

3320 pretest, due 2nd day of the term, Tues Aug 23. Put it in my mailbox, thanks.
(This version is NOT GRADED: *do it closed book, by yourself*)

Physics 3320: Math Diagnostic and First Homework.

YOUR NAME (neatly!)_____

IMPORTANT, PLEASE READ THIS FIRST!!

I'd like you to do this homework twice.

This first version (GREEN COPY if you pick it up in class) IS A PRETEST, due tomorrow (Tues) in my mailbox (left of the physics office).

This is not for a grade!

Please answer these questions *without looking anything up*.

Please, no talking to friends, not even opening a book, browser or notes!!!

Don't stress about it, just show me what you can do entirely by yourself.

Again, you will *not* be graded on this version.

The OTHER VERSION (WHITE COPY) is a regular homework (due Wed, start of class)

For that version, use any books, notes, talk to friends, come to office hours...

NOTE: No need to redo any questions you are confident about - just write down "*see green copy*" on any problems you want!

(If you run out of room, just attach some extra pages.)

Please do not "back fill" *anything* onto this (green version) once you've gotten any help!!

Please **show your work** or explain your reasoning whenever possible.

(In general, we will grade homeworks for clarity of explanation as much as we do for mere "correctness of final answer"!)

Remember, for this set, *please* don't look ANYTHING up (not even calculators that integrate).

If you don't know how to do something, say so. If you KNOW you could easily do it by using a resource, let us know, but don't do so until the "second pass", white version, of the homework!

1.) Integrals:

a) $\int \frac{4x}{(x^2 + a^2)^{3/2}} dx$ (where a is a known constant. Note that it is an indefinite integral)

b) $\frac{d}{dx} \int_1^x f(y) dy$ (where $f(y)$ is some given, known (well behaved) function of y)

c) $\frac{d}{dx} \int_1^3 (\ln y + \ln x) dy$

2.) Make a quick sketch, in the x-y plane, of the following (two-dimensional) vector functions. Plot enough different vectors to give a feeling for what this field looks like in the x-y plane.

(a) $\frac{x}{\sqrt{x^2 + y^2}} \hat{\mathbf{x}} + \frac{y}{\sqrt{x^2 + y^2}} \hat{\mathbf{y}}$

Also just for this one (part a) - can you explain in words what this plot is showing?

(b) *Challenge!!* $(2\cos\theta \hat{\mathbf{r}} + \sin\theta \hat{\boldsymbol{\theta}})/r^3$

- 3.) a) Given the scalar function $T(x,y,z)$ (e.g. the temperature at any point in the room)
Which of the three operations (div, grad, or curl) can be sensibly operated on T ?
For each which can:

- i) give a formula for the result
- ii) explain in words how you would interpret the result.
- iii) is the result a vector or scalar?

- (b) Given an arbitrary vector function $\mathbf{V}(x,y,z)$ (e.g. the velocity of a flowing liquid)
Which of the three operations (div, grad, or curl) can be sensibly operated on \mathbf{V} ?
For each which can:

- i) give a formula for the result
- ii) explain in words how you would interpret the result.
- iii) is the result a vector or scalar?

4.) For each of the four vector fields sketched below....

Which of them have nonzero *divergence* somewhere? _____

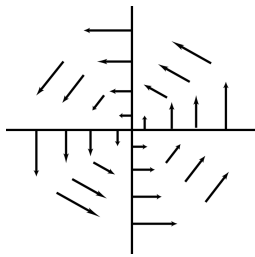
(If the divergence is nonzero *only* at isolated points, which point(s) would that be?)

Which of the following fields have nonzero *curl* somewhere? _____

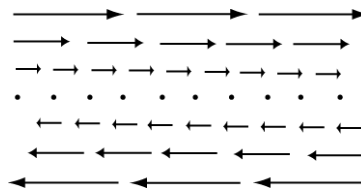
(If the curl is nonzero *only* at isolated points, which point(s) would that be?)

(A brief explanation of your answers below each figure would be welcome)

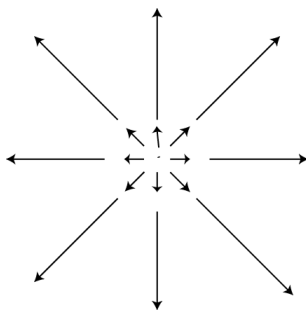
A.



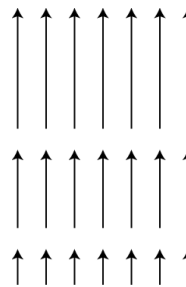
B.



C.



D.



5.) (a) Compute the divergence and curl of $\hat{\mathbf{i}}(x^2 + yz) + \hat{\mathbf{j}}(y^2 + zx) + \hat{\mathbf{k}}(z^2 + xy)$

b) *Delta functions:*

What is $\int_{-\infty}^{\infty} (x - 4)\delta(x - 6) dx$?

(c) *Complex numbers:*

i) What is $\text{Re}(2e^{i\pi/4})$?

ii) What is \sqrt{i} ?

(Give your answer BOTH in complex notation, $Ae^{i\theta}$, and in the form $a+bi$, please)

6.) a) What exactly is \mathbf{E} , the electric field? (Define it. How you you think about it, both mathematically *and* in words. Please define any technical words you introduce)

b) Gauss' law says: $\oint_S \vec{\mathbf{E}} \cdot \hat{\mathbf{n}} \, dA = q(\text{enclosed})/\epsilon_0.$

Suppose I evenly fill a cube (length L on a side) with electric charge. I then imagine a larger, closed cubical surface neatly surrounding this cube (length $2L$ on a side)

Can one *use* Gauss' law (above) to simply compute the value of the electric field at arbitrary points outside the charged cube? (Don't try, just tell me if you *could*, and why/why not?)

c) Briefly but clearly, walk us through the derivation that takes you from Gauss' law as written in part b to Gauss' law in "differential form".

7.) Given that an electric field in some region of space is given by $\vec{E}(x,y,z) = cx \hat{i}$,
(where c is a given constant)
What are the units of c ?

What can you tell us about the charge density throughout this region, $\rho(x,y,z)$?