Homework #4

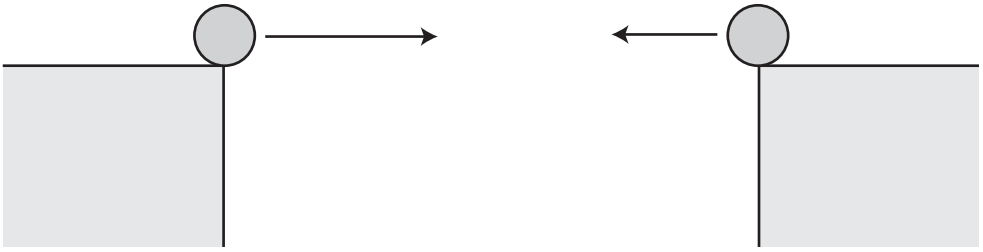
Due Friday, Feb. 25

1. A cannon can fire a cannonball with an initial velocity of 40 m/s. The cannon is 150 m away from a wall that is 15 m high.

(a) If the cannonball is fired at a 45° degree angle, does the cannonball make it over the wall?

(b) What is the maximum range of the cannon on flat ground if we want the cannonball to make it over the wall?

2. Two balls are rolled off two tables of the same height so that they leave the tables at the same instant, but with different horizontal velocities, as shown.



Do the balls hit in midair? Assume that the floor is sufficiently far down that they never hit the floor. Justify your answer with a correct physical argument. If the answer depends on the initial velocities of the ball, give an example where they hit and where they do not.

3. A tank has its gun pointed at 25° above the horizontal. The gun can launch a shell with an initial velocity of 120 m/s when the tank is at rest. Suppose now that the tank is moving at 60 m/s and fires its gun.

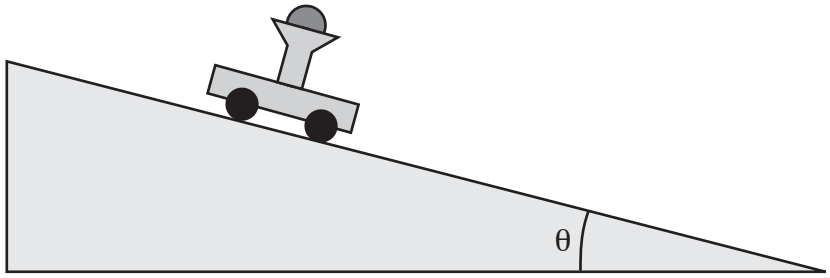
(a) What is the horizontal component of the initial velocity of the shell as seen by someone standing on the ground next to the tank?

(b) What is the vertical component of the initial velocity of the shell as seen by someone standing on the ground next to the tank?

(c) What is the initial angle of the projectile as seen by someone standing on the ground next to the tank? Explain how it can be different from 25°.

(d) If the tank wants to maximize its range while moving at 60 m/s, at what angle should it aim its gun?

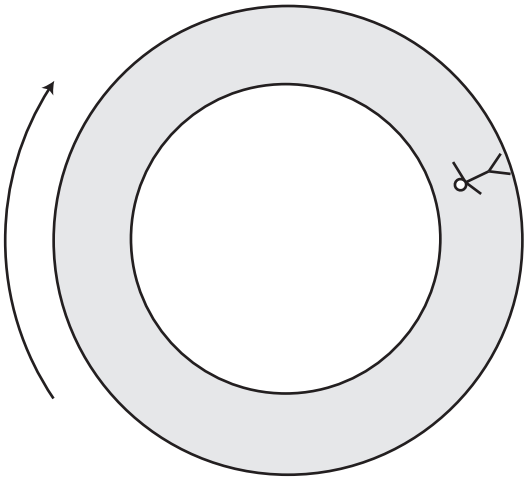
4. A toy cart has a spring-loaded funnel on top that can launch a ball into the air with an initial speed v_{ball}. If the cart is standing still, the ball goes straight up and comes straight down, and is caught by the funnel. As we demonstrated in class, when the cart is moving with constant speed in the horizontal direction, the ball is still caught by the funnel. Now we place the cart on an inclined plane of angle θ, as shown below.



Does the ball land in the funnel? Assume that the cart is moving with an initial velocity v_{cart} when the ball is launched. You can use the fact that the cart accelerates down the inclined plane with an acceleration $a = g \sin\theta$ down the plane. The answer will be demonstrated in class on the day the homework is due.

5. A cannon is firing down a hill with a slope of 20° below the horizontal. What angle should the cannon be aimed to maximize the range?

6. Intrepid astronaut Jane Danger has docked her rocketship at a space station that is shaped like a donut with outer radius 25 m.



(a) The space station is designed to rotate at a constant rate so that the "effective gravity" felt by a person standing on the outer wall is the same as on earth. To make this precise, find number of rotations per minute that the space station must make in order that an astronaut standing on a bathroom scale weighs the same as on earth.

(b) Jane decides to check the idea of "effective gravity" by dropping a ball in the space station from a vertical distance of 2.00 m from the floor and timing how long it takes to hit the floor. Calculate the time using a non-accelerating reference frame and compare it to the time it takes on earth.