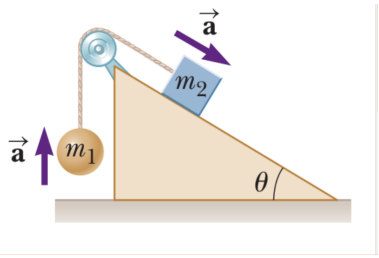
PHY121 Summer 2018
Problem Set #3
Due Tuesday 5/29

1. Atwood's Machine: Draw free-body diagrams for each object and determine the acceleration of the system for the following cases:



   (a) $m_1 = 13.0$ kg; $m_2 = 3.78$ kg; $\theta = 45°$; $\mu_k = 0$; $m_{pulley} = 0$ kg

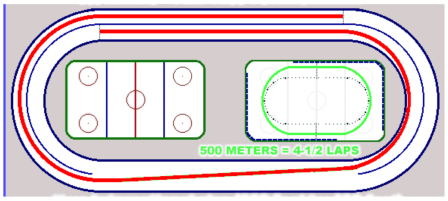
   (b) $m_1 = 83$ kg; $m_2 = 235$ kg; $\theta = 30°$; $\mu_k = 0$; $m_{pulley} = 0$ kg

   (c) $m_1 = 83$ kg; $m_2 = 289$ kg; $\theta = 30°$; $\mu_k = 0.2$; $m_{pulley} = 0$ kg

   (d) Bonus: Why can't we analyze this system for a massive pulley (...yet)?

2. A car of mass 2000 kg travels around a level curve of radius 60 m. If the maximum frictional force that can be exerted upon the car by the road (determined by the coefficient of friction between the tires and the road) is 8000 N, how fast can the car travel without losing control? Report your answer in mi/hr.

3. A speed skater races around a standard, international size long track oval. Assuming the speed skater (80 kg) can travel at 20 m/s on the straightaways and keeps a constant speed around every turn:

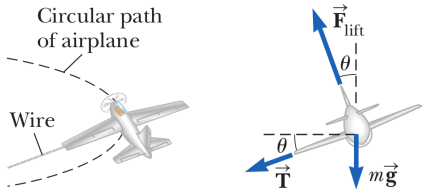


   (a) Determine the difference between his accelerations for the two radii. The smaller and larger radii are 25 m and 30 m.

   (b) Compare the centripetal forces for each radius.

(c) Assuming that the greater force you found in part b is the largest force that this skater can exert on his body before sliding out, determine the greatest velocity that the skater can obtain on any curved part of the track assuming that he does change his speed.

4. A student makes a model airplane and ties it to the end of a string. The motion and forces acting on the airplane are shown in the diagram. Assume that the mass and speed of the airplane are 0.85 kg and 30 m/s, and that the airplane makes an angle $\theta = 35°$ downward from horizontal at the end of a 70 m wire. The airplane does not move in the y direction. Determine the tension in the wire.



5. You want to go skydiving, but don't want to end up a soggy spot on the ground. Instead of giving up on the idea, you decide to run the numbers to determine if it's safe. You know that you'll be in free fall, so you look up any of the possible forces that will slow you down in order to allow you to open your parachute. Fortunately, there's a force called drag (or air resistance) how come no one's ever taught you about this before?

   The force due to drag is given by

$$F_D = \frac{1}{2}\rho v^2 C_D A \tag{1}$$

   where F_D is the drag force, ρ is the density of the fluid, v is the velocity of the object relative to the fluid, C_D is the drag coefficient (related to the geometry of the object), and A is the cross-sectional area of the object.

   (a) You reason that at some point you will reach a maximum speed (known as terminal velocity). What physical cause leads to this? Determine your terminal velocity.

   (b) After you reach terminal velocity you will pull the cord to release your parachute. How does this cause you to slow down?