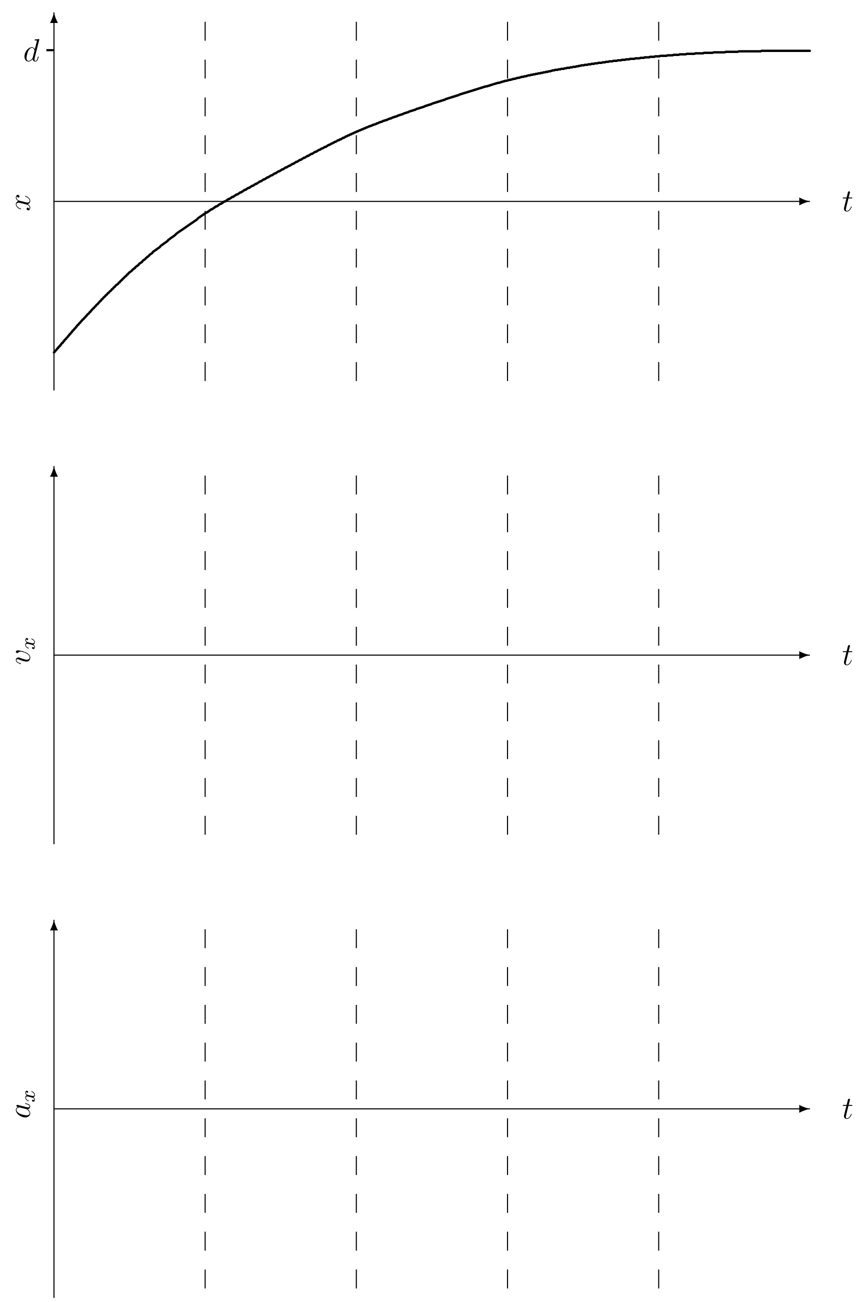
Exam 1; Phys 185 Name ________________

**Note:** As I walk around, you can ask me for help; for example, to supply an equation or a number you have forgotten down, or to give you algebra aid. If you do, however, I will write down what help I provided on your exam, and grade your answer accordingly.

**1. (20 points)** The top graph displays how position depends on time for an object that gradually, but ever more slowly, approaches $x = d$. Make a qualitative sketch of the corresponding velocity versus time and acceleration versus time graphs for this motion.



**2. (30 points)** You have a tall building, a spherical ball made of an aerogel material, and some lab equipment that allows you to measure the speed $v$ of the ball just before it hits the ground. You can look up the density of air $\rho$, and the acceleration due to gravity $g$. You can measure the radius of the ball $r$, and the mass of the ball $m$.

(a) Describe (in one or two sentences) an experiment to measure the drag coefficient $C_D$ on the ball. Find the equation you would use to calculate $C_D$.

(b) What significance does the fact that the ball is made of an aerogel have? What significance does the fact that it is a sphere have?

**3. (40 points)** You have a cannon that launches rubber balls with an initial speed of $v_i = 12.6$ m/s. You set it at an angle $\theta = 38°$ above the horizontal, and shoot a ball at a high vertical wall standing a distance $l = 9.20$ m in front of the cannon.

(a) Find $v_{fx}$ and $v_{fy}$ at the instant before the rubber ball hits the wall. (**Bonus +5 points** if you solve everything symbolically, only plugging in numbers at the very end.)

(b) The instant *after* the rubber ball bounces off the wall, the $y$-component of its velocity remains the same as it was just before it hit the wall. But the $x$-component of its velocity reverses its direction (same magnitude, opposite sign). Find out where, relative to the cannon, the ball falls back to the ground.

**4. (30 points)** You set up a device where you have a bucket tethered to a rope, and the bucket rotates at a constant speed $v$ in a vertical circle with radius $r$. You then place a small ball with mass $m$ in the bucket. What is the minimum $v$ you must have in order for the ball not to fall out of the bucket during rotation?

**5. (80 points)** In Lab 3, "Acceleration due to Gravity," you set two light gates a distance $\Delta x$ apart, and measured the time the cart took, $\Delta t$, to cover that distance.

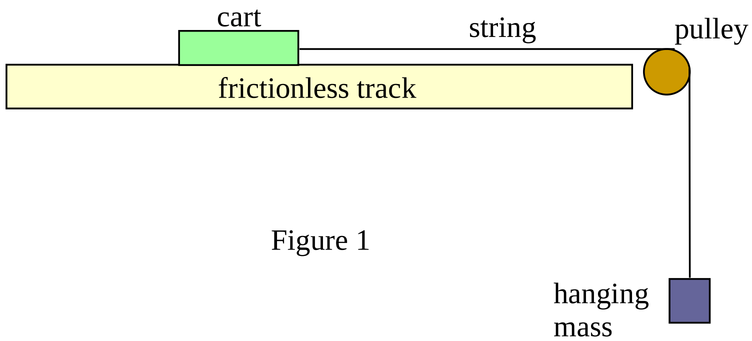



Figure 1

A source of error was difficulty setting the initial velocity at the first light gate. So you persuade the physics department to spend money for a mechanism so that $v_i = 0.000$ m/s.

(a) In the lab, you saw that the acceleration of the cart was $a = 2\Delta x/(\Delta t)^2$, under the assumption that $v_i = 0$ at the first light gate. Derive this equation.

(b) Repeat the calculation we did in class, and use it to derive the equation for $g$ we used in the lab—find the equation for $g$ in terms of $\Delta x$, $\Delta t$, $m_{\mathsf{hang}}$, and $m_{\mathsf{cart}}$.

(c) You now realize that friction is another source of error, and that the physics department is now out of money to buy tracks with nearly no friction. Say you know that the coefficient of rolling friction between the cart and the track is $\mu_r$. What would your altered equation for $g$ then be, accounting for friction?

(d) But your track might not be perfectly level! Say it has a tilt of $\theta$ with respect to the horizontal. What would your altered equation for $g$ then be, accounting for everything?