Physics 7A, Section 1 (Speliotopoulos)
Final Exam, Fall 2010
Berkeley, CA

Rules: *This final is closed book and closed notes. You are allowed three one-half sheets of 8.5" x 11" paper on which you may write out formulas and basic facts on both sides. You may not write out solutions to homework problems or specific examples on your sheets. You are also allowed to use scientific calculators in general, but not ones which can communicate with other calculators through any means.* ***Anyone who does use a wireless-capable device will automatically receive a zero for this final 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 midterm:

- *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.*

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

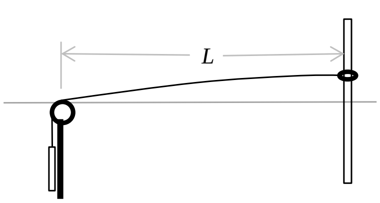
If at any point during the exam you have any questions, just raise your hand, and we will see if we are able to answer them.

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

Name: ________________________________ *Disc Sec Number:* ________________________

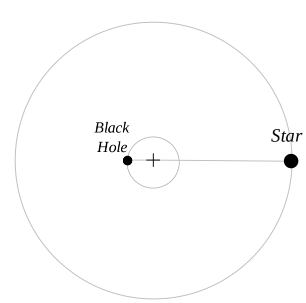
Signature: _____________________________ *Disc Sec GSI:* ____________________________

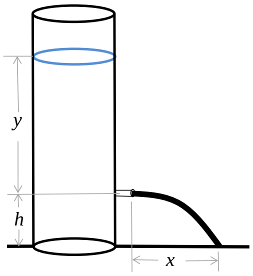
Student ID Number: _____________________



1. The figure to the left shows a string with length, L, connected on one side to a ring that is threaded through a frictionless rod, and on the other side a block with mass, M, that is hanging off a frictionless post. The string and the block have the same mass. If the string oscillates vertically, what are the frequencies, f_n, of the standing waves formed? Express f_n in terms of g, L, and an integer, $n \geq 0$. Assume that the amplitude of the wave is small so that the block does not move vertically.

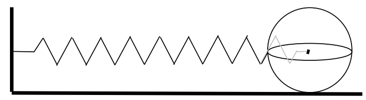
2. The figure on the right shows a star with mass, $M = 0.67\ M_{\odot}$ ($M_{\odot} = 1.99\ \times 10^{30}\ kg$ is the mass of the Sun), and a black hole with mass, $M_{BH} = 3.8\ M_{\odot}$, that are rotating about their center of mass. There are no other bodies near these stars whose effects you have to consider. The orbital speed of the star is $v_s = 440\ km/s$, and the gravitational constant is $G = 6.674 \times 10^{-11}\ m^3/kg \cdot s^2$. Assume that the orbits of both the star and the black hole are circles. Find the orbital period, T, of the star, the orbital speed of the black hole, v_{BH}, and the total angular momentum, L, of the system.



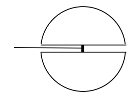


3. The figure on the left shows a container—opened on top—with a cross-sectional area, A_C, containing a fluid filled to a height, y, above a spigot. This spigot is located at height, h, above a table, and has a cross-sectional area, A_S. Do not assume that $A_C \gg A_S$. The spigot is opened, and water from the container that shoots out of the spigot lands on the table at a point, x, from the container. As the level of the water, y, decreases, the point where the stream of water lands on the table, x, decreases as well. What is v, the rate at which x decreases with time?

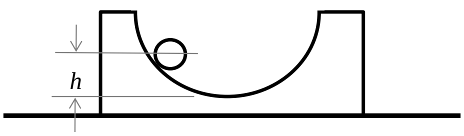
4. In the figure on the right, a sphere of mass, $M = 2\ kg$ is attached to a spring with constant, $k = 100\ N/m$. There is a small slot cut into the middle of the sphere, and the spring is attached to a rod at its center; the sphere is free to rotate without friction about this rod. The spring is stretched a certain distance and released. What is the maximum possible speed of the sphere if during its motion the sphere must always roll without slipping? Take the coefficient of static friction, μ_s, between the table and the sphere to be 0.80, and the rotational inertial of the sphere to be that of a solid sphere.



Side view

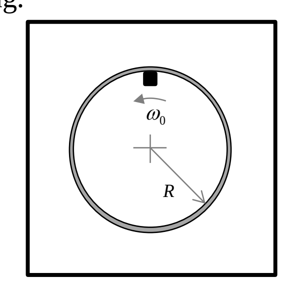


Top view

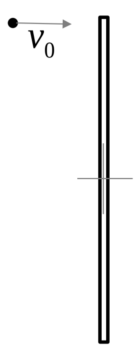


5. Figure A on the left shows a sphere with mass, m, and radius, r, on a block with mass, M. This block is resting on a table, and has a hemisphere with radius, R, cut out of it. While the table is frictionless, the inside of the hemisphere is not. The sphere and block are both initially at rest, and the sphere is placed at a height, h, on the block. The sphere is then released. What is the speed, v, of the disk, and the speed, U, of the block when the disk reaches the bottom of the cut-out hemisphere? Assume that the sphere rolls without slipping.

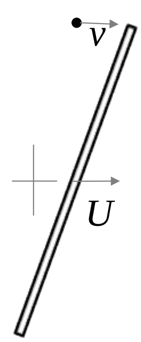
6. The figure on the right shows a hoop of radius, R, fixed onto the top of a table. Inside the hoop is placed a small block with negligible size. There is the same coefficient of kinetic friction, μ_k, between the block, and both the table and the inside surface of the hoop. The block has an initial angular velocity, $\omega_0 = \sqrt{g/R}$. Find $\omega(t)$, the angular velocity at any subsequent time, t, and the total time, T, that it takes for the block to stop.



7. The figure below shows a small mass, m, moving at an initial speed, v_0, colliding with a stick with length, L, and mass, M. Both the mass and the stick lie on top of a table. The collision happens at the tip of the stick. After the collision the mass continues in the same direction, but now with the speed, v. For a specific value of the ratio m/M, the stick will collide with the small mass a second time. What is this value, and how far will the small mass have traveled between collisions? Assume that the collision is elastic.



Before Collision



After Collision