Sample 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 rifle fires bullets with an initial speed of 550 m/s. Neglect air resistance in this problem.

(a) (13 points) The rifle is aimed directly at the center of a target ("bull's-eye") that is 50 m away and at the same height as the rifle. By how much does the rifle miss the bull's-eye?

(b) (20 points) At what angle θ above the horizontal should the rifle be aimed to hit the bull's-eye exactly? Use the small angle approximation

$$\sin\theta \simeq \theta, \qquad \cos\theta \simeq 1, \tag{1}$$

valid for small θ in radians. Check the small angle approximation by comparing the value of $\sin\theta$ and θ for your result.

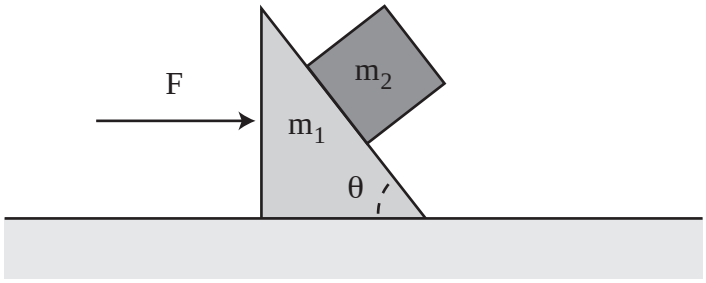
2. A car is going up a 15° slope. A small mass is attached to a string that hangs from the rear view mirror.

(a) (11 points) Suppose the car is going up the slope at a constant speed of 20 m/s. At what angle does mass hang? (Assume that the mass is not swinging back and forth.)

(b) (11 points) Is it possible to drive the car so that the dice hang exactly parallel to the roof of the car? Explain using a free-body diagram. If it is impossible, explain why. If it is possible, find the acceleration of the car required to make it happen.

(c) (11 points) Is it possible to drive the car so that the dice hang exactly perpendicular to the roof of the car? Explain using a free-body diagram. If it is impossible, explain why. If it is possible, find the acceleration of the car required to make it happen.

3. (33 points) A block of mass $m_2 = 0.33$ kg is placed on a wedge with mass $m_1 = 1.5$ kg and angle $\theta = 65°$, as shown. The coefficients of friction between the two blocks are $\mu_s = 0.30$ and $\mu_k = 0.20$. Neglect friction between the wedge and the ground.



Find the minimum and maximum values of F so that the blocks move together without slipping.