Spring 2011 Physics 7A, Instructor: Yildiz

Final Exam

Rules: This exam is closed book and closed notes. You are allowed three sides of a formula sheet of 8.5" x 11" of paper. You are allowed to use scientific calculators in general, but not ones which can communicate with other calculators through any means, nor ones that can do symbolic integration. Anyone who does use a wireless device will automatically receive a zero for this midterm. Cell phones must be turned off during the exam, and placed in your backpacks.

Please make sure that you do the following during the exam: 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 your solutions that you do not want the grader to grade. We will give partial credit on this exam, so if you are not altogether sure how to do a problem be sure to write down a clear diagram of the problem with a coordinate axis, show forces acting on each object, and equations required to solve the problem.

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

Name: ________________________________

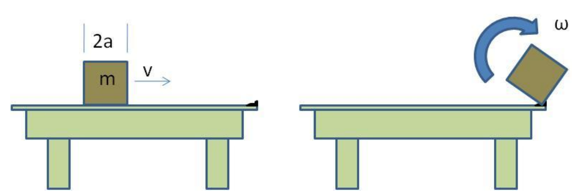
Signature: _____________________________

Student ID Number: _____________________

Disc Sec Number: ________________________

Disc Sec GSI: ____________________________

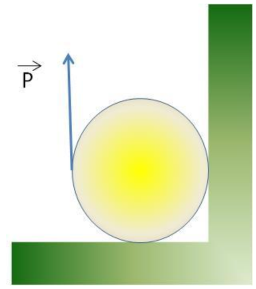
1. (20 points) A solid cube of side 2*a* and mass *m* is sliding on a frictionless table with uniform velocity ***v*** as shown in the figure (left). It hits a small object at the end of the table that causes the cube to tilt as shown in the figure (right).



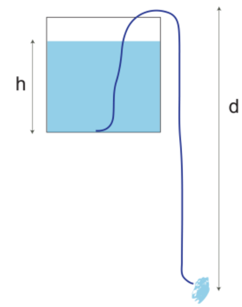
A. Find the moment of inertia of the cube about its center of mass.

B. Find the minimum value of the magnitude of ***v*** such that the cube tips over and falls off the table. (*Note 1:* The cube undergoes an inelastic collision at the edge. *Note 2*: If you are unable to derive the moment of inertia of the cube about its CM in part A, take it as I_{CM} in part B.)

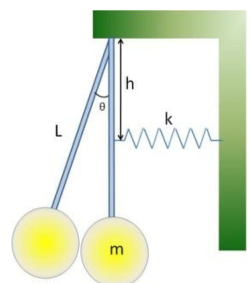
2. (15 points) Figure shows a vertical force applied tangentially to a uniform cylinder of weight F_g. The coefficient of static friction between the cylinder and all surfaces is 0.5. The force ***P*** is increased in magnitude until the cylinder begins to rotate. In terms of F_g, find the maximum force ***P*** that can be applied without causing the cylinder to rotate. (*Suggestion*: Show that both friction forces will be at their maximum values when the cylinder is on the verge of slipping.)



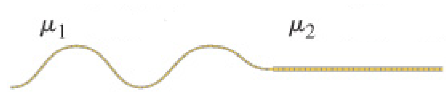
3. (15 points) A woman is draining her fish tank by siphoning the water into an outdoor drain. The rectangular tank has footprint area *A* and depth *h*. The drain is located distance *d* below the surface of the water in the tank where *d* >> *h*. The cross sectional area of the siphon tube is *A′*. Find the time interval required to empty the tank in terms of *A, A′, h* and *d*. Ignore friction of water. Do not neglect the area of the siphon tube.



4. (15 points) A pendulum of length *L* and mass *m* has a massless spring of force constant *k* connected to it at a distance *h* below its point of suspension. The spring is not stretched when the pendulum is vertical. Find the frequency of vibration of the system for small values of amplitude (small θ).



5. (25 points) A cord stretched to a tension F_t consists of two sections whose linear densities are μ_1 and μ_2. Take x = 0 to be the point (a knot) where they are joined, with μ_1 referring to the section of the cord to the left and μ_2 that to the right. The cord is set into a vibration with a frequency of *f* by an oscillator on the left which generates a sinusoidal wave $D = A\sin(k_1x-\omega_1t)$ starts at the left of the cord, traveling to right. When it reaches the knot, part of it is reflected and part is transmitted. Amplitude of the reflected wave is A_R and amplitude of the transmitted wave is A_T.



A. Find k_1 and ω_1.
B. Write down the wave equation for the reflected wave.
C. Write down the wave equation for the transmitted wave.
D. Find A_T and A_R in terms of μ_1, μ_2 and *A*.
E. Using the wave equations you have derived for the reflected and transmitted waves, show that a reflection of a traveling pulse at a <u>*fixed*</u> end is inverted and but its overall shape (e.g. wavelength, amplitude, frequency) is unchanged (*Hint.* Consider the oscillation of the string at *x*

= 0 as a function of time). How much energy is transferred to the transmitted wave during the reflection at a fixed end?

F. Similarly, show that a reflection of a traveling pulse at a *free* end is NOT inverted and its overall shape is unchanged.

G. Comment on why we do not observe reflections when the wave travels within a homogenous medium.

6. (10 points) Consider the apparatus shown in the figure, where the hanging object has mass *M*. The vibrating blade at the left maintains a constant frequency *f*. The string has length *L* and is vibrating in its second harmonic (left). The wind begins to blow to the right, applying a constant horizontal force *F* on the hanging object (right). What is the magnitude of the force wind must apply to the hanging object so that the string vibrates in its first harmonic.