University of California at Berkeley
Department of Physics
Physics 7A, Spring 2014

Midterm 1
Feb. 25, 2014

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 electronics that can send or receive wirelessly are allowed, but you may use a calculator if you with (won't help much…). Your description of the physics involved in a problem is worth significantly more than any numerical answer. 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!

1) (20 points)   Women's Basketball.

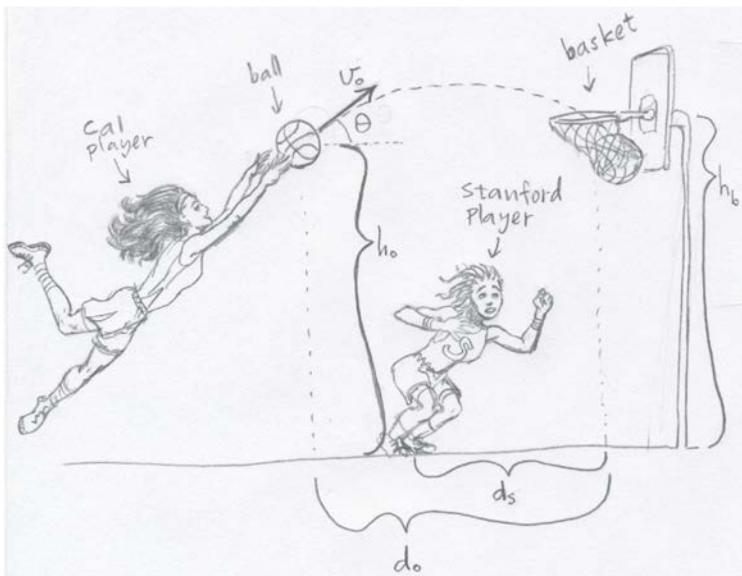
The score is tied as the clock winds down in the final seconds of the Cal − Stanford Women's Basketball game. A Cal player has the ball and makes a jump shot, releasing the ball from a height of h_o above the ground and a horizontal distance d_o from the basket, which is a height h_b above the ground, as shown in the diagram.

a) What is the magnitude of the ball's acceleration at the highest point of its trajectory? As always, show your work and/or justify your answer.

b) If the ball's trajectory is initially at an angle of θ above the horizontal, then what initial speed v_o is required so that the ball lands in the basket on its downward trajectory?

c) Expressed as a function of v_o and θ, what is the smallest value of the ball's speed as it travels from the Cal player to the basket?

d) A Stanford player standing a horizontal distance d_S from the basket starts to run towards the basket at the moment the ball is released. If the Stanford player starts from rest and then runs with a constant acceleration until she reaches the basket, what acceleration does she need to maintain to reach the basket at the same time that the ball does? Express your answer as a function of any combination of g, d_S, d_o, v_o and θ.



2) (20 points)   Racecar driver

At a crucial moment near the end of a Nascar race, the driver of the car close behind the leader sees an opportunity and depresses the gas pedal in such a way as to make the car's velocity obey the following equation:

$v(t) = A + Bt^2$

where v is the car's velocity in m/s, t is the elapsed time in s, A and B are positive constants, and $t = 0$ is the exact time when the driver starts to make his move. The car is traveling along a straight piece of the racetrack for this entire problem.

a) What are the physical units of the constants A and B?

b) What is the formula for the acceleration of the car as a function of time starting at $t = 0$?

c) What is the formula for the position of the car along the track as a function of time starting at $t = 0$? Set the position of the car to 0 at $t = 0$.

d) If the numerical values of A and B are 80 and 6, respectively (with the units you found for each of them above), then how far does the car get after 2 seconds?

3) (20 points) Two blocks on a Ramp

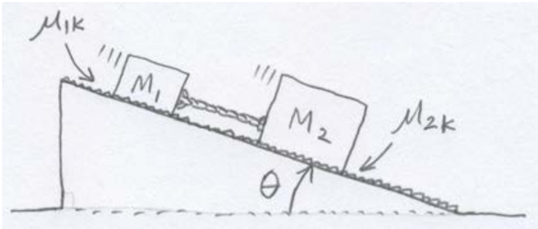
Two blocks with masses M_1 and $M_2 = 2M_1$ are sliding down a ramp with the first block higher up the ramp, as shown in the diagram. The two blocks are tied together with an ideal (massless and non-stretchy) rope.

a) If the coefficient of kinetic friction between the first block and the ramp is μ_{1k}, then what is the *direction* and *magnitude* of the force of friction acting on the first block? As always, show your work or justify your answer.

b) If the rope has non-zero tension, then what is the *upper limit* for the coefficient of kinetic friction μ_{2k} between the second block and the ramp?

c) Assuming that $\mu_{2k} = \mu_{1k}/2$, what is the *magnitude* and *direction* of the acceleration of the first block?

d) In this case, what is the tension in the rope?



4) (20 points) Sliding in a funnel

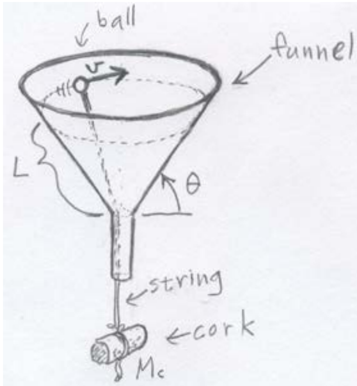
A small steel ball is sliding without friction in a horizontal circular path at constant speed v inside a stationary funnel, as shown in the diagram. An ideal (massless & non-stretchy) string connected to the ball hangs from the ball down L of the slope of the funnel and passes through the hole at the bottom, so that it supports a cork of mass M_c. The sides of the funnel form an angle of θ to the horizontal, as shown in the diagram.

a) Draw and clearly label a free body diagram of the ball by itself AND make a second free body diagram of the hanging cork by itself.

b) What is the tension T in the string? As always, show your work or justify your answer.

c) What is the magnitude of the ball's acceleration? Express your answer in terms of v, L, and θ.

d) What is the mass M_b of the ball?



5) (20 points) Sliding blocks with no friction

Two blocks are stacked on top of an incline as shown in the diagram. The uppermost block is cube shaped and it has mass M_1, whereas the block below it has mass M_2 and is wedge shaped with the same angle θ as the incline. You may assume that there is *no friction* in any part of this problem.

a) Make two separate free body diagrams, one for each of the blocks.

b) Given that the lower block is constrained to move along the slope, derive a formula for the vertical acceleration of the lower block as a function of its horizontal acceleration. Define your axes clearly and take care with signs.

c) What is the magnitude of the vertical component of the acceleration of the upper block? As always, show your work or justify your answer.

d) What is the magnitude of the horizontal component of the acceleration of the upper block?