PHY 411 **Winter 2021**

Homework 1—due by 9:00 PM, Monday, Jan 11

Please read carefully first. The following will be strictly enforced.

- **You may write by hand and scan as a single PDF, or write in latex (using the template file provided) or Word, and generate PDF. Please submit one PDF file only. Only questions and sub-parts that are numbered clearly, with numbers corresponding to those in this document, will be graded. See the syllabus for more detailed rules.**
- ***Submit late homework into the late D2L dropbox for reduced credit (see syllabus); late submissions will be accepted until 8 AM on Friday (Jan 15). Emailed or paper copies of homework are never accepted; in particular, do not attach homework to email to make an end-run around the D2L deadline or late deadline; such emails are automatically deleted and do not count as submissions.***
- You can always write all problems by hand, unless specifically told to do otherwise. However, any graphs you may be asked to draw *must* be generated on the computer. Hand-drawn graphs will not be graded (i.e., they will get a grade of zero).
- You are welcome to work in groups on the homework; however, the actual homework submission must be your own work. In particular, **do not** sit with the homework of someone in your group and copy down the solution.
- For homework, you are only permitted to look at your text (and Griffiths), everything posted for this course in D2L, and a math handbook. **Do not** look at any other text, **do not** look on the internet, **do not** discuss solutions with anyone outside of class.

Homework problems begin on the next page

1. By constructing an appropriate set of vectors, prove that the line segment joining the midpoints of two sides of a triangle is parallel to the third side and half its length.

2. The ability to handle pages of vector math is a critical and necessary component of electrodynamics problems. With that in mind, show by *explicit computation* that

$$\vec{\nabla} \times (\vec{\nabla} \times \vec{A}\,) = \vec{\nabla}(\vec{\nabla} \cdot \vec{A}) - \nabla^2 \vec{A}$$

for any arbitrary vector $\vec{A}$. **Do not** use Levi-Civita notation; I'm trying to get you to see all the terms and the cancellations.

3. Prove the vector identity

$$\vec{A} \cdot (\vec{B} \times \vec{C}) = \vec{B} \cdot (\vec{C} \times \vec{A}) = \vec{C} \cdot (\vec{A} \times \vec{B})$$

You may do so by explicit computation or by using the Levi-Civita notation (*your choice*).

4. Electrodynamics problems often involve spherical or cylindrical coordinates. Moreover, a number of problems require the Dirac δ-function. Therefore, here is an opportunity to remind yourself about spherical coordinate systems and brush up on the Dirac δ-function.

In spherical coordinates (r, θ, ϕ), a charge Q is uniformly distributed over a spherical shell of radius R. Express this charge distribution as a three-dimensional charge density $\rho(\vec{x})$ using Dirac δ-functions.

Note: This is easy enough that you could just guess the solution and write it down, but in the spirit of the exercise to learn about handling spherical coordinates, localize the charge to a spherical shell of radius R by writing the charge density in terms of the Dirac δ-function as

$$\rho(\vec{x}) = C\,\delta(r - R)$$

and then determine the constant C by integrating $\rho(\vec{x})$ over all space.