UNIVERSITY OF COLORADO AT BOULDER **PHYS 2210**

CLASSICAL MECHANICS AND MATH METHODS, SPRING, 2011

Homework 1

(Due Date: Start of class on Thurs. Jan 13)

NOTE: Be sure to show your work and explain what you are doing. (Correct answers, for which we cannot follow the work, are worth no credit).

1. Please install Mathematica 8.0 on your computer, or find a computer you can regularly use that has it installed. See our course website for instructions on how to download your (free!) copy. (You will use it throughout the term, so please get it set up now. It's a big slow download)

2. Mass density of a star (12 pts: 4+4+4):

(a) A very simplistic model of a gaseous star might give you the mass density, ρ as a function of radius, r as

$$\rho(r) = \begin{cases} \rho_0 e^{-r/H} & r < R \\ 0 & r \geq R \end{cases} \tag{1}$$

Just looking at the expression, try to give some simple, physical interpretation of the three parameters ρ_0, H, and R. What are their units? What do they mean, or tell you, physically?

(b) Make a simple sketch of the mass density as a function of radius. (Your axes, where possible, should show how ρ_0, H, and R are involved)

(c) An even more simplistic model might instead give

$$\rho(r) = \begin{cases} c_0/r & r < R \\ 0 & r \geq R \end{cases} \tag{2}$$

In this case, can you compute the total mass of the star in terms of the two parameters c_0 and R? (If so, do it!) What are the units of c_0?

3. And now, a couple of math review questions: (12 pts: 4+4+4)

(a)

$$\int dx \frac{4x}{(x^2 + a^2)^{3/2}} \tag{3}$$

(where a is a known constant. Note: this is an indefinite integral. Can you do this without computer assistance?).

(b)

$$\frac{d}{dx} \int_1^x dy f(y) \tag{4}$$

(where f(y) is some given, known (well behaved) function of y)

(c)

$$\frac{d}{dx} \int_0^1 dy (y + x) \tag{5}$$

CONTINUED

4. Given vectors $\vec{A}$ and $\vec{B}$. ("Given" means you know the components, or alternatively, the length and angle of the vectors) (12 pts: 3+3+3+3)

(a) Define the dot product mathematically in two very different looking ways. (Hint: one way should involve the components, the other, the length/angles)

(b) Give a brief physical interpretation of what the dot product means or tells you (you can give a concrete example if you like)

(c) Define the vector cross product mathematically in two very different looking ways. (Hint: one way should involve the components, the other, the length/angles)

(d) Give a brief physical interpretation of what the cross product means or tells you (you can give a concrete example if you like)

Extra credit (up to 6 bonus points, but won't count off if you don't do it!).

Use the appropriate part of the question above (4) to figure out the angle between the diagonal of one face of a cube and the "body diagonal" of the cube. *Hint: Let your cube have side length one, with one corner at the origin. Can you write down simple expressions for the vectors that represent a face diagonal, and the body diagonal?*

5. *And lastly, a (slightly tough? You tell me!) Phys 1110 review question:* (12 pts)

You're at the airport, in a hurry to catch a plane, and the wheels on your suitcase (mass m) have completely frozen up, so they are skidding along the floor (with some small, constant coefficient of kinetic friction μ_K) Assuming you can pull (at any angle you want!) with some given, fixed arm-force $|\vec{F}_{\text{arm}}|$, at what angle from the horizontal should you pull to accelerate forward as fast as possible? After you find the angle - figure out a formula for this maximum possible forward acceleration for your suitcase. Your answers for both angle and acceleration should be in terms of *just* the given constants m, μ_K, and/or $|\vec{F}_{\text{arm}}|$ (and of course g).

(Explicitly check both your answers by considering units, and also examining the limit of $\mu_K \to 0$.)

Notes: Remember that we model kinetic friction as being simply proportional to the normal force, $|\vec{F}_{\text{arm}}| = \mu_K|\vec{N}|$. Of course in this problem you need to be careful, the normal force is NOT the weight of the suitcase - draw a free body diagram!)