Physics 7A, Section 1 (Prof. Speliotopoulos)
Final Exam, Fall 2008
Berkeley, CA

Rules: *This final exam is closed book and closed notes. You are allowed two sides of one-half sheet of 8.5" x 11" of paper on which you can write whatever notes you wish for the exam. You are also allowed to use scientific calculators in general, but not ones that can communicate with other calculators through any means.* ***Anyone who does use a wireless-capable calculator will automatically receive a zero for this exam.*** *Cell phones must be turned off during the exam, and placed in your backpacks.* ***In particular, cell-phone-based calculators cannot be used.***

Please make sure that you do the following during the exam:

- *Write your name, discussion number, and ID number on all documents you hand in.*
- *Make sure that the grader knows what s/he should grade by circling your final answer.*
- *Answer all questions that require a numerical answer to three significant figures.*

We will give partial credit on this exam*, so if you are not altogether sure how to do a problem, or if you do not have time to complete a problem, be sure to write down as much information as you can on it. This includes any or all of the following: Drawing a clear diagram of the problem, telling us how you would do the problem if you had the time, telling us why you believe (in terms of physics) the answer you got to a problem is incorrect, and telling us how you would mathematically solve an equation or set of equations once the physics is given and the equations have been derived. Don't get too bogged down in the mathematics; we are looking to see how much physics you know, not how well you can solve math problems.*

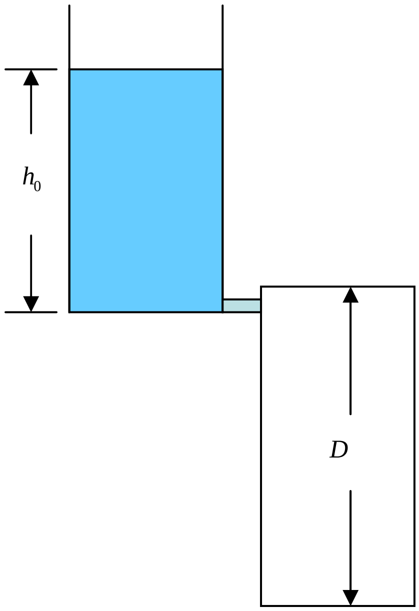
If at any point in the exam you have any problems, just raise your hand, and we will see if we are able to answer it.

Please be sure to write the following information on the front of your bluebook, and remember to sign your name! There are six questions, and the point total for the exam is 120 pts.

Name: ________________________________ *Disc Sec Number:* ________________________

Signature: _____________________________ *Disc Sec GSI:* ____________________________

Student ID Number: _____________________



1. A container, open to the atmosphere, is filled with water to a height, h_0. It is connected to a second, *closed* container through a small spigot (see figure). The spigot is opened, and the water (which has density, ρ) starts to flow from one container to the other. Some time later, the water stops flowing, and there is water remaining in the first container even though the total height, *D*, of the second container is greater than h_0. What is the height of the water left in the first container? Remember that the pressure of a gas is proportional to its density, $P_{gas} \propto \rho_{gas}$, and you may assume that none of the gas in the second container escapes. The cross-sectional areas of the two container are the same, and the initial pressure in the second container is atmospheric pressure, P_0. (Do *not* use $B = -\Delta p / (\Delta V / V)$ since the amount by which the volume of air in the second container changes could be quite large.) (20 pts)

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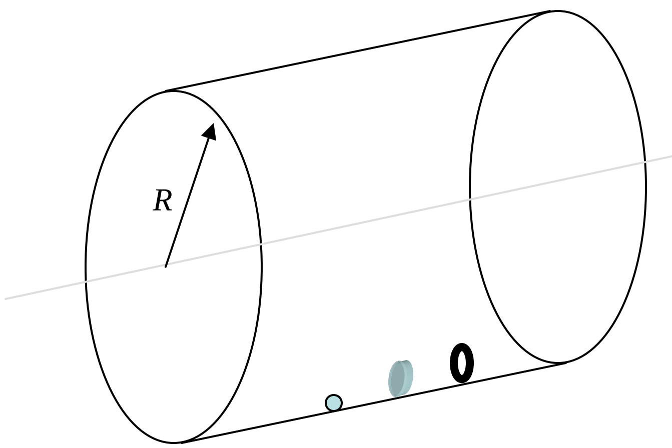
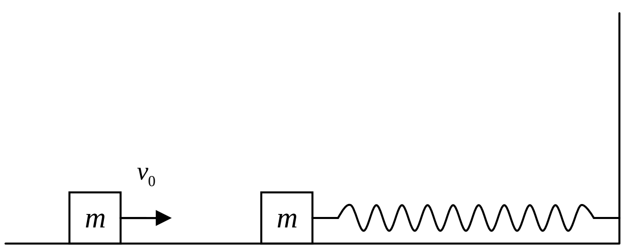
2. A large drum with radius, *R*, lies sideways so that the axis of the drum is parallel to the ground. On the bottom of the drum is a solid cylinder, a thin hoop, and a solid sphere (see figure). They are rolling without slipping, and they have the same center of mass velocity v_{cm} at this point. What is the maximum v_{cm} so that only one of the three objects is able race completely around the inside of the drum without falling off? What is the minimum v_{cm} so that all three are able to race completely around the inside of the drum? The radii of all three objects are much smaller than *R*, and they each can have different masses. (20 pts)





3. A block with mass, *m*, is resting on a table, and is connected to a spring with spring constant, *k*, (see figure). A second block with the same mass, *m*, and an initial velocity, v_0, is slid towards the first block, and collides with it. (20 pts)

a. The collision is totally inelastic, and the two blocks stick together after the collision. What is the position, $x(t)$, of the two blocks after the collision? Take $t = 0$ when the two blocks collide with each other.

b. A third block with the same mass, *m*, and the same initial velocity, v_0, is slid towards the two oscillating blocks. The third block collides with the two other blocks at a time, T_C, after the first collision. This collision is also totally inelastic. What must T_C be so that immediately after the collision the blocks are at rest? What is the position, $x(t)$, of the three blocks after this collision?

c. What must T_C be so that immediately after the collision the blocks have the maximum possible velocity? What is the position, $x(t)$, of the three blocks after the collision in this case?

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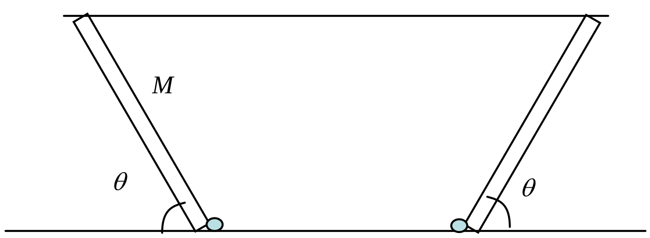
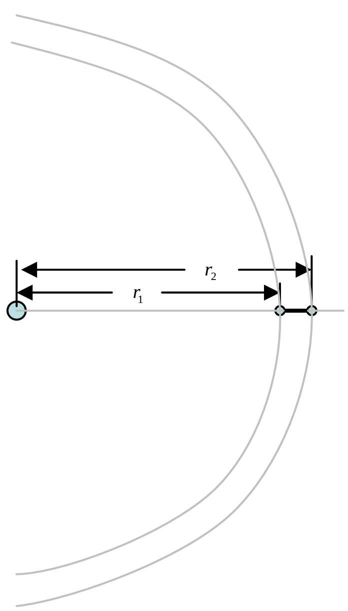
4. The sculpture below was placed in a local park. It consists of two beams connected to the ground by hinges. A cable, parallel to the ground, connects the two. The mass of each beam is *M*, and they each have length, *l*. (20 pts)

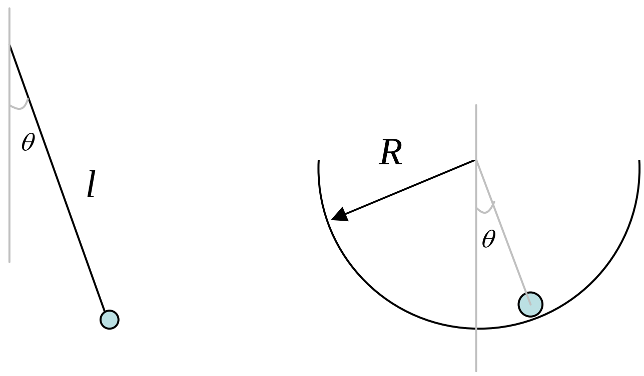


a. What is the forces (magnitude and direction) on the two hinges? In this part of the problem, you may assume that the cable has negligible mass.

b. As the wind blows through the sculpture, standing waves will be excited in the section of the cable between the two beams. What is the lowest frequency of standing wave that can be excited if the length of the cable is *L*? In this part of the problem, take the linear mass density of the cable to be μ. You may, however, still assume that the cable is light enough that its mass will not contribute significantly to the tension on the cable.



5. Two satellites, each with the same mass, *m*, are in circular orbits about a neutron star. The radius of the first satellite's orbit is r_1, and the radius of the second satellite's orbit is r_2 (see figure). The two satellites are aligned along the same radial line from the center of the star, and they are tethered together by a cable. What is the tension on the cable as the satellites orbit the star? Express it in terms of $l = r_2 - r_1$ and $r = (r_1 + r_2)/2$. You may assume that $l << r$, that Newton's Universal Law of Gravitation still holds, and that you can neglect changes in r_1 and r_2. Thus, the two satellites remain aligned along the radial line as they orbit the star. (Hint: Look at the center of mass motion of the satellites, and remember that $(1+x)^p \approx 1 + px$, when x << 1). (20 pts)



6. A ball with radius, *r*, and mass, *m*, is place within a bowl of radius *R*. There is a coefficient of static friction, μ_s, between the ball and the bowl (see figure). Although this μ_s is small, as long as the ball is not released too high up in the bowl (at not too large of a θ), the ball will roll without slipping, and it will undergo simple harmonic motion. (20 pts)

   a. What must *l* be so that the period of oscillation of the ball is the same as that of the simple pendulum shown in the left of the figure?
   b. What is the maximum θ_0 such that the ball *will* start slipping? You may assume that $\theta_0 << 1$, and that the ball undergoes simple harmonic motion up to this angle.