**University of California at Berkeley**
**Department of Physics**
**Physics 7A, Spring 2016**

Midterm 1
Feb. 23, 2016

You will be given 120 minutes to work this exam. No books are allowed, but you may use a single-sided, handwritten formula sheet no larger than an 8 ½" by 11" sheet of paper. No calculators or other electronics are allowed (wouldn't help much anyhow…). Your description of the physics involved in a problem is worth significantly more than the final answer by itself. Show all work, be careful with signs, and take particular care to explain what you are doing. Please express your answers using the symbols provided in the problem descriptions or define any new symbols you use, tell us why you're writing any new equations, and clearly label any drawings that you make. Write your answers in a blue book (or green book), and do not use any extra scratch paper. Please BOX your answers. Good luck!

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1) (25 points) The Big Game.

Stanford leads by 3 points in the final seconds of the Big Game, but Cal has the ball and is trying for a passing play. The Cal quarterback throws the ball with an initial speed of $v_o$ at an initial angle θ above the horizontal, as shown in the diagram. The quarterback releases the ball at a height of $h_o$ above the ground, which is the same height that it is caught by the wide receiver (who is standing in the end `zone).

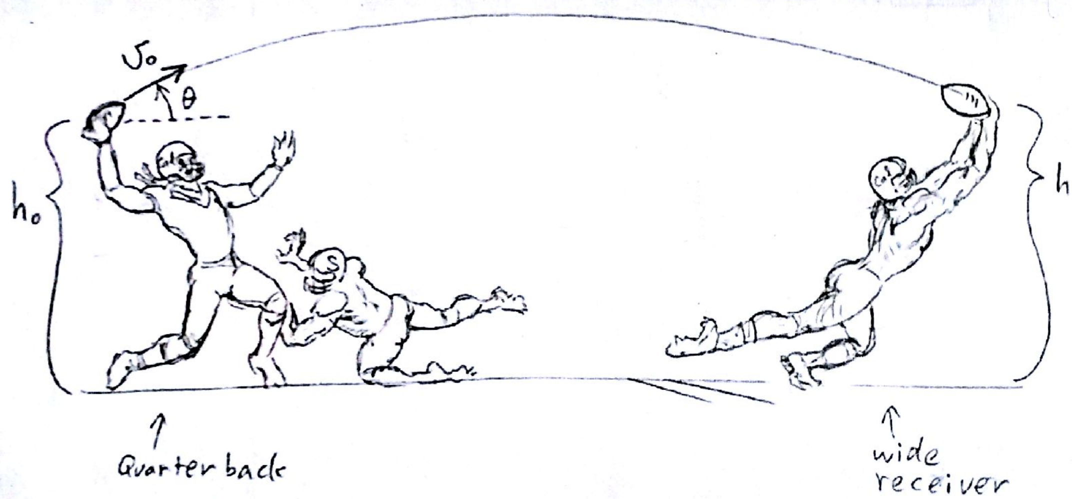
a) How long is the ball in the air from the time it is thrown until it is caught? Please express your answer as a function of any combination of $h_o$, $v_o$, θ, and any relevant physical constants. As always, show your work and/or justify your answer.

b) What is the horizontal distance between the quarterback and the location where the wide receiver catches the ball?

c) If the wide receiver starts from rest at the moment the ball is thrown from a point midway between the quarterback and the location where he catches the ball, then what is the magnitude of his acceleration? You may assume that he runs with constant acceleration. Express your answer as a function of θ and any relevant physical constants.

d) What is the magnitude of the ball's acceleration immediately before it is caught?

e) What is the relative velocity of the ball with respect to the wide receiver immediately before he catches the ball? Express your answer as a vector and clearly label your axes.




2) (25 points) Two blocks and a pulley on an incline

Two blocks are tied together by an ideal rope that passes around an ideal pulley that is connected to an incline, which forms an angle θ with respect to the horizontal as shown in the diagram. The upper block has mass $M_a$ and the lower block has mass $M_b$. The static and kinetic coefficients of friction for the interface between the ramp and the bottom surface of the lower block are $\mu_s$ and $\mu_k$, respectively. There is *no* friction *between* the two blocks.

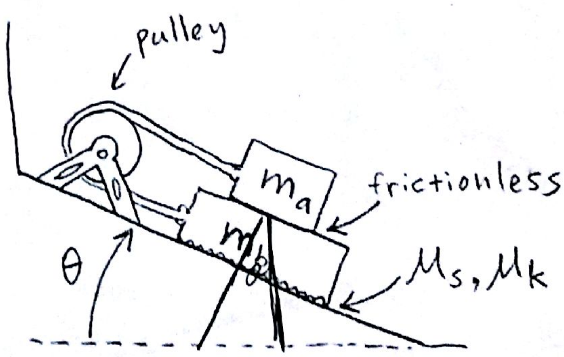
a) Draw 2 free body diagrams, one showing all forces acting on the upper block alone, and a second diagram for the lower block alone.

b) What is the *magnitude* and *direction* of the normal force from the lower block acting on the upper block?

c) If the blocks are *not* sliding, then what is the *minimum* value for the mass $M_a$ of the upper block? Consider the cases for both large and small values of θ and $\mu_s$.

d) If the blocks are sliding, then what is the magnitude of the acceleration of the upper block?

e) If the blocks are sliding, then what is the tension in the rope?

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3) (25 points) Round Up carnival ride

A carnival ride called the "Round Up" consists of a spinning cylindrical wall with radius $R$ that riders stand against while it rotates. Once the rate of rotation is high enough, the floor drops so that the riders' feet are no longer supported from below, as shown in the first diagram.

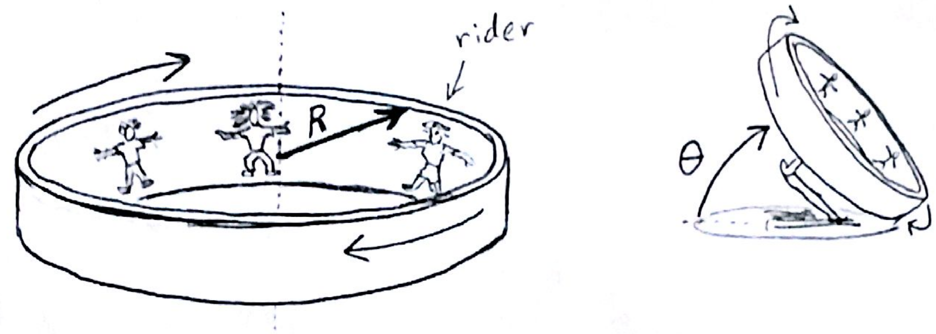
a) If the coefficient of static friction between the rider and the wall is $\mu_s$, then what is the *maximum* period of time $T_{max}$ that it can take a rider of mass $m$ to make one complete revolution around the circle? Express your answer in terms of any combination of $m$, $R$, $\mu_s$, and any relevant physical constants.

b) At some point, the whole cylinder tilts to an angle θ, as shown in the second diagram; the rate of rotation is high enough so that the rider never slides or falls from the wall. Now what is the magnitude of the normal force from the wall acting on the rider when the rider is at her *highest* position? Express your answer to this and all following questions in terms of any combination of $m$, $T$, $R$, $\mu_s$, θ, and any relevant physical constants.

c) What is the magnitude of the normal force from the wall acting on the rider when the rider is at her *lowest* position?

d) What is the magnitude of the force of static friction on the rider when she is at her *highest* point?

e) What is the magnitude of the force of static friction on the rider when she is at a height midway between her highest and lowest positions?




4) (25 points) Weights and springs

A weight of mass $M_a$ is suspended from the ceiling by a single massless spring with spring constant $k$. A second weight of mass $M_b$ is suspended by three equal length massless springs, each with spring constant $2k$, which are each connected to the bottom of the first weight as shown in the diagram.

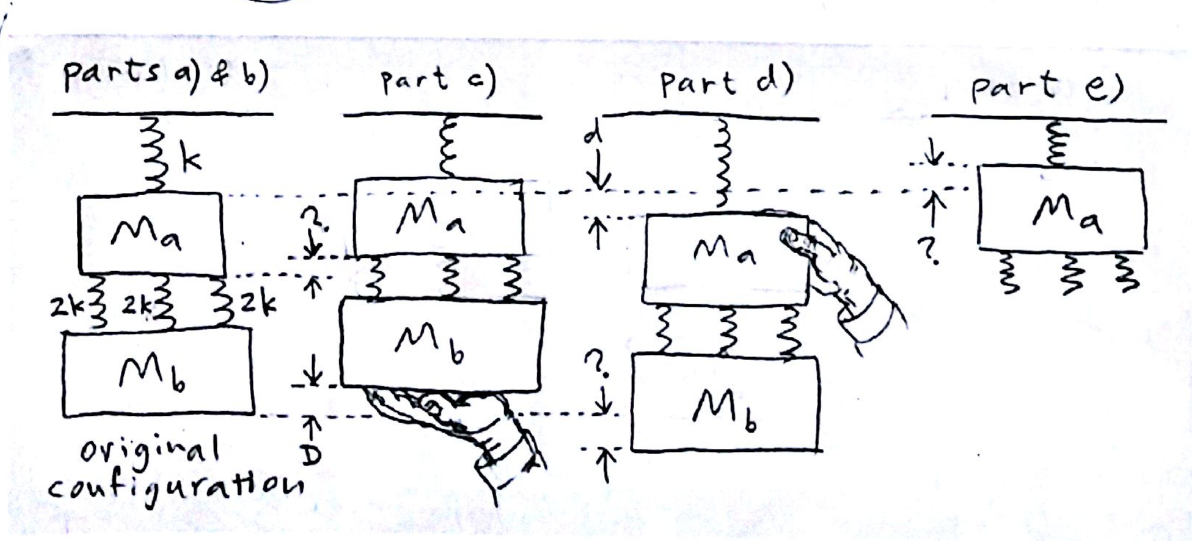
a) If none of the weights or springs are moving, then what is the *direction* and *magnitude* of the force from the top spring acting on the upper weight $M_a$?

b) What is the *direction* and *magnitude* of the force from *one* of the lower springs acting on the first weight $M_a$?

c) If the lower weight is lifted up and held motionless a distance $D$ higher than it was initially, as shown in the second diagram, then by how much will the upper weight be raised?

d) If the upper weight is pulled downward and held in place a distance $d$ below its initial height as shown in the third diagram, then how much lower will the lower weight be compared with the original configuration?

e) If the bottom weight is now disconnected from the lower springs as shown in the fourth diagram, then once the top weight stops bobbing up and down, by how much higher will the upper weight be compared to the original configuration?

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