Physics 7A Section 1
Fall Semester 2003
Second Midterm
November 12, 2003 (6:10-7:40 pm)

Instructions

1. This is a **closed book** exam. You are allowed to bring along only 1 8.5”x11” “cheat sheet”, pens, pencils, scientific calculator, and blue books.
2. **Read all questions carefully.** Attempt the easiest ones first.
3. **Write your name, Discussion Section #, GSI name and SID#** on the top of all materials you intend to hand in and want to be graded.
4. While cleanliness and legibility of your hand-writing will not get your extra credit, they will help to make sure that your answers get the credit they deserve. In case you make mistakes be sure to cross them out so they will not be mistaken as your answer. It helps to put a box or circle around your final answers.
5. **Partial credit**: You will not *get credit automatically* for writing down an equation. You will get at least 90% of the total credit if you can show how the equation(s) can be used to solve the problem. Try to express your question in terms of symbols you are given in the question. When you substitute numbers into these symbols to obtain a numerical answer, make sure that you specify also the units. A pure numerical answer without calculation to support it will get no credit.

You are provided with the following constants for your reference. There is no guarantee that they will all be required in solving the problems.

Useful Constant:

Earth’s acceleration: $g=9.80\ m/s^2$.
Gravitational Constant $G=6.67\times10^{-11}\ Nm^2/Kg^2$.
Mass of Earth=6×10^{24} Kg; Radius of Earth=6.4×10^{3} Km

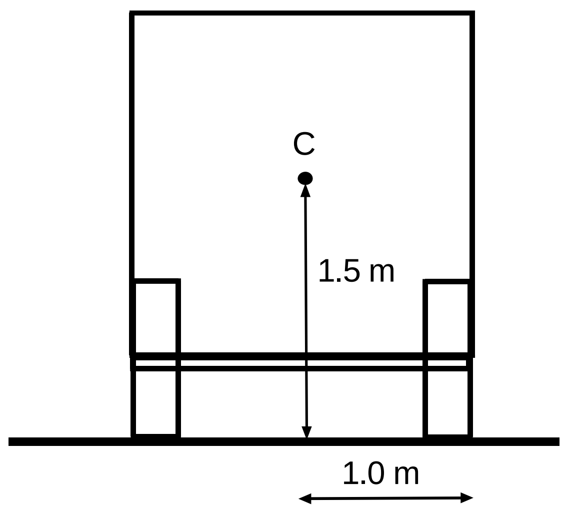
Question 1 (25 Points)

A car accelerates with a *constant* acceleration on a *circular* race track of radius equal to 0.7 Km. The car starts from rest at t=0 second and reaches a speed of 120 Km/hr at t=8 seconds.

(a) What are the centripetal and tangential accelerations of the car at t=10 seconds?

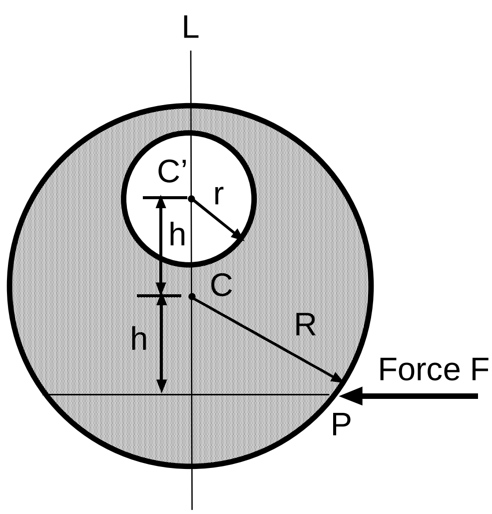
(b) The coefficient of static friction between the car's tire and the track is 0.3. The mass of the car is 2300 Kg. What is the maximum speed of the car before the car will skid on this race track?

(c) The location of the center of mass C of the car relative to its tires is shown in the figure below. What is the maximum speed of the car before it will *roll over* on this race track?



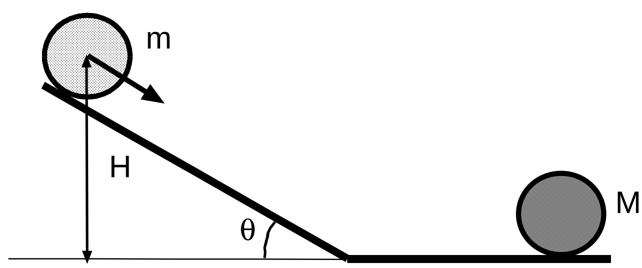
Question 2 (25 Points)

A uniform circular disk of radius R and thickness T has a circular hole (of radius r and center at C') punched out from it as shown in the figure below. The disk is made from a material of density ρ and is suspended from a *frictionless* hinge located at its center C. The distance between C' and C is h.



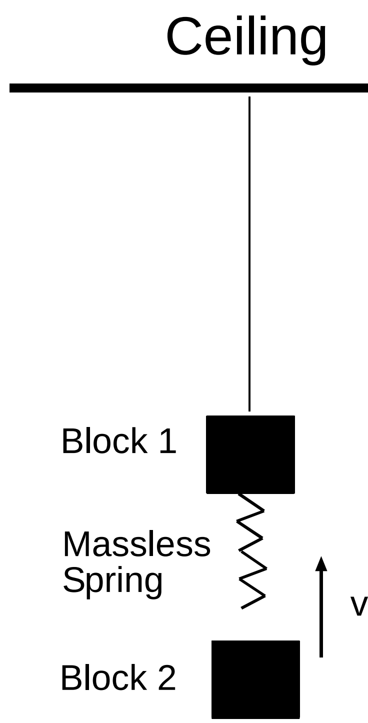
(a) Where is the center of mass of this disk? Give its location in terms of its distance from the line L joining C and C' and from the point C.
(b) What is the moment of inertia of the disk when it rotates about an axis perpendicular to it and passing through the hinge at C?
(c) The disk is originally at rest. It is then struck at the point P shown in the figure by a force F which lasts for a short duration δt. What is the angular velocity ω of the disk immediately afterwards?

Question 3 (25 Points)
(a) A *solid rigid disk* has radius R, thickness T and mass m. It is released at rest from a height H (>>R) on the top of a *slope* which is inclined at an angle of θ to the ground (see figure below). The disk rolls *without slipping* in a vertical plane down the slope
(a) What is the velocity V_1 of the disk at the bottom of the slope?
(b) As the disk rolls further (still without slipping) along the horizontal ground it collides *elastically* with a *stationary solid rigid sphere* of radius R and mass M. The collision occurs with the centers of the disk and the sphere both lying inside the same vertical plane defined by the rolling disk. You can assume that the friction of the ground is large enough that *both during and after collision* the disk and the sphere roll on the ground *without slipping*. What are the velocities V_1' and V_2 of m and M, respectively, after their collision?



Question 4 (25 Points)
An astronaut has a mass of 80 Kg on the surface of the earth. This astronaut blasts off *vertically* from earth in a rocket with the escape velocity. Assume that the rocket reaches the escape velocity almost instantaneously and for the rest of the journey the rocket is no longer accelerating the astronaut. As the rocket escapes from the earth's gravitational field the *apparent weight (ie the gravitation pull)* of the astronaut gradually decreases to zero. Determine
(a) the apparent weight of the astronaut as a function of distance from surface of earth.
(b) what is the *rate* of decrease of the astronaut's apparent weight when the rocket is at a distance equal to earth's radius R_E from the surface of earth .

Question 5 (25 Points)
A cubic block (Block 1) of mass m is suspended by a *massless* string from the ceiling. At the bottom of Block 1 is a *massless* and *dissipationless* spring with spring constant k. Block 1 is then hit by another cubic block (Block 2) also of mass m but traveling upwards as shown in the figure below.



(a) Suppose the velocity of Block 2 is V_o just before it strikes the spring attached to Block 1. What is the velocity of the center of mass (CM) of the two blocks before collision?
(b) How high will the CM rise after collision before it comes to rest?
(c) What is the maximum compression of the spring? (*Hint*: suppose you are traveling with the CM of the two blocks, what will you see? What will happen to the two blocks as they compress the spring?)

--------------------END OF QUESTIONS---------------------