UC Berkeley, Physics 7A, Fall 2016, Reinsch
First Midterm Exam

You are allowed two sides of a sheet of 8.5” x 11” paper containing hand-written notes. Calculators are not allowed.

Please make sure that you do the following:

- *Write your name, discussion number, ID number on your bluebook/greenbook.*
- *Make sure that the grader knows what should be graded by circling your final answer.*
- *You must explain how you arrived at your answers.*

Problem 1

An airplane is flying along a straight line path which we call the x axis, and we will study one-dimensional motion along this axis. At time $t = 0$, the velocity of the airplane is v_0. From $t = 0$ to $t = t_1$ the airplane accelerates in the positive x direction with constant acceleration a_0. From $t = t_1$ to $t = t_2$ the airplane accelerates in the positive x direction with constant acceleration $2a_0$. All parameters above are positive, and $t_2 > t_1$.

(a) Calculate the instantaneous velocity at $t = t_2$.

(b) Calculate the distance traveled from $t = 0$ to $t = t_2$.

(c) A person walks from the back of the airplane to the front, starting at the back at $t = 0$. The distance between the person and the back of the plane is $D = b\,t^3$, where b is a positive constant. Calculate the instantaneous velocity of the person relative to the ground at $t = t_1$.

(d) Calculate the instantaneous acceleration of the person relative to the ground at $t = t_1/2$.

Problem 2

In this problem we use an x axis that is horizontal and a y axis that points vertically upwards. At time $t = 0$, a baseball player hits a baseball at the location $x = 0, y = h$, where h is a positive constant. The initial velocity vector is (v_{x0}, v_{y0}). Both v_{x0} and v_{y0} are positive values. The baseball player is a super-athlete and is able to run so fast that she can catch the baseball that she originally hit at $t = 0$. She does this by running along the x axis with constant acceleration a, starting from the origin with zero velocity. When she catches the baseball, its y coordinate is $2h$ and its velocity component in the y direction is negative.

(a) Write out the x and y coordinates of the baseball as functions of time.

(b) Calculate the value of the time t when the baseball player catches the baseball. What assumption must be made about v_{y0} so that this t value is real?

(c) Calculate the value of the acceleration a of the baseball player.

Problem 3

This problem deals with the standard topic of a box of mass m sliding down an incline. You must explain all of your results even if you have the formulas on your formula sheet. The incline makes an angle θ with the horizontal. The coefficient of kinetic friction is μ_k.

(a) Draw a free-body diagram for the box, labeling all of the forces. Assume the downhill direction is to the lower right.

(b) For this part of the problem we will use an xy coordinate system with the x axis horizontal and pointing to the right, and the y axis pointing vertically upwards. Calculate the x and y components of all of the vectors you drew in part (a) and of the acceleration vector.

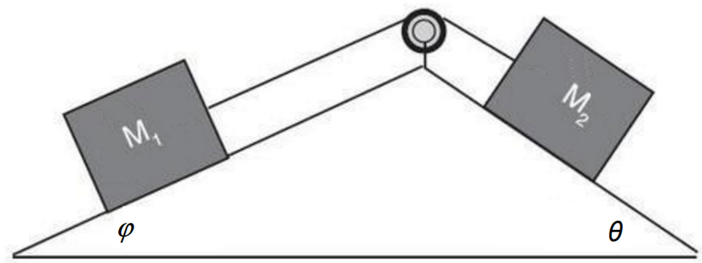
(c) For this part of the problem we will use a different coordinate system, with axes called x' and y'. The x' axis is parallel to the surface of the slope and pointing down the slope, and the y' axis perpendicular to the slope and pointing to the upper right. Calculate the x' and y' components of all of the vectors you drew in part (a) and of the acceleration vector.

Problem 4

There are two blocks on sloping surfaces as shown in the diagram. The string and pulley are massless. The ramps do not move. The coefficient of kinetic friction between M_1 and the surface it is on is μ_k. The corresponding frictional coefficient for M_2 is zero. We assume that the blocks are moving to the right (with M_1 going up its ramp, and M_2 going down its ramp). In general the speeds will not be constant.

(a) Draw free-body diagrams for both masses.

(b) Calculate the tension in the string.



Problem 5

As an astronaut you are very busy but you do find time to build the apparatus shown in the picture below. This is in a zero-g environment. There is a cylinder that rotates about a fixed vertical axis as shown by the curved arrow. A very small sphere of mass m is attached to the cylinder using two pieces of massless string, both of length L. The points where the strings attach to the cylinder are separated by a distance L, so we have an equilateral triangle. We assume the radii of the sphere and cylinder are negligibly small compared to L. The speed of the sphere is v and it is a constant, so we have uniform circular motion. If the *sin* or *cos* of an angle appears in your answers you must express it in terms of integers like 1, 2 and 3, and possibly square-roots thereof.

(a) Draw a free-body diagram for the sphere and calculate the tension in the strings.

(b) If you take this device back to Earth and show it to your friends, what will be the minimal value for v so that the lower string does not go slack (meaning the tension goes to zero)? Explain in detail even if you have relevant formulas on your formula sheet. For this part of the problem and the next two, we have the familiar acceleration g at the surface of the Earth.

(c) Repeat part (b) assuming the axis of rotation is horizontal.

In this case, we calculate the minimal value for v such that neither string goes slack when the sphere is at the highest point.

(d) Continuing with the configuration of part (c), if the value of v is twice the value you computed in part (c) what is the tension in each string when the sphere is at the highest point?