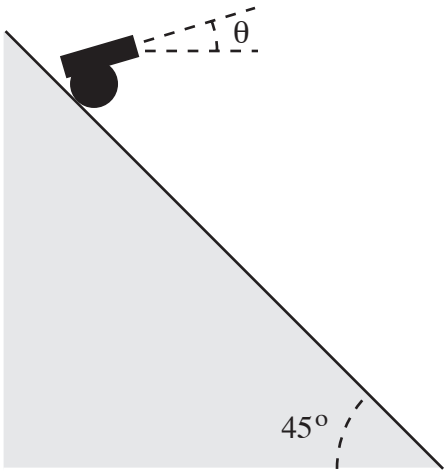
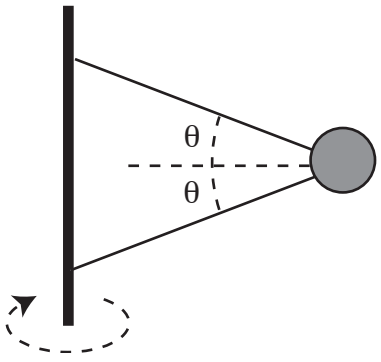
Midterm 1

There are 3 problems worth 33 points each. You must show your work and justify your answer to receive full credit.

1. A cannon fires down a 45° slope, as shown below. At what angle θ above the horizontal should the cannon fire in order to maximize the time the cannonball spends in the air? Neglect air resistance.



2. A 0.055 kg ball is attached via two massless strings to a rotating rod, as shown below. The strings are tied to the rod, and the ball rotates with the rod at a rate of 2.1 revolutions per second. The angle θ is 35°, and each of the strings has length 0.12 m.

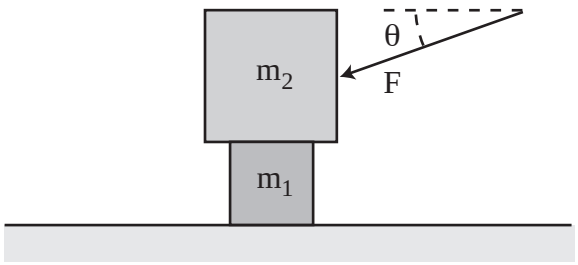


(a) (10 points) Draw a free body diagram for the ball. Clearly identify all forces and the direction in which they act.

(b) (7 points) Find the acceleration of the ball.

(c) (16 points) Use the results of parts (a) and (b) to find the tension in both of the strings.

3. Two blocks of mass $m_1 = 0.30$ kg and $m_2 = 0.52$ kg are placed on a frictionless horizontal surface. A force $F = 12$ N pushes on m_2 at an angle of $\theta = 20^\circ$ below the horizontal, as shown below.



(a) (13 points) Find the acceleration of the system assuming that the frictional force between the blocks is strong enough that they move together without slipping.

(b) (7 points) Find the frictional force that is required so that the blocks move together without slipping.

(c) (13 points) Find the minimum coefficient of static friction between the blocks that will allow the blocks to move together without slipping.