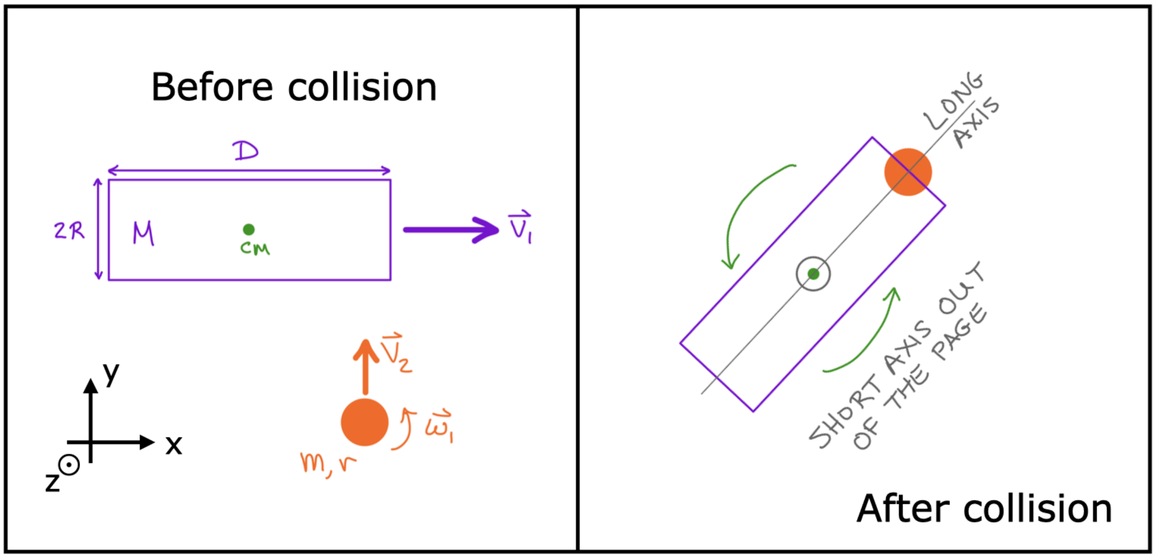
Physics 2211 GPS Week 14

Problem #1

A spaceship with mass M can be modeled as a thick solid cylinder of length D and radius R. It travels through space with speed v_1 to the right, and it is not rotating about any axis. A small, solid, spherical asteroid (mass m, radius r) travels with speed v_2 in the $+\hat{y}$ direction, and it rotates about its own CM counterclockwise with angular speed ω_1. The asteroid and spaceship collide in such a way that the asteroid gets embedded on the front end of the spaceship. After the collision, the ship+asteroid system is rotating counterclockwise about the spaceship's short axis, with an unknown angular speed ω_2.



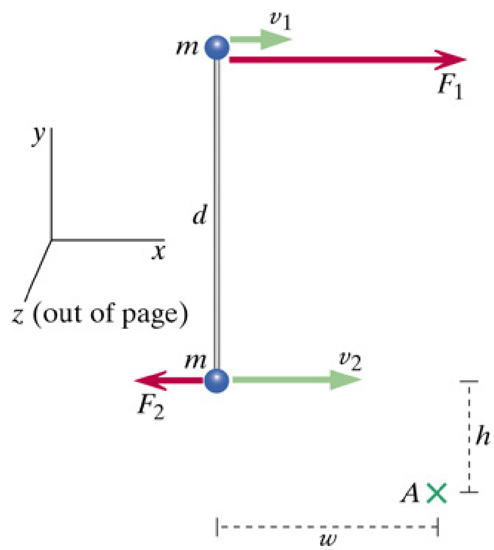
(a) Determine the total angular momentum of the ship+asteroid system before the collision. Use the center of mass of the ship as the reference point.

(b) Determine the final angular speed ω_2 for the ship+asteroid system after the collision. The moment of inertia of a solid cylinder about its short axis is $I_c = (1/12)MD^2 + (1/4)MR^2$, and the moment of inertia of a solid sphere about its center of mass is $I_s = (2/5)mr^2$.

Problem #2

Approximate the total angular momentum of the solar system. Make sure to list all simplifying assumptions you've made. You can find planetary information (masses, distances, speeds, etc) online.

Problem #3



In the figure two small objects each of mass $m = 0.235$ kg are connected by a lightweight rod of length $d = 1.20$ m. At a particular instant they have speeds $v_1 = 25$ m/s and $v_2 = 58$ m/s and are subjected to external forces $F_1 = 41$ N and $F_2 = 16$ N. A point is located distances $w = 0.80$ m and $h = 0.32$ m from the bottom object. No other external forces are acting on this system.

(a) What is the velocity of the center of mass?

(b) What is the total angular momentum of the system relative to point A?

(c) What is the rotational angular momentum of the system?

(d) After a short time interval $\Delta t = 0.035$ s, determine the total (linear) momentum of the system?

(e) Calculate the new rotational angular momentum of the system?

Problem #4

A yoyo can be approximated as a solid disk of mass m and radius R. Two identical such yoyos have their strings tied together and are wound so that the two yoyos are touching each other. These stuck together yoyos are ejected into deep space far from any other objects. Shortly after being ejected, the center of mass of the yoyos has an initial velocity $\vec{v}$ as indicated in the diagram. At this instant, the stuck together yoyos are rotating about the center of mass counterclockwise with an angular speed $|\vec{\omega}_i|$. As the yoyos fly through space the strings unwind so that at some later time all of the string has unwound from each yoyo. At this time, the velocity of the center of mass is $\vec{v}$ and the distance between the centers of the yoyos is d.

Determine the unknown angular velocity (magnitude and direction) of the center of mass for the tied together yoyos in the final state. You can neglect the mass of the string and you can assume that the yoyos are tied to the string so that the string is not slipping on the axle of the yoyo.