Assignment I, PHYS 301 (Classical Mechanics)
Spring 2013
Due 1/10/14 at start of class

This course will be challenging, and this first homework is to ensure that you're really ready to handle the Mathematics in this course. Formally, the math Prerequisites are MATH 323 (Differential Equations) and/or "Math Methods" (a.k.a. Methods of Applied Physics). If you've mastered the content of these courses, this assignment shouldn't be too difficult.

The point of this homework is to find out where you are mathematically. If you struggle mightily with a lot of this assignment, you may wish to ask yourself if you are really ready for this course.

Although I normally encourage you to work with classmates (so long as the work you turn in is your own), *on this homework I do NOT want you to work with any of your classmates.*

IN THIS COURSE, DO NOT USE MATHEMATICA OR CALCULATORS UNLESS I SPECIFICALLY TELL YOU THAT YOU SHOULD!

This homework assignment will be graded for effort, not necessarily correctness. It is meant for you to use as a tool to figure out what things you might want to brush up on early in the semester so that you don't fall behind. Please do not use the internet or other resources to help you out with this assignment – I want to see what you remember or can reason out on your own. (Remember, I'm only grading for effort on this assignment, so don't sweat it if you can't get a couple of the problems.)

As always, what you get out of a class is really a function of how much you put into it. You could turn this homework in and use online resources and calculators to suggest you know more than you do – but then I'm going to assume that the class is better prepared than it is and probably move way too fast. Alternatively, you could just do a few problems and turn it in, but then I'll assume you've forgotten things that you really remember quite well and you'll be bored mindless – not exactly the best use of your tuition money. Therefore, it is in your best interest to put some effort into this, but to do it honestly (without using calculators, computer algebra systems like mathematica, or getting help from your fellow students).

Please put your answers on a separate sheet of paper. If you want to type them up in LaTeX, that would be awesome – but not expected.

1. List down all the mathematics classes you've taken since you graduated from High School (or equivalent). (Please list course names, not course numbers!)
2. List all the Physics courses you've taken since you graduate from High School (or equivalent). (Again, please list course names, not course numbers!)
3. Evaluate $\sin(\frac{-4\pi}{3})$.
4. Evalute $\tan^{-1}(\sqrt{3})$.
5. Evaluate $\sqrt[3]{-27}$.

6. Solve for $x : x^3 - x^2 = 2x$.

7. Find x and y so that both of these equations are satisfied:

$$8x + 4y = 16$$
$$6x - 3y = 24$$

8. Put the following ten numbers in order from smallest to largest (remember, don't look anything up!): (i) number of seconds in a year, (ii) number of molecules per cubic centimeter of air at sea level, (iii) π, (iv) density of liquid water in kg/m^3, (v) 0, (vi) the charge of an electron in Coulombs, (vii) the speed of light in a vacuum in meters/second, (viii) a lightyear in meters, (ix) kT at room temperature in electron volts, (x) $\ln(e^e)$.

9. Find $\lim_{x\to 0}\left[\frac{\sin^2 x}{x^3}\right]$.

10. Simplify: $\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{2}{x}\right)$.

11. Simplify: $\frac{\mathrm{d}}{\mathrm{d}x}\left(\frac{4x^2}{3x-5x^2}\right)$.

12. Simplify: $\frac{\partial}{\partial t}\left(3x^2t^{5/3}\right)$.

13. Integrate $\int_0^1 x\exp(-x^2)\mathrm{d}x$

14. Find the gradient of $f(x, y, z) = x^2 + y^3 + z^4$.

15. Compute $\vec{\nabla}\times\vec{V}$ if $\vec{V} \equiv y^2\hat{x} + (2xy + z^2)\hat{y} + 2yz\hat{z}$.

16. Compute $\vec{\nabla}\cdot\vec{V}$ (with $\vec{V}$ defined as above).

17. Evaluate $\int_{\vec{a}}^{\vec{b}}\vec{V}\cdot\mathrm{d}\vec{\ell}$ with V defined as above and $\vec{a} = 0\hat{x} + 0\hat{y} + \hat{z}$ and $\vec{b} = 3\hat{x} + 2\hat{y} - \hat{z}$. You may choose your own path (which might tell you something about the answer to one of the previous problems).

18. Simplify $\cosh(3i\pi)$.

19. Solve the following differential equation: $r\frac{\mathrm{d}r}{\mathrm{d}t} = 3$ with $r(t = 0) = r_\circ$.

20. What is the determinant of the following matrix?

$$\begin{pmatrix} 1 & 2 & -1 \\ 0 & -3 & 0 \\ 3 & 0 & 1 \end{pmatrix}$$

21. Find the eigenvalues and normalized associated eigenvectors for the following matrix:

$$\begin{pmatrix} 2 & 3 & 0 \\ 3 & 2 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

22. What is the surface area of a spherical ball with diameter 4 cm?

23. Three men and three women (a total of 6 people) are prepared to enter an empty room. Three people enter the room. What is the probability that there are 2 men and 1 woman in the room?

24. Approximate for $x \ll 1$ (retain terms up to first order in x): $f(x) = \frac{\sqrt{1+x}}{\sqrt{1-x}}$.

25. Under normal circumstances, which is larger – the static coefficient of friction or the kinetic coefficient of friction? (Or are they usually the same?)

26. Write down Newton's three laws of motion. (From memory! No cheating!)

27. What is the moment of inertia of a disk of radius R with total mass m uniformly distributed over the disk?

28. What is the magnitude of the centripetal acceleration of a point mass m moving with velocity v in a perfectly circular orbit a distance r about mass M?

29. What is the relationship between torque and angular momentum?

30. Are there any problems on this warm-up set completely unlike problems you've solved before? If so, which ones?