Angular Momentum

Rotation · 7 questions · step-by-step answers at the end

Name: Date: Score: / 7

USEFUL EQUATIONS

$L = I\omega$ $L = rmv\sin\theta$ $I_1\omega_1 = I_2\omega_2$ $\tau\Delta t = \Delta L$ $K = \tfrac{1}{2}I\omega^2 = L^2/(2I)$

Questions

Show your working in the space under each question.

1. A disk (I = 0.25 kg·m²) spins at 10 rad/s. A 0.50 kg lump of clay sticks to its rim at r = 0.50 m. Find the new ω.

2. A skater with I = 3.0 kg·m² spins at 2.0 rev/s. She pulls in her arms and I drops to 1.2 kg·m². Find her new spin rate and how her kinetic energy changes.

3. A lump of clay is dropped onto a spinning turntable and sticks. What happens to ω, and is kinetic energy conserved?

4. A 2 kg particle moves at 3 m/s along the line y = 4 m (parallel to x). What is its angular momentum about the origin?

5. A hoop and a disk have equal mass and radius. Which is harder to start spinning?

6. A constant torque of 8 N·m acts for 3 s on a wheel at rest. Find the final L.

7. A spinning star collapses to half its radius (mass unchanged). By what factor does its spin rate change?

Step-by-step answers

Angular Momentum

1. $I_2 = 0.25 + (0.50)(0.50)^2 = 0.375$ kg·m²; $\omega_2 = (0.25)(10)/0.375 \approx$ **6.7 rad/s**.

2. 1. No external torque, so L is conserved: $(3.0)(2.0) = (1.2)\omega_2$.
2. $\omega_2 = 6.0/1.2 =$ **5.0 rev/s**.
3. $K = L^2/(2I)$. L is the same, and I is 2.5 times smaller, so K is **2.5 times larger**.
4. The extra kinetic energy comes from the work her muscles do pulling her arms in.

Answer: 5.0 rev/s; K increases by a factor of 2.5

3. I increases, so **ω decreases**. KE is **not** conserved: this is a rotational sticky collision.

4. $L = mvr_\perp = 2(3)(4) =$ **24 kg·m²/s**, and it stays constant.

5. The **hoop**: all its mass is at the rim, so it has the larger I.

6. $\Delta L = \tau \Delta t =$ **24 kg·m²/s**.

7. $I \propto R^2$, so I drops by 4 and **ω becomes 4×**.