3) (20 points) Two blocks on a Ramp

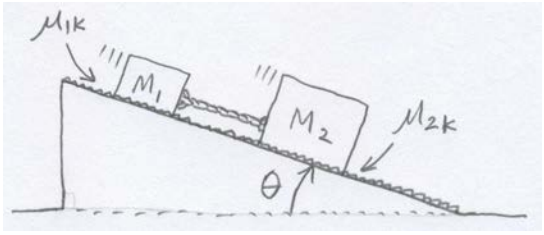
Two blocks with masses M_1 and $M_2 = 2M_1$ are sliding down a ramp with the first block higher up the ramp, as shown in the diagram. The two blocks are tied together with an ideal (massless and non-stretchy) rope.

a) If the coefficient of kinetic friction between the first block and the ramp is μ_{1k}, then what is the *direction* and *magnitude* of the force of friction acting on the first block? As always, show your work or justify your answer.

b) If the rope has non-zero tension, then what is the *upper limit* for the coefficient of kinetic friction μ_{2k} between the second block and the ramp?

c) Assuming that $\mu_{2k} = \mu_{1k}/2$, what is the *magnitude* and *direction* of the acceleration of the first block?

d) In this case, what is the tension in the rope?



4) (20 points) Sliding in a funnel

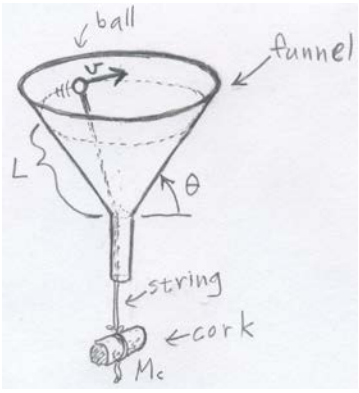
A small steel ball is sliding without friction in a horizontal circular path at constant speed v inside a stationary funnel, as shown in the diagram. An ideal (massless & non-stretchy) string connected to the ball hangs from the ball down L of the slope of the funnel and passes through the hole at the bottom, so that it supports a cork of mass M_c. The sides of the funnel form an angle of θ to the horizontal, as shown in the diagram.

a) Draw and clearly label a free body diagram of the ball by itself AND make a second free body diagram of the hanging cork by itself.

b) What is the tension T in the string? As always, show your work or justify your answer.

c) What is the magnitude of the ball's acceleration? Express your answer in terms of v, L, and θ.

d) What is the mass M_b of the ball?



5) (20 points) Sliding blocks with no friction

Two blocks are stacked on top of an incline as shown in the diagram. The uppermost block is cube shaped and it has mass M_1, whereas the block below it has mass M_2 and is wedge shaped with the same angle θ as the incline. You may assume that there is *no friction* in any part of this problem.

a) Make two separate free body diagrams, one for each of the blocks.

b) Given that the lower block is constrained to move along the slope, derive a formula for the vertical acceleration of the lower block as a function of its horizontal acceleration. Define your axes clearly and take care with signs.

c) What is the magnitude of the vertical component of the acceleration of the upper block? As always, show your work or justify your answer.

d) What is the magnitude of the horizontal component of the acceleration of the upper block?