Name ______________________________________ Date ___________ Period_________

1. A particle travels in a circular path and point *P* is at the center of the circle.

(*a*) If the particle's linear momentum is doubled without changing the radius of the circle, how is the magnitude of its angular momentum about *P* affected?

Because ***L*** is directly proportional to ***p***, *L* is doubled.

(*b*) If the radius of the circle is doubled but the speed of the particle is unchanged, how is the magnitude of its angular momentum about *P* affected?

Because ***L*** is directly proportional to ***r***, *L* is doubled.

2. One way to tell if an egg is hardboiled or uncooked without breaking the egg is to lay the egg flat on a hard surface and try to spin it. A hardboiled egg will spin easily, while an uncooked egg will not. However, once spinning, the uncooked egg will do something unusual; if you stop it with your finger, it may start spinning again. Explain the difference in the behavior of the two types of eggs.

The hardboiled egg is solid inside, so everything rotates with a uniform angular speed. By contrast, when you start an uncooked egg spinning, the yolk will not immediately spin with the shell, and when you stop it from spinning the yolk will continue to spin for a while.

3. The angular momentum of the propeller of a small single-engine airplane points forward. The propeller rotates clockwise if viewed from behind.

(*a*) Just after liftoff, as the nose of the plane tilts upward, the airplane tends to veer to one side. To which side does it tend to veer and why?

The plane tends to veer to the right. The change in angular momentum $\Delta \boldsymbol{L}_{prop}$ for the propeller is upward, so the net torque $\boldsymbol{\tau}$ on the propeller is upward as well. The propeller must exert an equal but opposite torque on the plane. This downward torque exerted on the plane by the propeller tends to cause a downward change in the angular momentum of the plane. This means the plane tends to rotate clockwise as viewed from above.

(*b*) If the plane is flying horizontally and suddenly turns to the right, does the nose of the plane tend to veer upward or downward? Why?

The nose of the plane tends to veer downward. The change in angular momentum $\Delta \boldsymbol{L}$ prop for the propeller is to the right, so the net torque $\boldsymbol{\tau}$ on the propeller is toward the right as well. The propeller must exert an equal but opposite torque on the plane. This leftward directed torque exerted by the propeller on the plane tends to cause a leftward-directed change in angular momentum for the plane. This means the plane tends to rotate clockwise as viewed from the right.

4. You are sitting on a spinning piano stool with your arms folded.

(*a*)When you extend your arms out to the side, what happens to your kinetic energy? What is the cause of this change?

The rotational kinetic energy of the you-stool system is given by $K = \frac{1}{2}I\omega^2 = \frac{L^2}{2I}$

Because the net torque acting on the you-stool system is zero, its angular momentum ***L*** is conserved.

Your kinetic energy decreases. Increasing your moment of inertia *I* while conserving your angular momentum *L* decreases you kinetic energy $K = \frac{L^2}{2I}$

(*b*) Explain what happens to your moment of inertia, angular speed and angular momentum as you extend your arms.

Extending your arms out to the side increases your moment of inertia and decreases your angular speed. The angular momentum of the system is unchanged.

5. A 2.0-kg particle moves directly eastward at a constant speed of 4.5 m/s along an east-west line.

(*a*) What is its angular momentum (including direction) about a point that lies 6.0 m north of the line?

(*a*) The magnitude of the particle's angular momentum is given by:

$$L = rp\sin\phi = rmv\sin\phi = mv(r\sin\phi)$$

Substitute numerical values and evaluate L:

$$L = (2.0\,\text{kg})(4.5\,\text{m/s})(6.0\,\text{m}) = 54\,\text{kg}\cdot\text{m}^2/\text{s}$$

Use a right-hand rule to establish the direction of $\vec{L}$:

$$L = \boxed{54\,\text{kg}\cdot\text{m}^2/\text{s, upward}}$$

(*b*) What is its angular momentum (including direction) about a point that lies 6.0 m south of the line?

(*b*) Because the distance to the line along which the particle is moving is the same, only the direction of $\vec{L}$ differs:

$$L = \boxed{54\,\text{kg}\cdot\text{m}^2/\text{s, downward}}$$

(*c*) What is its angular momentum (including direction) about a point that lies 6.0 m directly east of the particle?

(*c*) Because $\vec{r}\times\vec{p} = 0$ for a point on the line along which the particle is moving:

$$\vec{L} = \boxed{0}$$