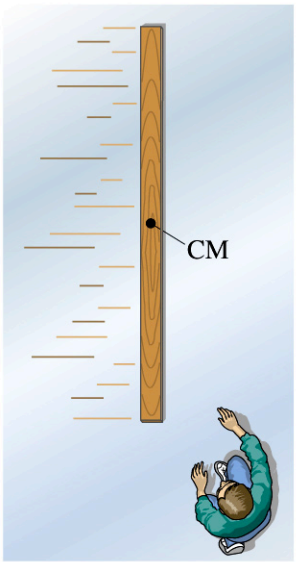
Physics 121 - Spring 2004 - workshop module 8
Rotational Motion and Dynamics

1. It catches most people's attention when you hear of engines falling off jet airplanes. It happens with a surprisingly high frequency. How can an airplane be in such poor shape that the engine *falls* off? It turns out that engines are held onto airplanes with breakaway bolts. In certain catastrophic engine failures, these bolts will snap and the engine will fall off the airplane … by design. Why is it necessary to design such a feature into commercial aircraft?

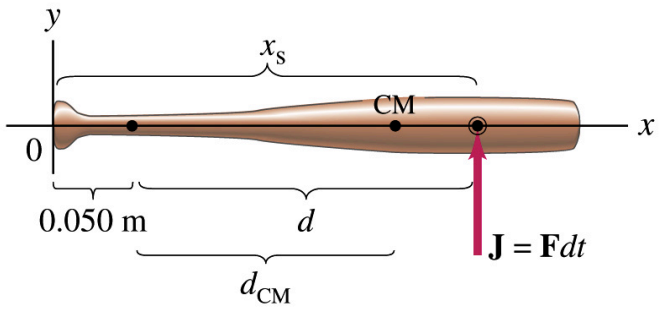
2. The pilot of a propeller-driven airplane decides to descend abruptly. The propeller is at the front of the airplane and rotates clockwise as seen by the pilot. She lowers the nose of the airplane from a horizontal attitude to one in which the nose is pointed well below the horizontal. As she does this, the nose of the airplane also swings to the left (as seen by the pilot). Explain why this happens.

3. A 200-kg beam, 2.0 m in length, slides broadside down the ice with a speed of 18 m/s. A 50-kg man, at rest, grabs one end as it goes past and hangs on as both he and the beam go spinning down the ice. Assume frictionless motion.



   a. How fast does the center of mass of the system move after the collision?
   b. With what angular velocity does the system rotate about its center of mass?

4. A baseball bat has a "sweet-spot" where a ball can be hit with almost effortless transmission of energy. A careful analysis of baseball dynamics shows that this special spot is located at the point where an applied force would results in pure rotation of the bat about the handle. Determine the location of the "sweet spot" of the bat shown in the Figure. The linear mass density of the bat is given roughly by (0.56 + 3.5x2) kg/m, where x is in meters measured from the end of the handle. The entire bat is 0.84 m long. The desired rotation point should be 5.0 cm from the end where the bat is held.



5. The axis of the Earth precesses with a period of about 25,000 years. This is much like the precession of a top. Explain how the Earth's equatorial bulge gives rise to a torque exerted by the Sun and the Moon on the earth (see Figure which sketches the situation on December 21). About what axis do you expect the Earth's rotation axis to precess as a result of the torque due to the Sun? Does the torque exist 3 months later?