YOUR NAME (neatly!)____

IMPORTANT, PLEASE READ THIS FIRST!!

On all homeworks, use whatever resources you need, including Griffiths, other texts, talking to peers, office hours. But remember that in the end, what you turn in must be your own work, reflecting your own understanding. Copying or working directly from solutions (found online, or from other students) is not what I would consider “collaboration” – use your judgment, and remember these homeworks are intended to help you learn the material.

We grade homeworks for clarity of explanation as much as we do for mere "correctness" of final answer.

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

(a) $\frac{x}{(x^2+y^2)^{3/2}}\hat{\mathbf{x}}+\frac{y}{(x^2+y^2)^{3/2}}\hat{\mathbf{y}}$

Explain briefly in words what this plot is showing. (Is it physically realizable?)

Optional, Extra credit (try it when you're done with the rest of the homework)

Do the same as above for the field $(2\cos\theta\ \hat{\mathbf{r}}\ +\ \sin\theta\ \hat{\theta})/r^3$

(Here, I am assuming we are in 3-D spherical coordinates, but there is no azimuthal dependence. How should you "sketch" this?)

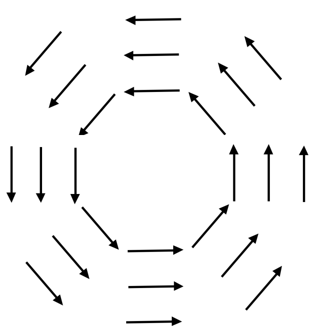
(Where have you seen this field before?)

2.) 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?)

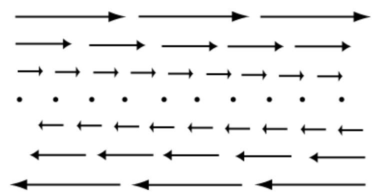
Which of the following fields have nonzero *curl* somewhere? ___________________
(If the curl is nonzero *only* at isolated points, which point(s) would that be?)

Briefly explain your answers below each figure.

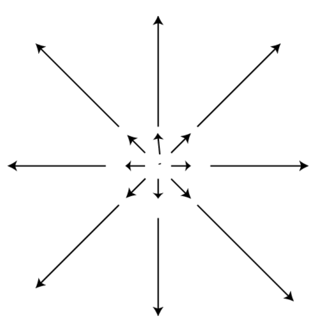
A. (Note: All arrows are the same length)



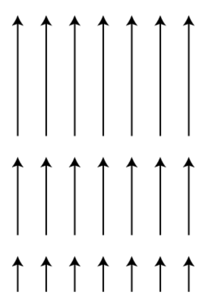
B.



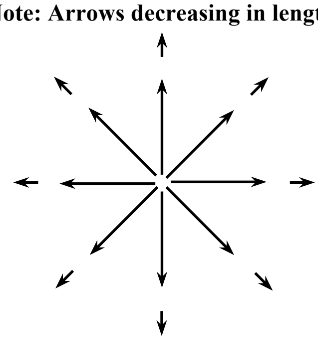
C. (Note: Arrows growing in length as r^2)



D.



E. (Note: Arrows decreasing in length as $1/r^2$. Think of a "Coulomb field" of a point charge here…)



3.) (a) Compute the divergence <u>and</u> curl of $(x+y)\hat{\mathbf{i}} + (y+z)\hat{\mathbf{j}} + (x-2z)\hat{\mathbf{k}}$.

a-ii) Could the field in part a be a physical electrostatic field in some limited region of space near the origin? *Circle one:* Yes No It depends.
Very briefly, explain your reasoning.

b) **Delta function review (Griffiths Ch 1.5)** Given the following mathematical form for a volume charge density $\rho(\vec{r})$, *DESCRIBE* the charge distribution in words, and also draw a little sketch showing where the charges are: $\rho(\vec{r}) = a\delta^3(\vec{r}-\vec{R}) + b\delta(r-R)$, where a, b are given constants with appropriate units, $\vec{R}$=(2,0,0), and as usual $r = |\vec{r}|$.

What are the (SI metric) units of a and b?

What is the total charge, in terms of the given constants in the equation?

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

b) Gauss' law says: $\oint_S \vec{\mathbf{E}} \cdot \hat{\mathbf{n}} \; dA \; = \; q(\text{enclosed})/\varepsilon_0.$

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 you *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?)

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

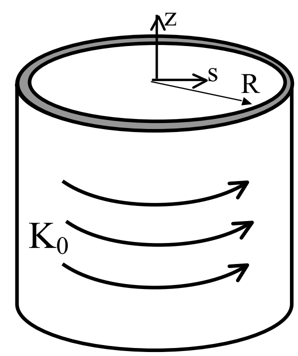
What, if anything, can you tell us about the charge density throughout this region, $\rho(x,y,z)$?

b) What is the voltage associated with this E field? (Is your answer unique?)

6.) **Ampere's law review (Ch 5 of Griffiths)**

You have an infinitely tall, infinitesimally thin cylindrical sheet of surface current running around the z-axis, i.e.

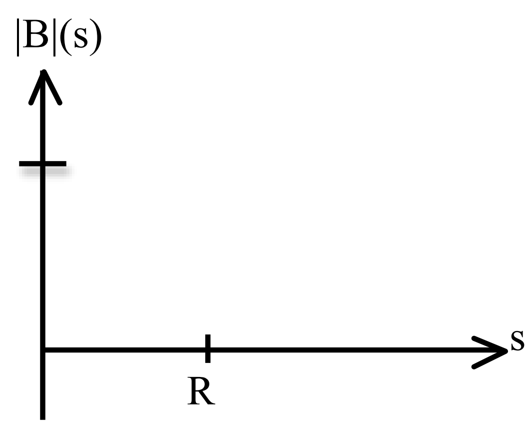
$\vec{\mathbf{K}} = \mathbf{K}_0 \hat{\varphi}$ at s=R (otherwise 0) .



i) What are the SI units of $\mathbf{K_0}$?

ii) Sketch the magnitude of the resulting B field as a function of radial distance, s (<u>both inside and outside the sheet</u>) below. *(4 pts)*

Please label the "tickmark" on the vertical graph with given quantities so I know the scale.



Briefly, show/explain your work below. *(If you grabbed a formula from Griffiths, explain concisely where it comes from)*