. She then pulls her arms inward and her leg inward toward the axis of rotation. As a result, her angular speed
 - (a) increases
 - (b) decreases
 - (c) remains constant
3. Barbell A has 10 kg weights at each end and is 3 m long. Barbell B has 20 kg weights at each end and is 1.5 m long. Which barbell has a greater moment of inertia if rotating about its center of mass? (assume the bar's mass is negligible)
 - (a) barbell A
 - (b) barbell B
 - (c) they have the same moment of inertia
 - (d) not enough information is given
4. A child runs toward a merry-go-round with a constant momentum and jumps onto the edge of the merry-go-round exerting a force on the merry-go-round tangential to the edge. Consider the system of the child and merry-go-round. Net external forces on the system include gravitation and the force of the ground. Which of these quantities are conserved for the child-merry-go-round system during this process?
 - (a) kinetic energy
 - (b) angular momentum
 - (c) all of the above

5. An electron has
- (a) orbital angular momentum (i.e. translational angular momentum)
 - (b) spin angular momentum (i.e. rotational angular momentum)
 - (c) both orbital and spin angular momentum

I have a great idea for a “catching-machine” that catches a baseball and tells you the speed of the ball based on how fast it’s rotating. The machine consists of very lightweight aluminum rods (they are so light that you can neglect their mass) connected to massive objects with nets at the ends, 2.0 m from the center, that catch the baseball. The mass of each object at the end of a rod that holds a net is 10 kg. The entire machine sits on a low-friction axle fixed to the ground. When it catches a baseball, the machine’s center of mass does not move.

6. If a baseball of mass 0.145 kg moving at 90 mph (40 m/s) in the direction shown in the figure below was caught by the machine, what would be the angular speed of the machine after catching the baseball?

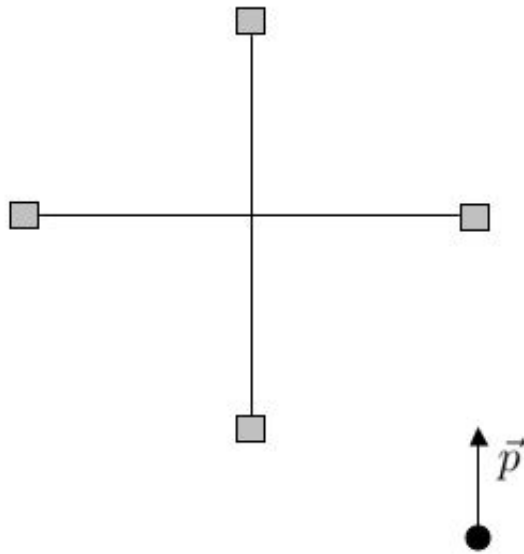


Figure 2:

7. If the machine had “bouncy” pads mounted with springs (like little trampolines) instead of the nets, so that the baseball rebounds directly backward with the same speed, would the machine rotate faster or slower than when the ball is caught in a net? Explain your answer.
8. You are on a merry-go-round at a distance of $R/2$ from the center where R is the radius of the merry-go-round. Describe one way of making the merry-go-round slow down (decrease the angular speed of the merry-go-round) without touching anything external to the merry-go-round. You are able to move on the merry-go-round. Use physics to back up your ideas. (5 pts. extra credit for a second method of slowing the merry-go-round.)

Answer Key for Exam A

1. (b)

2. (a)

3. (b)

4. (b)

5. (c)

6. see key.

7. see key.

8. Possible ideas include:

(1) Move to the outer edge of the merry-go-round and sit down, thereby increasing the moment of inertia of the system.

(2) Walk around the merry-go-round (at the distance $R/2$ in the direction of rotation (i.e. walk clockwise if the merry-go-round is rotating clockwise).

(3) Strip off your clothes and throw them in a tangential direction in the same direction as your linear momentum.