Physics 8A, Lecture 2 (Speliotopoulos)
Final Exam, Fall 2015
Berkeley, CA

Rules: *This final is closed book and closed notes. You are allowed two sides of three sheets of 8.5" x 11" paper on which you can write whatever notes you wish. You are* ***not*** *allowed to use calculators of any type, and any cellular phones must remain off and in your bags for the duration of the exam.* ***Any violation of these rules constitutes an act of academic dishonesty, and will be treated as such.***

Numerical calculations: *This exam consists of six problems, and each one is worth* ***20 points****. Four of the problems ask you to calculate numbers. I have chosen the parameters in these three problems so that the answers can be expressed in terms of rational and irrational numbers. If you find that in your calculation of these problems you end up with an expression which you cannot evaluate numerically—such as one containing an irrational number—simplify the expression as much as you can and leave it.*

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 problems, just raise your hand, and we will see if we are able to answer it.

Before the exam begins, fill in the following information on your bluebook:

Name: ________________________ *Disc Sec Number:* ____________________

Signature: ______________________ *Disc Sec GSI:* ______________________

Student ID Number: _______________ *Disc Sec Time:* _____________________

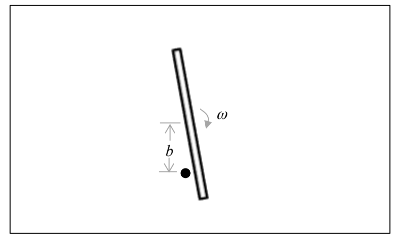
Write the following grading table on the front of your bluebook:

1	
2	
3	
4	
5	
6	
Total	

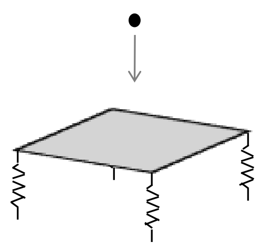
You must show your student ID when you hand in your exam!

1. One end of a rod with cross-sectional area, $A = 1.0 \times 10^{-4} m^2$, length, $L = 1.0\ m$, and thermal conductivity, $k = 0.2$ W/mK, is placed in an ice bath. The other end of the rod is held at temperature, $T = 50$ °C. Initially, there is M=1.0 kg of ice in the ice bath. How much time, t, will it take for all the ice to melt? Approximate the latent heat of fusion for ice as $L_{ice} = 300$ kJ/kg.

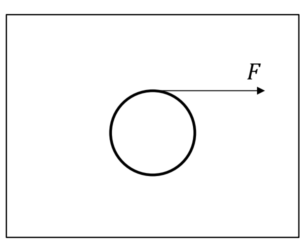
2. The figure on the right shows a rod with length, l, and mass, M, spinning on a frictionless table with angular velocity, ω. A point mass m is placed at a distance, b, from the center of the rod. After the rod collides with the point mass, the rod stops rotating. The point mass moves off with velocity u, while the rod moves off with velocity V. What is u and V? Express them in terms of any or all of the following variables: l, M, ω, m and b.
   a. What is u? Express it in terms of l, M, ω, m and b.
   b. What is V? Express it in terms of l, M, ω, m and b.



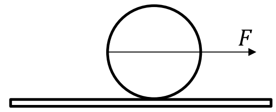
3. Four identical springs with spring constants, k, are attached to the bottom of a square plate with mass, M. A small piece of gum with mass, m, is dropped from a height, h, onto the center of the plate, and sticks to it. The plate+gum starts oscillating along the vertical direction. You may assume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



4. The figure below shows a *sphere* with mass, M and mass, R, resting on the surface of a frictionless table. A string is wrapped around the circumference of the disk, and a force, F, is applied to it. The string does not slip on the sphere.
   a. What is the acceleration, a, of the center of mass of the sphere and the angular acceleration, α, of the sphere? Express them in terms of M, R, and F.
   b. If D is the distance that the center of mass of the sphere moves, and L is the total length of string unwound while traveling the distance D, what is D/L? You should get a number independent of M, F and R.

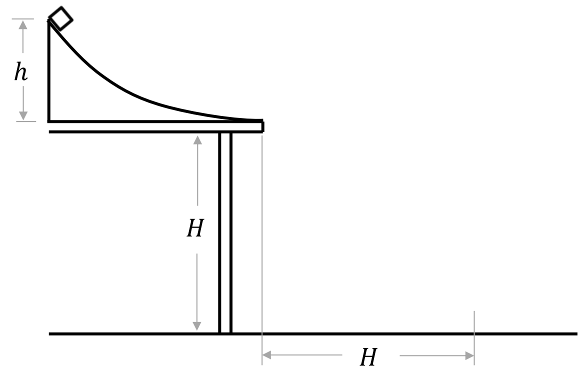


Top View



Side View

5. The figure on the right shows a block with mass $m = 1.0$ kg sliding down a ramp of height $h = 1/2$ m. It leaves the ramp with *only* a horizontal velocity, and lands a distance, $H = 1.0$ m from the edge of the table. The table has a height, $H = 1.0$ m as well.
   a. What is the velocity, v_0, at which the block leaves the ramp?
   b. What is the work done by friction? (The only non-conservative force on the block is friction.).



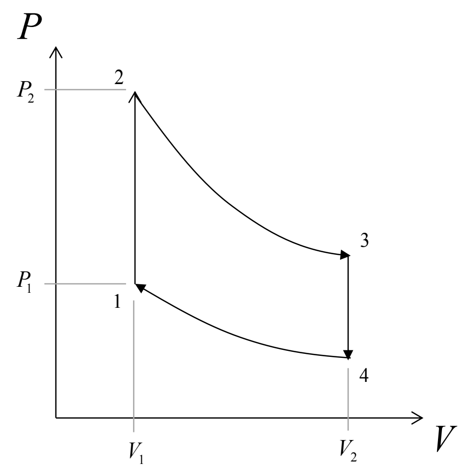
6. The cycle on the right is made up of the following thermal processes:

$$1 \rightarrow 2: \text{ Isovolumetric}$$
$$2 \rightarrow 3: \text{ Adiabatic}$$
$$3 \rightarrow 4: \text{ Isovolumetic}$$
$$4 \rightarrow 1: \text{ Adiabatic}$$

The volumes $V_1 = 10^{-4}$ m^3 while $V_3 = 10$ m^3, while $P_1 = 1$ x 10^5 Pa and $P_2 = 2$ x 10^5 Pa. *A diatomic gas is used in the cycle.*
   a. What is the work, W, done in the cycle?
   b. What is the total amount of heat, Q_h, that flows into the system?
   c. The efficiency of the cycle is defined by

$$e = \frac{W}{Q_h}.$$

   What is the efficiency of this cycle?

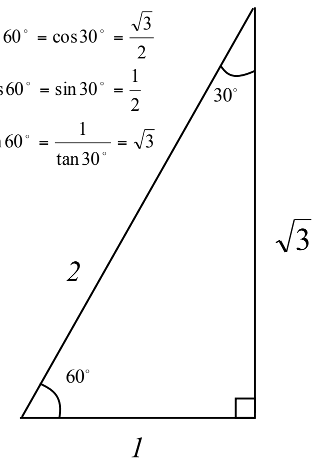


Physics 8A Math Info Sheet

$\sin 60^\circ = \cos 30^\circ = \frac{\sqrt{3}}{2}$

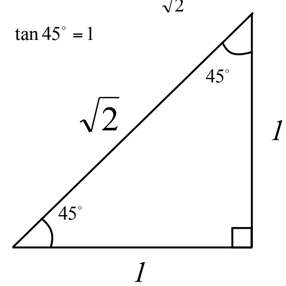
$\cos 60^\circ = \sin 30^\circ = \frac{1}{2}$

$\tan 60^\circ = \frac{1}{\tan 30^\circ} = \sqrt{3}$



$\sin 45^\circ = \cos 45^\circ = \frac{1}{\sqrt{2}}$

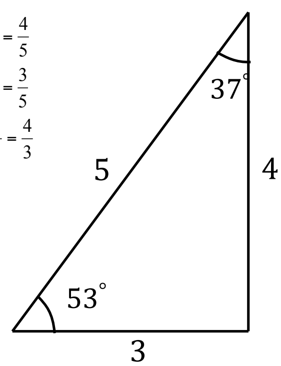
$\tan 45^\circ = 1$



$\sin 53^\circ = \cos 37^\circ = \frac{4}{5}$

$\cos 53^\circ = \sin 37^\circ = \frac{3}{5}$

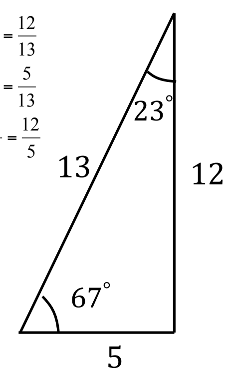
$\tan 53^\circ = \frac{1}{\tan 37^\circ} = \frac{4}{3}$



$\sin 67^\circ = \cos 23^\circ = \frac{12}{13}$

$\cos 67^\circ = \sin 23^\circ = \frac{5}{13}$

$\tan 67^\circ = \frac{1}{\tan 23^\circ} = \frac{12}{5}$



Quadratic Equations:

The solution of the quadratic equation $ax^2 + bx + c = 0$ is

$$x = \frac{1}{2a}\left(-b \pm \sqrt{b^2 - 4ac}\right)$$

Derivatives:

$$\frac{d(x^n)}{dx} = nx^{n-1}$$

Integrals:

$$\int x^n \, dx = \frac{x^{n+1}}{n}$$