Torque and Angular Momentum

Pre-Lecture Questions

Problem Set #29 (due next time)

Lecture Outline

1. Angular Momentum of a Point Particle
2. Angular Momentum of an Extended Object
3. Torque and Angular Momentum

Pre-Class Summary:

We have now added the idea of angular momentum to our understanding of motion. We defined angular momentum as,

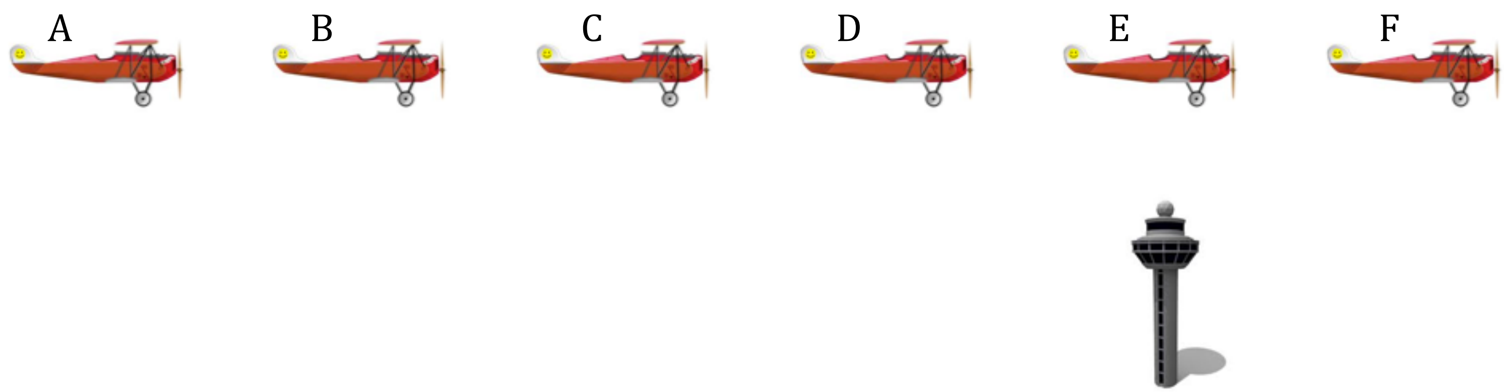
$$\vec{L} \equiv \vec{r} \times \vec{p}$$

For a rigid object, the angular momentum can be calculated using $\vec{L} = I\vec{\omega}$.

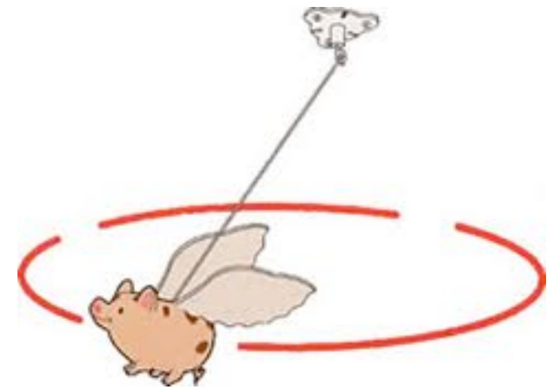
We followed the same path that led us to rewrite the Second Law in terms of linear momentum to rewrite the Second Law for Rotation,

$$\Sigma\vec{\tau} = \frac{d\vec{L}}{dt}$$

The airplane below travels horizontally staying at the same altitude and speed as if flies by the tower. The plane is shown at six different positions. Rank these based upon the angular momentum of the plane about the base of the tower.

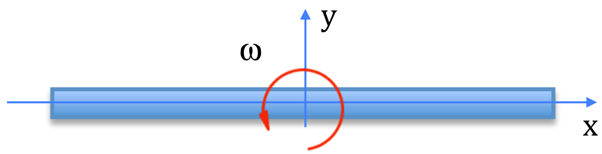


Example 1: The Flying Pig is a toy that hangs from the ceiling and rotates around in a circle while flapping its wings. It has a mass of 500g, flies in a circle of radius of 40cm, and goes around every 2.0s. Find the angular momentum of a flying pig.



http://www.youtube.com/watch?v=BEeQQZdt5ok

The uniform stick at the right is pivoted in the middle and rotates in the x-y plane. It has a mass, m, and a length, b.

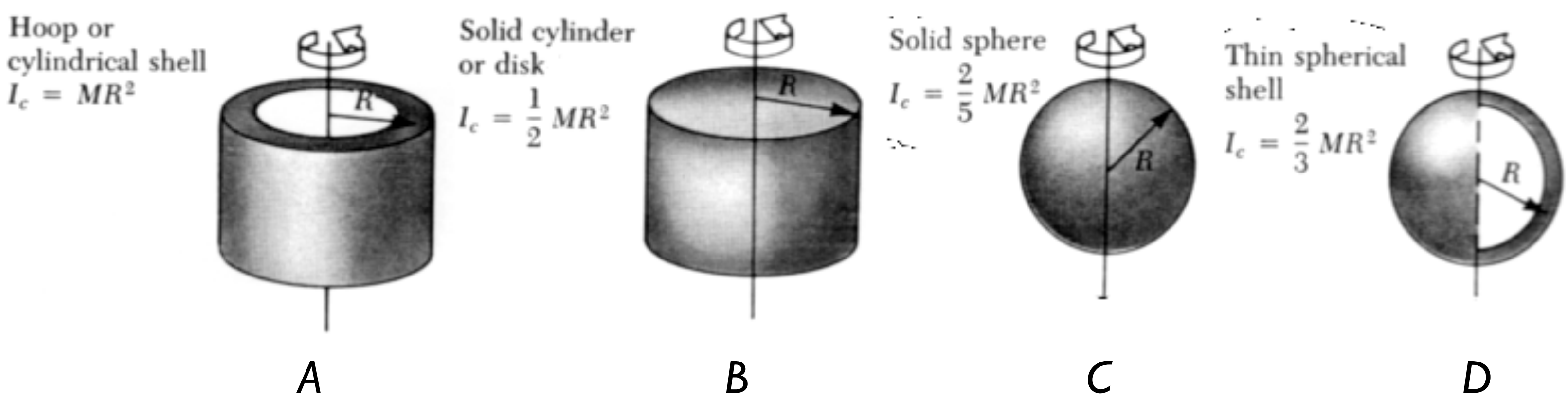


1. *Draw a small portion of the stick dm at some location x along the stick.*
2. *Draw the velocity vector for dm and find its magnitude in terms of x and ω.*
3. *Find the small amount of angular momentum, dL, due to the motion of dm. Express it in terms of ω, dm, and x.*
4. *Label the length of dm with dx.*
5. *Construct the ratio below in terms of b and dx.*

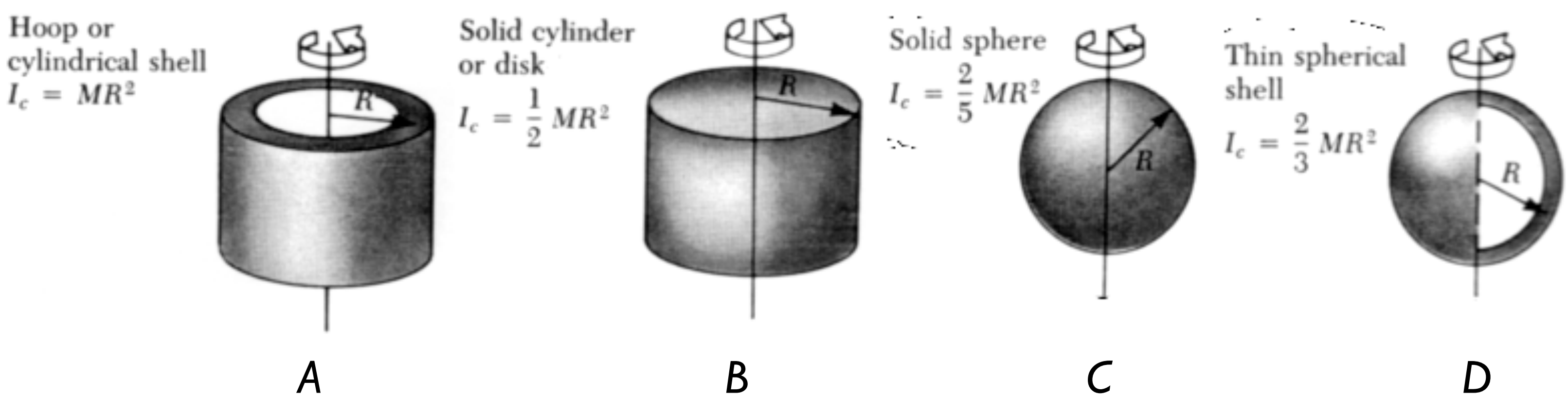
$$\frac{dm}{m} = \frac{\boxed{}}{\boxed{}}$$

6. *Solve for dm and substitute the result into dL.*
7. *Integrate over all the dx's to get the total angular momentum of the stick.*

Each of the objects shown below has the same mass and radius. They are spinning at the same rate. Rank them from greatest to least based upon the magnitude of their angular momentum.



Each of the objects shown below has the same mass and radius. They are all spinning at a rate such that they all have the same angular momentum. Rank them from greatest to least based upon their angular velocity.



Example 2: A 90.0cm long bat has a center-of-mass 60.0cm from the handle end and a rotational inertia of $0.200\text{kg} \cdot \text{m}^2$ about that end. During a swing, the center-of-mass of the bat starts from rest and reaches a speed of 30.0m/s in 65.0ms. Find (a)the final angular momentum and (b)the net torque provided by the batter.

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