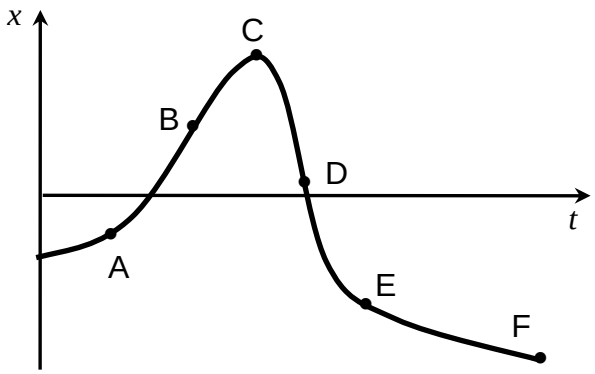
INSTRUCTIONS: Write your NAME on the front of the blue exam booklet. The exam is closed book, and you may have only pens/pencils and a calculator (no stored equations or programs and no graphing). Show all of your work in the blue book. For problems II-V, an answer alone is worth very little credit, even if it is correct – so show how you get it.

Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

I. Multiple Choice Questions (4 points each) Please write the letter corresponding to your answer for each question in the grid stamped on the first inside page of your blue book. No partial credit is given for these questions.

The following graph shows the trajectory of an object moving along the x-axis as a function of time.



1. At which point does the object have its maximum speed?

   a.) A b.) B c.) C d.) D e.) E f.) F

2. At which point does the object's acceleration have its maximum magnitude?

   a.) A b.) B c.) C d.) D e.) E f.) F

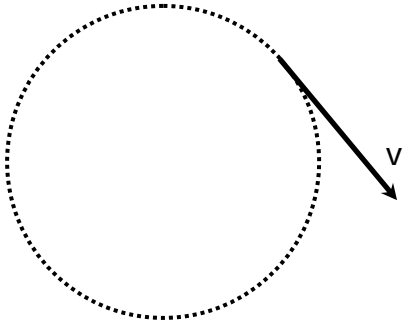
3. An object is dropped from rest and falls a distance D in some time T. If the time during which it falls is doubled, the distance it falls will be:

   a.) $4D$ b.) $2D$ c.) D d.) $D/2$ e.) $D/4$

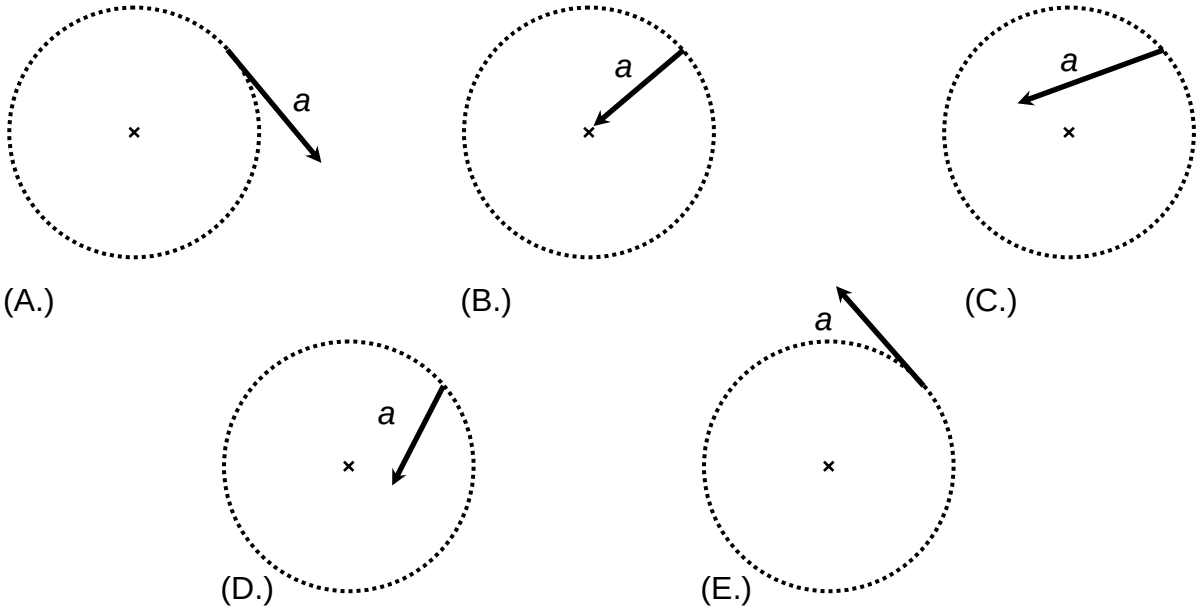
4. A football is thrown upwards at an angle of 60° above the horizontal plane. A headwind blows in the quarterback's face, causing a horizontal acceleration of 0.50 m/s^2 in a direction opposite the football's motion. If the football's initial velocity is 30.0 m/s, how long does it take to reach its maximum height?

   a) 0.38 sec b) 2.7 sec c) 3.1 sec d) 1.5 sec e) 1.6 sec

5. As a ball moves along a circular path, its speed is seen to increase. Its velocity is shown at a given point along its circular trajectory in the figure, below.



At the position shown, which of the following vectors indicates the possible direction of the net acceleration ***a*** of the ball. (The "x" indicates the center of the circle in each case.)



Problems (20 points each)

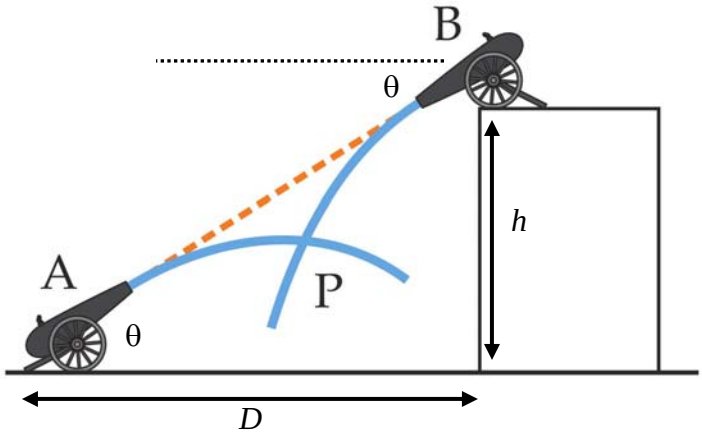
II. Two identical cannons are pointed directly toward each other as shown in the figure, next page. When fired, the cannonballs will follow the trajectories shown. "P" is the point where the trajectories cross each other. Ignore the effects of air resistance in this problem. See the figure on the next page for details, including angle and length definitions. Take the muzzle velocity to be v_0.

a) If we want the cannonballs to collide, should the gun crew fire cannon A first, cannon B first, or should they fire both simultaneously? Why? (Give your explanation in a couple of sentences, potentially using a drawing to explain your reasoning. There is no reason to solve equations for this part.)

b) Write down equations for the horizontal and vertical positions of cannonball A and cannonball B in a common coordinate system. Make sure you indicate your choice of axes. Assume that

the angle the cannons are aimed above/below the horizontal is θ, the horizontal distance between the cannons is D, and the height of the platform on which cannon B is sitting is h.

c) Assuming you fire the cannons so the cannonballs hit, at what height will the cannonballs collide?



III. This is an article that actually appeared in the San Francisco Chronicle some years ago:

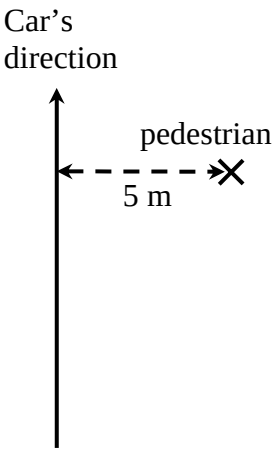
London Man Slain With Turnip

(Associated Press)

London. Police said yesterday a man was fatally injured after being hit by a turnip that was thrown from a passing car.

The attack apparently was carried out by a gang who toss vegetables at random passers-by. Another man suffered stomach injuries after being hit by a cabbage, police said.

Leslie Merry, 56, died nine days after he was hit by a turnip that knocked him to the ground as he walked near his home in London's East End, Scotland Yard said. He had a broken rib and ruptured spleen and died from respiratory problems.

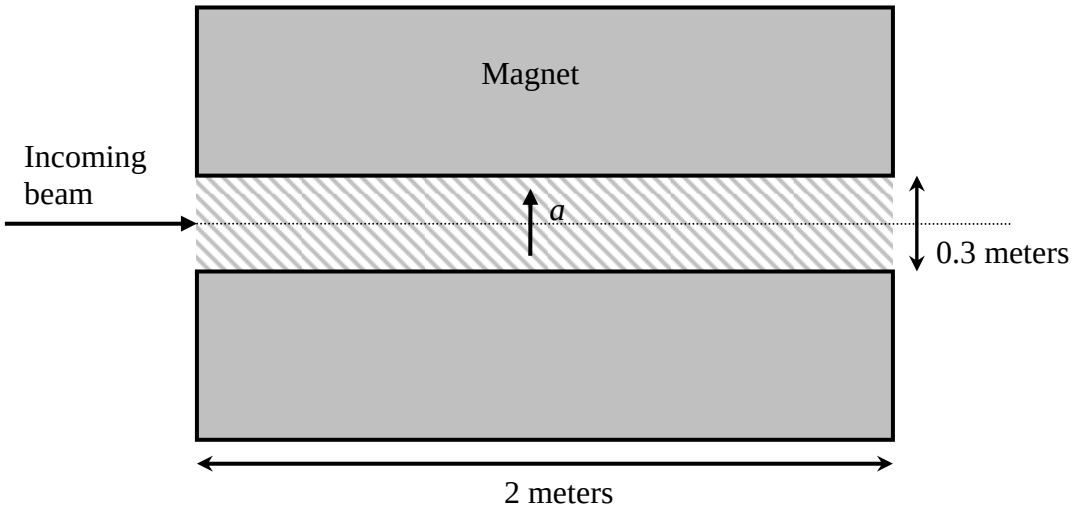


a) Assume that the ruffians were driving their car at 60 km/hr. If the turnip was thrown perpendicular to the car's velocity at 30 m/s, what was the turnip's speed when it hit the hapless pedestrian? (Note the difference in units here for the two given velocities.)

b) If the pedestrian was standing 5 meters to the side of the car's path, at what distance behind the pedestrian should the turnip have been thrown from the car so that it hits him? Use the velocities and directions given in part a).

IV. In particle accelerators, "sweeping" magnets are often used to bend unwanted particles created in a production target away from the secondary beam. A system that does this is shown in the sketch below. The magnet produces a force on the particles, creating a constant acceleration perpendicular to the beam direction. The magnet has a length of 2 meters and a horizontal aperture of 0.3m. Assume the beam enters at the center of the magnet gap, and that the acceleration due to the magnet is only felt while the beam is inside the magnet, in the hatched region shown. Neglect gravity in this problem.

a) Write down the horizontal and vertical equations of motion using the unknown acceleration *a*. Be sure to indicate your choice of coordinate axes.
b) Assuming the particles have an initial velocity of 2.0×10^8 m/s, what is the minimum acceleration necessary so that the particles smash into the walls of the magnet instead of escaping downstream?



V. On the Indiana Toll Road, a speeding car traveling at 125 km/hr (34.7 m/s) blasts past a stationary State Police cruiser. The police car pulls out immediately and begins to accelerate at a rate of 2.2m/s^2 until it reaches its maximum speed of 190 km/hr (52.8 m/s), which it maintains until it catches up with the speeder. Use meters and seconds as the units for this problem.

a) Sketch the positions as a function of time for the speeder and the police car, using the same set of axes for both.
b) How long does it take the police car to catch up to the speeder?
c) How far does each car travel?