Physics 8A, Lecture 1 (Speliotopoulos)
Final Exam, Fall 2016
Berkeley, CA

Rules: *This final exam is closed book and closed notes. You are allowed two sides of one and one-half 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 four problems, and each one is worth 25 points. Two of the problems ask you to calculate numbers. I have chosen the parameters in these two 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.

Name: ______________________________ *Disc Sec Number:*______________________

Signature: ___________________________ *Disc Sec GSI:*_________________________

Student ID Number: ___________________ *Disc Sec Time:*_________________________

1	
2	
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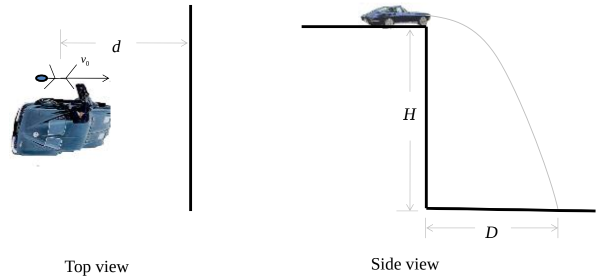
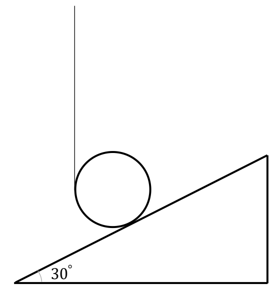
Total	

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

1. In the Star Trek reboot movie, Young Kirk drops out of a Corvette speeding at a velocity, v_0, towards a cliff (see figure to right). [He was taking his uncle's car out for a joyride, a robot cop was chasing him, and his car was heading to a cliff.] Young Kirk slides along the ground and travels a distance, $d = 5\,m$, before stopping right at the edge of the cliff. The car flies off the cliff and after falling a height, $H = 50\,m$, hits the ground, a distance, $D = 30\,m$, from the bottom of the cliff. What is the coefficient of kinetic friction, μ_k, between Young Kirk and the ground? The velocity v_0 is not known, but can be determined, and assume that the car did not slow down after Young Kirk dropped out of it. I would strongly recommend that you do not put in numbers until the very end of the calculations.



2. The figure on the right shows a string wrapped around the outside of a solid disk of radius R and mass M. The disk is on a frictionless incline. It is being pulled upward with force F.



   a. If $F < F_C$ it moves down the incline. What is this F_C?

   b. Take $F = F_C/2$. What is the acceleration a and the angular acceleration α of the disk?

c. What happens when $F > F_C$?

3. Sunlight shines on the side of a house with area A. It deposits energy on the wall at a rate of S watts per square meter. The thickness of the wall is L, and it is filled with an isolator with a conductivity k. If the inside of the house is at a temperature T_0, what is the temperature of the outside wall if the temperature inside the house and on the outside wall is in steady state and does not change with time? (An AC unit is located inside the house and is removing heat from the house at a sufficient rate so that the temperature inside the house is always at T_0.)

4. A rod with mass M and length l hangs vertically, and can pivot without friction about one end (see figures). A second mass $m = 4M/3$ has an initial velocity of v_0 collides with the midpoint of the rod and sticks to it.

   a. What is the angular velocity $\frac{d\theta}{dt}$ of the rod+mass immediately after collision?

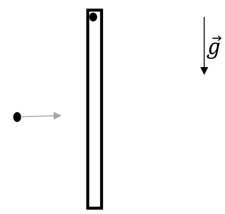


Fig. A

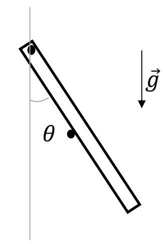


Fig. B

   b. What is the maximum angle, θ_{max}, to which the rod+mass will rise?

c. When will the rod+mass to reach $\theta = -\theta_{max}$ the *first* time?

5. Figure A on the right shows a box with volume V_0 floating on water in coldest part of the day. The *fraction* of volume of the box seen above the water at that time is f_0 (a dimensionless number). Figure B shows the same box floating on water, but now during the hottest part of the day. The *fraction* of volume of the box at that time that is seen above the water is $f = f_0 + 900\times10^{-6}$. What is the temperature difference, ΔT, between the hottest and coldest part of the day? The coefficient of volumetric expansion for the box is $\beta = 30 \times10^{-6}$, and you can neglect any expansion of the water.

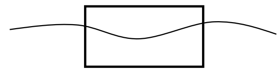


Fig. A

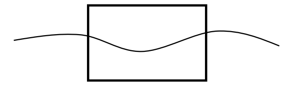
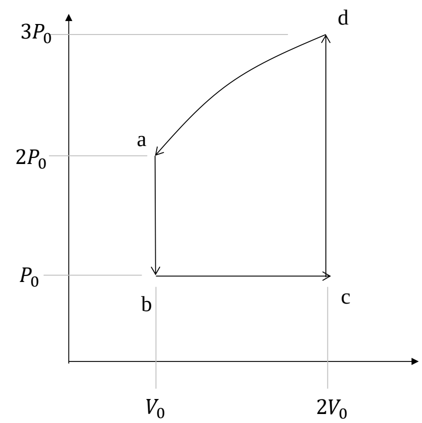


Fig. B

6. The figure on the right shows a thermodynamic cycle being used as a heat pump with a COP of $\eta = 10$. The heat pump uses a diatomic gas. The cycle is made up of three known thermal processes:

$$a \rightarrow b \quad \text{isovolumetric}$$
$$b \rightarrow c \quad \text{isobaric}$$
$$c \rightarrow d \quad \text{isovolumetric}$$



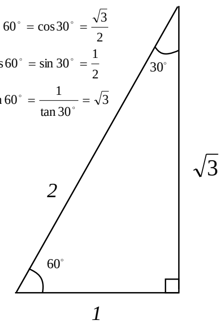
The process from $d \rightarrow a$ is not known. What is $\Delta Q_{da}/P_0V_0$ where ΔQ_{da} is the heat flow from $d \rightarrow a$? Express it in terms of P_0

Physics 8A Math Info Sheet

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

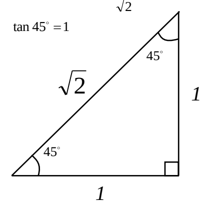
$\cos 60^\circ = \sin 30^\circ = \frac{1}{2}$

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



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

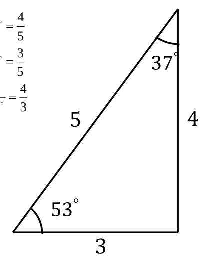
$\tan 45^\circ = 1$



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

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

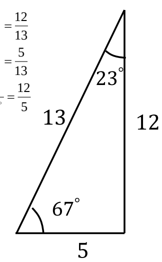
$\tan 53^\circ = \frac{1}{\tan 37^\circ} = \frac{4}{3}$



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

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

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



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:

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

Rotational Inertias: