Assignment 3; Phys 185 Name ________________

1. (20 points) You have an object with mass m moving on a flat surface, released with initial velocity v_i. The coefficient of kinetic friction between the surface and the mass is μ_k.

(a) Find the distance the object will travel before coming to a halt, in terms of v_i, μ_k, m, and g.

(b) You also have a second object which is released with the same initial velocity v_i. This second object is placed in a sleeve that reduces friction by 1%, so that its coefficient of kinetic friction with the surface is $0.99\mu_k$, but increases its total mass by 1%, so that its mass is $1.01m$. Which object will travel a larger distance before coming to a halt?

2. (40 points) You drop a spherical 4.1 kg object from a bridge with height 84 m over the water. Take $C_D = 0.5$, the density of air $\rho = 1.22$ kg/m^3, and the radius of the object to be 0.25 m.

(a) Assuming you can ignore air resistance, calculate the speed at which the sphere will hit the water, and the time it will take to reach the water.

(b) But we really can't ignore the air resistance. Calculating the motion by accounting for drag force requires calculus, so we won't do that. Instead, circle the most accurate *approximate model* from amongst the following options:

i. Assume constant acceleration of g until the sphere reaches terminal velocity, and afterwards have it continue falling with this constant terminal velocity.

ii. Assume a constant velocity equal to the terminal velocity downward throughout the fall.

iii. Assume constant acceleration throughout, but reduce the downward acceleration to $g - \frac{1}{2}C_D m$, where m is the mass, to account for the drag force.

iv. Assume constant acceleration throughout, but reduce the acceleration to $g\frac{1}{2}C_D$, to account for the effect of the drag force.

Explain why you think your choice is the best approximation among these options.

(c) Use your choice of approximate model to calculate the speed at which the sphere will hit the water, and the time it will take to reach the water. Compare these to your answers from (a)—do they make sense?

3. (40 points) Lab 3 was not meant to measure g accurately. But you decide to fix some of your sources of error and do a better job. First, you devise an automatic release mechanism for the cart, so that it does in fact start with a zero initial velocity as it heads into the first photogate. Then you make some calculations, establishing that the cart never goes fast enough to take the drag force into consideration, and that the pulley's mass and friction at the pulley are so small that they shouldn't matter. And so you set up the equipment and measure Δt and the distance between the photogates, calculating g by using the equation from Lab 3.

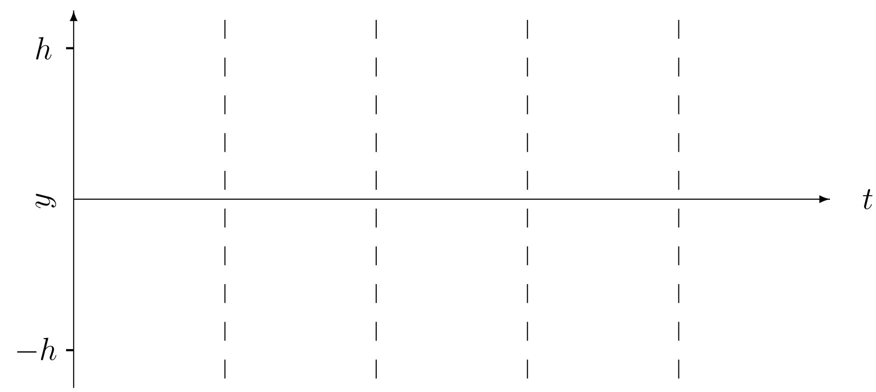
(a) Your g result turns out to be improved, but still not good. You then realize that you didn't account for the track possibly being tilted, and that there was friction between the cart and the track. No matter: you realize that if you could measure the tilt angle θ and the coefficient of kinetic friction μ_k, you could still use your data from the experiment, as long as you altered the equation for g to account for the tilt and the friction. Find this improved equation for g.

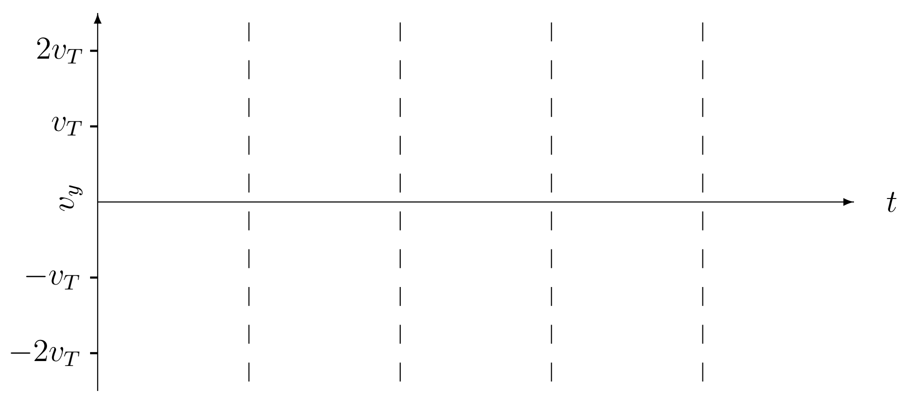
(b) Check that your answer is the same as what is given in the pre-lab for Lab 3 when $\theta = 0$ and $\mu_k = 0$.

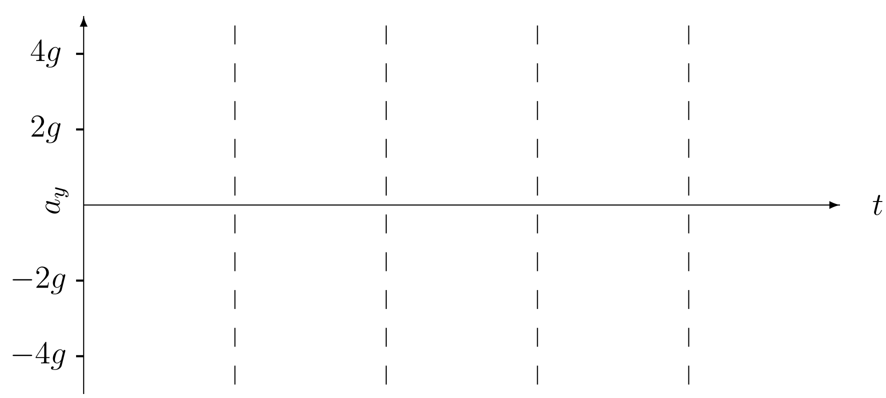
(c) Propose an experiment you can perform in the lab with equipment that you've used so far, that will allow you to determine μ_k for the friction between the cart and track. Keep your experiment simple; for example, don't incline the track—that's an unnecessary complication.

Extra Problems (not graded)

4. (0 points) You go to the top of a very high skyscraper with height h, and shoot a ball directly downwards. Air resistance, however, is not negligible, and the initial speed of your ball as it heads down is $2v_T$, where v_T is the terminal speed for the ball. Make *qualitative* sketches of the ball's $y(t)$, $v_y(t)$, and $a_y(t)$. *Hint:* You can figure out exact values for all three at $t = 0$; start there.







5. (0 points) You're doing the experiment in Lab 2, with the cart going up and down an inclined low-friction track. You notice that the accelerations going up and down are slightly different; $a_{\mathsf{up}} = -2.1$ m/s^2 and $a_{\mathsf{down}} = -1.9$ m/s^2; where these are accelerations along an x-axis tilted to be parallel with the track, with the $+x$-direction pointing up (away from the motion detector).

(a) Find θ, the angle at which the track is tilted. *Hint:* If you solve this symbolically, you'll find that θ depends on $\frac{1}{2}(a_{\mathsf{up}} + a_{\mathsf{down}})$ and g.

(b) on next page

(b) Find μ_k, the coefficient of kinetic friction between the track and the cart. *Hint:* If you solve this symbolically, you'll find that μ_k depends on $\frac{1}{2}(a_{\mathsf{up}} - a_{\mathsf{down}})$, g, and θ.