Physics 211 Practice Exam 1

- There are eight questions, each worth fifty points.
  - Question 1 tests your ability to add and subtract vectors.
  - Question 2 tests your ability to understand motion when the acceleration changes partway through, and to make position/velocity/acceleration graphs.
  - Question 3 tests your ability to understand two-dimensional projectile motion, and to use the quadratic formula.
  - Question 4 tests your ability to add and subtract vectors.
  - Question 5 tests your ability to understand two-dimensional motion.
  - Question 6 tests your ability to understand one-dimensional motion in stages, and to make position/velocity/acceleration graphs.
  - Question 7 tests your ability to understand motion in two dimensions, to deal with an acceleration that changes partway through, and to make position/velocity/acceleration sketches.
  - Question 8 tests your ability to understand projectile motion.

Question 1

A pilot wants to fly from Syracuse to Baltimore. Syracuse lies 300 miles north of Baltimore.

Her aircraft can fly at 400 miles per hour in still air.

However, the airplane is traveling through the jet stream, which blows at 100 miles per hour to the east.

There are three vectors in this problem:

- The velocity vector of the airplane relative to the ground. This determines the direction the plane travels. Call this vector $\vec{A}$.
- The velocity vector of the airplane relative to the air (of magnitude 400 mph).This vector is determined by the direction the airplane is pointing. Call this vector $\vec{B}$.
- The velocity vector of the wind relative to the ground (magnitude 100 mph, pointing east). Call this vector $\vec{C}$.

a) She wants to fly due south. If she points her airplane directly south, describe (qualitatively) which direction she will wind up traveling in. (5 points)

b) Write a vector equation relating vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$. (5 points)

c) Illustrate the vector equation you wrote for part b) graphically, by drawing a triangle whose sides are the three vectors involved. (10 points)

Question 1, continued

d) In what direction should she point her aircraft if she wants to travel directly south to Baltimore? (20 points)

c) How long will it take for her to reach Baltimore? (10 points)

Question 2

A Syracusian lives at the top of a snowy hill. They are having trouble getting their car up the hill, though, since there is an icy patch that is $d = 20$ meters long in the middle of the hill; when they try to drive up the ice, they slide back down. (If the driver can make it past the icy patch, they will be fine.)

The driver has an idea: they will accelerate as much as possible on the snow, and hope that they can make it past the ice before they slide back down.[1] When the car is on snow, it accelerates forward at 1 m/s^2; when the car is on ice, however, it accelerates backwards at 2 m/s^2.

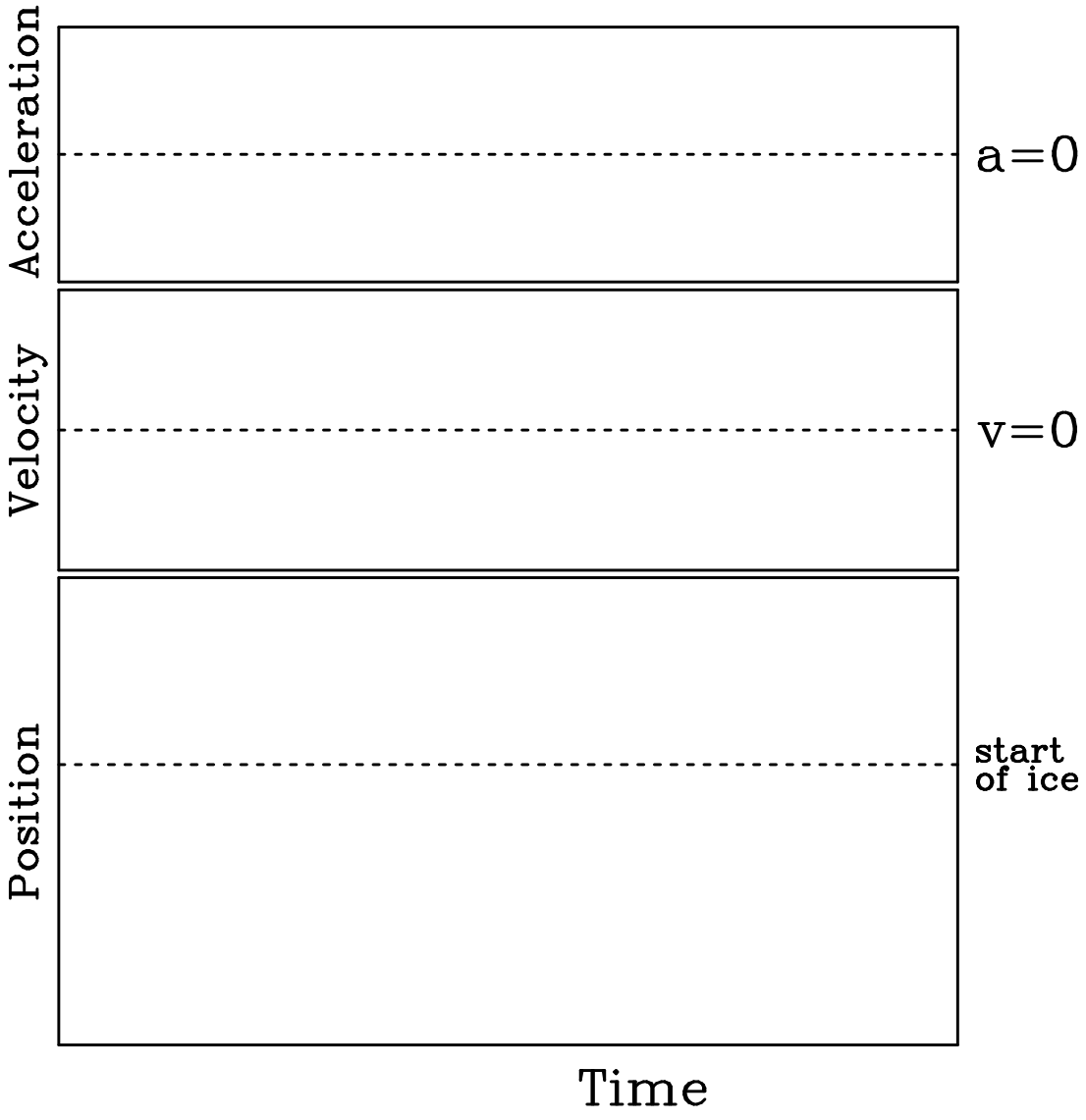
a) Suppose that the driver has a running start of $s = 30$ meters to build up speed before encountering the ice. How fast will they be going when they get to the ice? (10 points)

b) Will the driver make it to the other side of the icy patch? (20 points)

[1] Don't actually drive like this. People in physics problems are trained professionals driving on roads with nobody else around.

Question 2, continued

c) On the axes given, sketch graphs of the driver's acceleration vs. time, velocity vs. time, and position vs. time, starting from the moment that the driver begins accelerating, and ending when the driver exits the icy patch (either on the top, after successfully getting past it, or on the bottom, after sliding back down). (20 points)



Question 3

A football (soccer) player takes a shot on goal. They kick the ball at an angle $\theta = 30°$ above the horizontal at a speed of $v_0 = 15$ m/s. The ball bounces off of the crossbar, located a height $h = 2.4\,\text{m}$ above the ground. Ignore air resistance.

a) Write expressions for $x(t)$ and $y(t)$. (10 points)

b) How long after the ball is kicked does it strike the crossbar? You may give your answer as a numerical value or an algebraic expression in terms of θ, h, g, and v_0. (20 points)

Question 3, continued

c) In part (b), you likely used the quadratic formula. One of the two roots you obtained is the one you used to answer part (b). What is the physical meaning, if any, of the other one? (If you did not use the quadratic formula for part (b) but got it right, you will get full credit for this part.) (10 points)

d) What is the distance d between the kicker and the goal line? (You may give your answer as a numeric value or in terms of some of θ, g, h, and v_0.) (10 points)

Question 4

A walnut tree grows 100 meters north of a pecan tree.

A squirrel takes a walnut from the walnut tree, travels 30 meters at an angle 20 degrees south of east, and buries his walnut.

Another squirrel takes a pecan from the pecan tree, travels 50 meters due west, and buries her pecan.

a) How far apart are the two buried nuts? (30 points)

b) If someone wanted to walk from the buried pecan to the buried walnut, in which direction should she walk? (20 points)

Question 5

A firefighter in an airplane is trying to put out a fire by dropping a load of sand on it. She is flying horizontally toward the fire at an altitude of 100 meters, traveling at a speed of 60 m/s.

If she drops her sand directly over the fire, it will overshoot the target.

a) How far in advance of the fire must she release the sand in order for it to land on the fire? (25 points)

b) In what direction will the sand be traveling when it strikes the ground? (15 points)

Question 5, continued

c) Will the airplane be behind the load of sand, directly above it, or ahead of it when it lands on the fire? Justify your answer. (10 points)

Question 6

A person drops a baseball from a height h onto a hard floor. When the baseball hits the floor, it will bounce back at a speed equal to *half* of the velocity with which it hit the floor.

In terms of h and g, find:

a) how long it takes to hit the floor the first time (10 points)

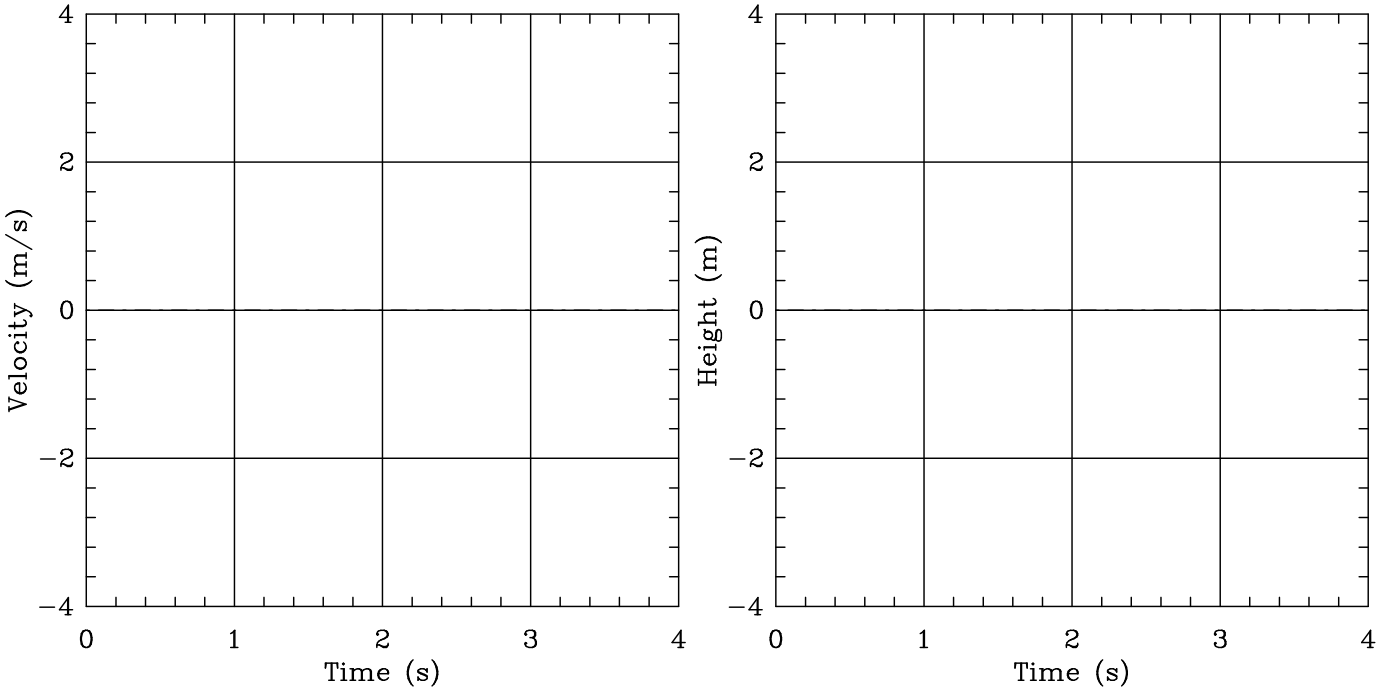
b) how fast it is going when it hits the floor the first time (10 points)

c) how high it travels after bouncing off the ground the first time (10 points)

Question 6, continued

d) the total amount of time between the ball being dropped and it hitting the floor the second time (10 points)

e) On the axes provided, graph the ball's velocity vs. time and position vs. time, starting at the time that it is dropped and ending when it strikes the ground for the second time. (10 points)



Question 7

A rocket is dropped out of a window and pointed sideways toward another building. A time τ after it is dropped, its motor fires, giving it an acceleration of $2g$ in the horizontal direction. (Its vertical acceleration is still g downward.)

After the motor fires, the rocket flies along its new path until it strikes another building, located a distance d away.

a) In terms of τ, g, and d, what are the position and velocity of the rocket when the motor fires? (10 points)

b) In terms of τ, g, and d, how long in total is the rocket in the air before it strikes the second building? (20 points)

c) Sketch graphs of v_x, v_y, x, and y as a function of time. Indicate the time τ on each graph. (20 points)

Question 8

A ball rolls off a shelf of height h at speed v. Answer the following in terms of h, v, and g.

a) How long does it take the ball to hit the floor? (10 points)

b) Where does the ball hit the floor? (10 points)

c) What is the ball's speed when it hits the floor? (10 points)

Question 8, continued

d) What direction is the ball moving in when it hits the floor? (10 points)

e) Suppose that the edge of the shelf had been curved, so that the ball's initial velocity was instead directed at an angle θ below the horizontal. Explain, using words or algebra as appropriate, what things you would have needed to do differently to solve the previous four parts, and which things would stay the same. (10 points)