UC Berkeley, Physics 7A, Summer 2015 (Reinsch)
Second Midterm Exam

This midterm is closed book and closed notes. 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 he should grade by circling your final answer.*
- ***You must explain how you arrived at your answers***.

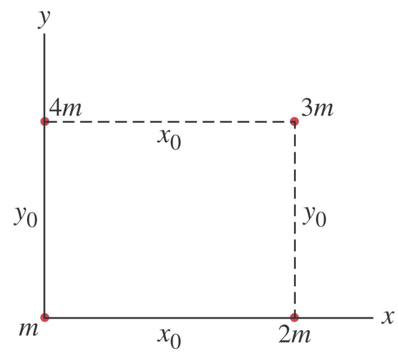
Problem 1

[20 points]

Four masses are arranged as shown in the figure at right.

(a) Calculate the x and y components of the gravitational force on the mass m at the origin.

(b) Calculate the x and y components of the gravitational field at the center of the rectangle, that is, at the location $x = x_0 / 2$, $y = y_0 / 2$.

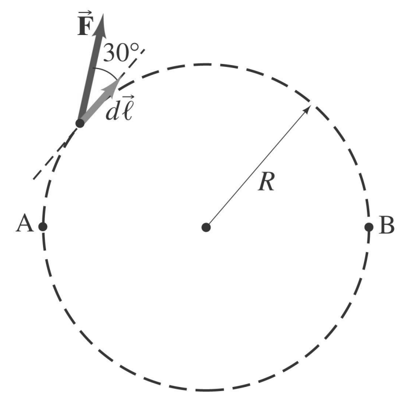


Problem 2

[20 points]

An object, moving along the circumference of a circle with radius R, is acted upon by a force of magnitude F. At all times, the direction of the force is at a 30 degree angle with respect to the tangent to the circle, as shown in the figure at right. The sine and cosine of 30 degrees are ½ and (√3)/2, respectively.

(a) Assuming the magnitude F is constant, calculate the work done by the force when the object moves along the semicircle from A to B. You must show how to set up the integral.



(b) Now repeat the calculation, assuming that the magnitude F increases linearly with the distance traveled (that is, F is equal to a constant times the distance traveled), starting with $F = 0$ at point A and reaching a maximal value of $F = F_0$ at point B.

Problem 3

[20 points]

Two cars are driving on a large horizontal surface even though it is very foggy and the drivers cannot see anything. One car has mass m_1 and is heading due North with speed v_1. The other car has mass m_2 and is heading North-East with speed v_2. The cars collide and stick together (without rotation). We define an x axis pointing to the East, and a y axis pointing North.

(a) What are the x and y components of the velocity vector after the collision?

(b) How much of the total kinetic energy was lost in the collision?

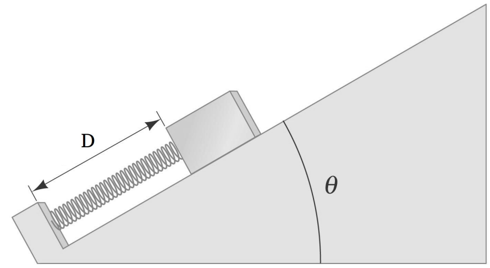
(c) What are the x and y components of the change in the momentum vector of car number 1?

(d) What is the change in the kinetic energy of car number 1? Is it possible for this to be positive?

Problem 4

[20 points]

A massless spring has an unstretched length of D_0 (this is the length of the spring when it is removed from the apparatus). The spring is compressed to a length D and a mass m is placed at its free end on a frictionless slope as shown in the figure at right. The spring is then released.



(a) How large must the spring constant k be so that the mass travels at least a distance $D_0 - D$ up the ramp? Express your answer for this k_{min} in terms g (the familiar magnitude of the acceleration due to the Earth's gravitational field) and the other variables given above. For the rest of this problem we will assume that k is larger than this value.

(b) What is the maximum speed achieved by the mass?

(c) How far has the mass traveled at the instant it reaches its maximum speed?

(d) If the mass is not attached to the spring, how far up the slope will the mass travel? We measure this distance relative to the starting location of the mass.

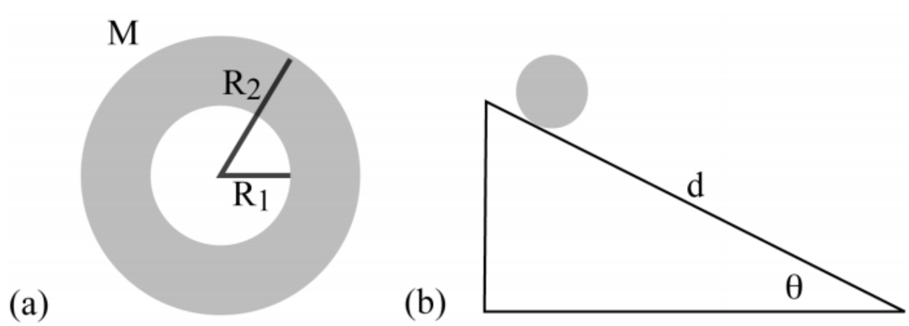
(e) Repeat part (d) assuming the mass *is* attached to the end of the spring, so the spring can pull back on the mass when the spring is longer than D_0.

Problem 5

[20 points]

As stated on the cover sheet, you must explain how you got your answers. For example, in part (a) below, you must set up an integral and solve it (you don't need to prove the hint).

You are handed a ball of mass M, and radius R_2, and you would like to determine whether the ball is solid or partly hollow. Start by assuming that the ball has a hollow cavity of radius R_1:



(a) Calculate the moment of inertia of this hollow ball, as a function of R_1 and R_2. [Hint: the moment of inertia of a thin spherical shell of mass m, radius r, is $2mr^2/3$.]

(b) One way to measure the moment of inertia of the ball, and hence determine if it is solid or partly hollow, is to measure the amount of time it takes to roll without slipping down an inclined plane length d, incline θ. Calculate this time as a function of moment of inertia, I. [Please solve this in terms of the symbol I, i.e., do not plug in the whole expression for I solved in part (a).]

(c) Will the ball take longer to roll down the incline if it is solid or partly hollow?