

Physics 7A, Section 3 (Speliotopoulos)
Final Exam, Spring 2011
Berkeley, CA

Rules: *This final exam is closed book and closed notes. You are allowed three sides of two sheets of 8.5" x 11" of paper on which you may write whatever you wish. You are also allowed to use scientific calculators in general, but not ones which can communicate with other calculators through any means, or ones that can do symbolic integration. **Anyone who does use a wireless-capable device will automatically receive a zero for this final.** 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 final:

- Write your name, discussion number, ID number on all documents you hand in.
- Make sure that the grader knows what s/he should grade by circling your final answer.
- Cross out any parts of the your solutions that you do not want the grader to grade.

Each problem is worth 20 points. We will give partial credit on this final, 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 the problem. 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.

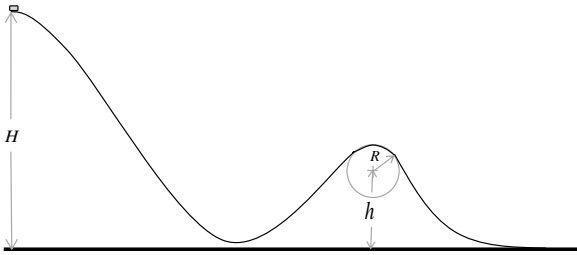
If at any point in the exam you have any questions, just raise your hand, and we will see if we are able to answer them.

Copy and fill in the following information on the front of your bluebook:

Name: _____ Disc Sec Number: _____

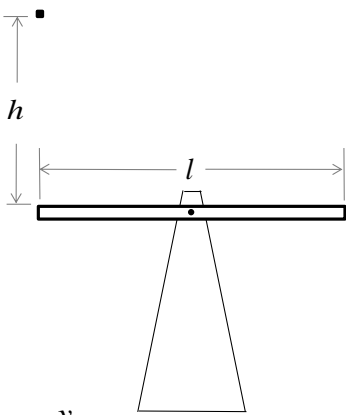
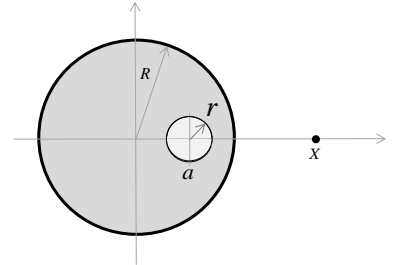
Signature: _____ Disc Sec GSI: _____

Student ID Number: _____



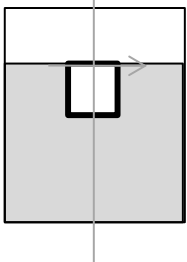
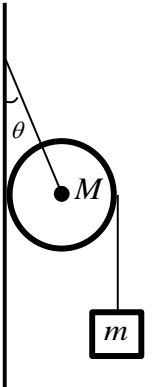
1. The C.R.Z.Y. amusement park designed a new roller coaster (see figure to left). Instead of having the car go around a loop, they have the car go over a circular hump with radius, R , and the center of this circle is at a height, h , above the ground. If the car starts from rest, what is the highest that H can be if the car is to go over the hump without flying off the track? Treat the car as a block, and neglect friction.

2. A uniform sphere has mass, M , and radius, R . A spherical mass of material with radius, r , centered a distance, a , from the center of the original sphere is removed (see figure to the right). Find the gravitational force on a small mass, m , at a distance, X , from the center of the sphere.



3. A horizontal rod with mass, M , and length, l , can rotate without friction about its center. A block with mass, m , and negligible size is dropped from a distance, $h > l/2$, above the rod (see figure to left). If the block sticks to the rod after colliding with it, what is the smallest that m can be if the rod + block is to rotate completely around its pivot point?

4. A disk with mass, M , and radius, R , is connected to a wall by a string that connects to a post through its center (see figure to the right). The string makes an angle, θ , with the wall. A block with mass, m , hangs from the disk by a second string wrapped around disk. Given the coefficient of static friction between the wall, μ_s , along with M , R , and θ , what is the maximum that m can be if the disk does not rotate? Above a specific μ_s the disk will not rotate irrespective the value of m . What is this μ_s in terms of θ ?

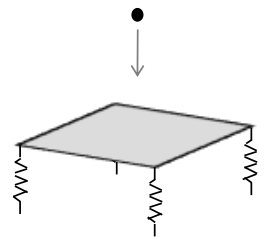


5. A cube with side, s , is placed in a container with a slightly compressible fluid whose density increases with depth,

$$\rho(y) = \frac{\rho_0}{1 + \frac{y}{\lambda}},$$

where y is a coordinate relative to an origin at the surface of the fluid; λ is larger than the height of the container (see figure to left). If the cube floats just submerged in the fluid, what is the mass, M , of the cube?

6. Four identical springs with spring constants, k , are attached to the bottom of a square plate with mass, M . A small piece of gum with mass, m , is dropped from a height onto the center of the plate, and sticks to it. The plate+gum starts oscillating along the vertical direction. What is the angular frequency of oscillations of the system? You may assume that the plate stays level while it oscillates, and does not rotate about its center.



7. A thin belt with, $M=0.25 \text{ kg}$, length, $L=2.0 \text{ m}$, and tension, $F_T = 20 \text{ N}$, is anchored between two walls. A speck of dust with mass, $m \ll M$, lies on top of the belt halfway between the two walls. Standing waves with $D(x,t) = A \sin(k_n x) \cos(\omega_n t)$ for a harmonic, n , can be excited in the belt; the coordinate, x , is measured from one wall. For $A=0.010 \text{ m}$, it is found that at standing wave frequencies below a harmonic, N , the speck of dust remains on the string, but for standing wave frequencies equal to or above, N , the speck flies off the string. What is N ?