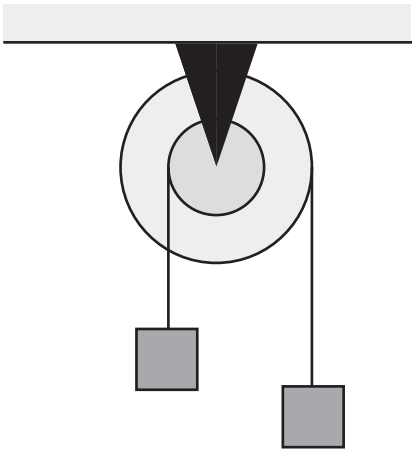
Sample Midterm #3

1. (33 points) A girl of mass 23 kg is standing at the center of a playground carousel with mass 80 kg and radius 2.4 m that is spinning at a rate of 1 revolution every 2.2 s. She walks slowly outward toward the edge of the carousel. Assume that the carousel is shaped like a solid cylinder with moment of inertia $I = \frac{1}{2}MR^2$.

(a) (15 points) What is the rate of rotation of the carousel (in radians/sec) when the girl reaches the outer edge of the carousel?

(b) (18 points) What is the minimum coefficient of static friction between her shoes and the carousel so that the girl can make it to the edge of the carousel without slipping?

2. Consider the souped-up Atwood machine pictured below. The two pulleys are attached so that they rotate together, and string is wound around both. The larger pulley has radius 0.38 m and moment of inertia 0.042 kg m^2, and the smaller pulley has radius 0.21 m and moment of inertia 0.019 kg m^2. The mass of the block on the left is 0.55 kg.



(a) (15 points) For what mass of the right block is the system in equilibrium?

(b) (18 points) Suppose that the two block weigh the same. Use conservation of energy to find the speed of the right block after it has dropped a distance of 0.50 m.

3. A satellite of mass m is orbiting a planet of mass M. This problem asks you to compare two possible circular orbits of the same satellite, one with orbital radius R and the second with radius $2R$.

(a) (18 points) In which orbit does the satellite have more total energy? (Define the gravitational potential energy to be zero at infinity.) How much more? (For example, 2 times as much, 4 times as much, *etc.*)

(b) (15 points) In which orbit does the satellite have more angular momentum? How much more?