Assignment IV, PHYS 111 (General Physics I)
Fall 2016
Due 9/16/16 at start of class

As always, please put your clearly written answers on separate paper.

Throughout this entire assignment, ignore the effects of air resistance on projectile motion unless specifically indicated otherwise.

1. Back in 1971, Astronaut Al Shepard hit a golf ball on the surface of the moon. It was awkward for him to hit the ball (with a space-suit on, it is hard to get a decent swing), but he estimated the ball went 200-400 yards anyway. Assume you are able to hit a golf-ball 250 yards on Earth. How far could you hit it under identical conditions on the moon? (g on the moon is about 1.62 meters per second squared). Leave your answer in yards, since that is the typical unit used in golf.

2. A baseball batter hits a ball that comes off the bat at an angle of 32 degrees. The ball is moving at 38 m/s as it leaves the bat. You may assume the batter hits the ball from ground level.

   a) Assuming no air resistance, how far from the batter would this hit land? Leave your answer in feet. (You'll get an unrealistically large answer; that's because air resistance really isn't totally negligible here).

   b) The center field fence is 410 feet from home plate. The fence is twenty feet tall. Assuming no air resistance, will this baseball clear the fence for a home-run? (Support your answer with calculations.)

3. You stand on top of a tower of height 18 m and throw a stone at an angle of $+27°$ with respect to the horizontal at a speed of 14 m/s.

   a) How long does it take for the stone to hit the ground?

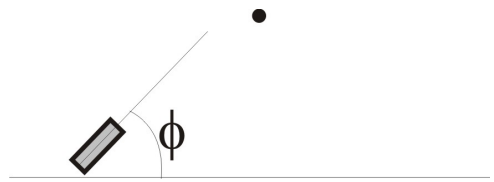
   b) At what horizontal distance from the tower does the stone hit the ground?

   c) What is the speed of the stone just before it hits the ground?

   d) Just before the stone hits the ground, what is the angle between the velocity of the stone and the ground?

4. A ball is thrown from level ground on Earth at some angle φ with respect to the horizontal. If the ball is originally thrown with speed v_i and the ball is moving with speed $v_i/3$ at the very top of its path, what was the angle φ?

5. A projectile is fired over a level surface on Earth with a speed v_i such that it passes through two points both a distance h above the horizontal. (The first time height h is reached is on the projectile's ascent; the second time on its descent).



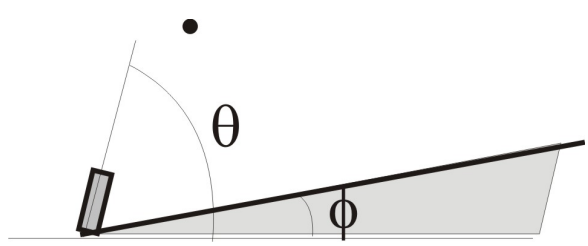
a) Show that if the gun is adjusted for maximum range, the horizontal distance the projectile travels between these two points is equal to:

$$\frac{v_i}{g}\sqrt{v_i^2 - 4gh}$$

This problem is similar to many in higher level Physics classes, where no numbers at all are given. Your task is to work with the symbols alone to develop an expression like the one above; this expression should work no matter what v_i and h are.

b) Find an expression for the time of flight for the projectile between the points a distance h above the horizontal if the initial launch angle $\phi = \pi/6$. Your answer should be in terms of variables v_i, h, and g *only*.

6. A cannon launches a projectile with initial velocity 175 m/s at an angle of 65° with respect to the horizontal (angle θ on the diagram). However, the area that the cannon is launching to is not level; in fact, the cannon is firing "up-hill" that has a steady grade of 28° with respect to the horizontal (angle ϕ in the diagram). How far "up the hill" does the projectile land? (In other words, how many meters up the slope would you have to walk in order to catch the cannonball?)



7. Let's say that you are firing a cannon in an attempt to hit a target that is 1400 meters directly East of you. The target and the cannon are on level ground. Your cannon always fires cannonballs with an initial speed of 135 m/s.

   a) Calculate the angle of elevation needed to hit the target. [There are actually two angles; find them both.]

   b) Let's say you wanted to hit the target with two separate cannonballs at the same time. You can do this by firing the first cannonball at the larger angle computed in part (a), then adjusting the launch angle and firing another cannonball at the smaller angle computed in part (a). How long would you have to change the firing angle in order to get both cannonballs to your target at the same time?

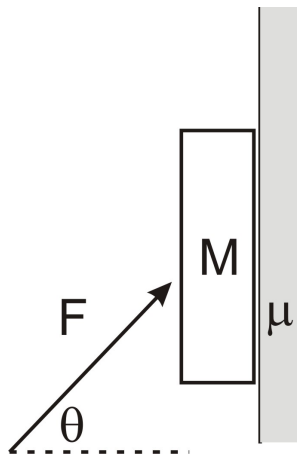
   c) [Extra Credit] Let's make this problem substantially trickier. Let's say that there is a "cross-wind" of 50 m/s directed towards the South. This turns the problem into a truly 3-d scenario, since the cannonball's launch velocity now must have an Eastward, Northward, AND Upward component in order to hit a target directly East of the cannon. (Much like 2-d problems, each of the three components are independent of each other).

      Assume that the crosswind adds a constant 50 (m/s) Southward value to whatever the North-South component of the cannonball velocity would be in the absence of the cross-wind. (This isn't at all realistic, but it gets us thinking about the right things).

      There are still two different elevation angles that will hit the target. (They will not be the same as what you found in part (a)). Each of these elevation angles will also have a different launch direction (you no longer launch each cannonball straight East; both must be directed a bit Northward as well). You are tasked to find the two different launching strategies that hit the target. (Each "launch strategy" includes an elevation angle (e.g. launch at a 23° angle above the horizontal) as well as a launch direction (e.g. launch at 37° North of East).)

8. You want to hold a book of mass M up against a wall (see picture below). Assume that the wall-book interface is frictionless. Thus, to merely "hold" it against the wall, the vector sum of the forces on the book must be zero.

   a) There are 3 forces on the book. What are they?
   b) Carefully draw a free body diagram for the book. Make sure your vectors are approximately the correct lengths.
   c) If $M = 2$ kg and $F = 30$ N, what would θ be to hold the book stationary?
   d) What does θ have to be for arbitrary F and M to hold the book stationary?
   e) If the book has a mass of 3 kg, you apply a force of 40 N, and $\theta = 60°$, what is the acceleration of the book? (Acceleration can be a scalar or a vector; here I'm looking for the vector, so give me magnitude and direction!)



9. Three masses accelerate to the right as shown below. The rightmost mass has mass M, and the other two masses are m_1 and m_2 as shown. The three masses are connected by ropes of negligible mass. The masses slide on a frictionless surface. The rightmost mass accelerates with constant acceleration a. The entire force generating this motion is not shown, but acts directly on mass M only. (The other masses accelerate because they are pulled by M). Determine:

   a) The magnitude of the force applied to M to make this system move.
   b) The tension in the rope between M and m_1.
   c) The tension in the rope between m_1 and m_2.
   d) The net force on m_1.

   (Remember, give all answers in terms of m_1, m_2, M, and a only!!!!)