Michigan State University
PHY 481 - Fall 2023
Homework 01

Due Sunday September 3, 2021 @ 11:59 PM

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Preface

0.1 Do the homework

Homework in this class is a very large part of the learning experience (and a large fraction of your grade!). The homework might look long, but that is because it is not really serving as a check on whether you are getting things from lecture. It is meant to help you learn the material, the importance of different aspects of the material, and the implications of the material on your future work. So there will typically be longer descriptions in the problem statements. The work you are being asked to do is no longer than a standard lecture course, but the kinds of questions might be different. We strongly encourage you to work together on these homework problems, but you must turn in your own work.

0.2 Submitting your homework

All of your "pen-and-paper" solutions can be turned via Gradescope. Please work separate problems on separate sheets of paper. **Gradescope asks you to identify the sheets for a given problem - please do this - it makes the grading much easier for us.** Gradescope will also ask for the python problem - just submit a sheet of paper with the name of the file on it. The actual Python file should be submitted to D2L. Homework solutions that require Python are to be turned in online using D2L > Assessments > Assignments > Homework 01. Make sure that your name appears in the filename of the notebook (e.g., First Name, Last Name - HW01.ipynb). For homeworks with multiple notebook submissions, you may either combine the notebooks or submit separate notebooks for each problem.

0.3 What is Homework 01 about?

Homework 01 emphasizes the mathematical formalism and related thinking that you will draw on in this class. This homework focuses on Sections 1.1-1.4 of Griffiths, which covers differential, integral, and vector calculus. It also serves as an introduction to using Python and Jupyter notebooks, which you will use on most homework assignments.

1 Griffiths Problems

Do Problems 1.4 and 1.7

2 What operations can be done to different functions?

1. 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, and/or curl) can be sensibly operated on T? For each which can:
   - give a formula for the result,
   - explain in words how you would interpret the result, and
   - identify if the result is a vector or scalar.
2. Given the vector function $\vec{V}(x, y, z)$ (e.g., the velocity of a flowing fluid), which of the three operations (div, grad, and/or curl) can be sensibly operated on $\vec{V}$? For each which can:
   - give a formula for the result,
   - explain in words how you would interpret the result, and
   - identify if the result is a vector or scalar.

3 Determine the gradient of a scalar function

In Griffiths, $\vec{\mathscr{z}} = \mathscr{z}\,\hat{\mathscr{z}} = \vec{r} - \vec{r}\,'$ represents the displacement vector between source charges $\langle x', y', z' \rangle$ and the field point (also known as the observation point) – location of test charge – $\langle x, y, z \rangle$. Griffiths script-$\mathscr{z}$ is a **critically important** vector in electrodynamics as it underlies all of the mathematical models that describe how source charges produce electric and magnetic fields. To that end, you will often do some mathematical manipulations of the Griffiths script-$\mathscr{z}$ vector. You are asked to perform two common manipulations below. Note that the del operator (∇) is with respect to the unprimed variables (x, y, z) and therefore you can treat the primed variables (x', y', z') as constant when you take the derivatives.

1. Calculate the gradient of the magnitude of the Griffiths script-$\mathscr{z}$ vector (i.e., $\nabla\,\mathscr{z}$).
2. Calculate the gradient of the inverse of the magnitude of the Griffiths script-$\mathscr{z}$ vector (i.e., $\nabla\frac{1}{\mathscr{z}}$).
3. Show the gradients of these functions can be written as functions of the Griffiths script-$\mathscr{z}$ vector ($\vec{\mathscr{z}}$) and/or its magnitude ($\mathscr{z}$). (*Hint: it might be easier to do this by explicitly writing out the function in Cartesian coordinates.*)

4 Python: introduction

The modern approach to solving and visualizing E&M problems requires heavy use of computation. As a consequence, there will be use of computation in this course on homework problems in the form of Python. You do not need any computational experience for this course as you will learn some fundamentals early on and keep using them throughout the course. Python is in use across the sciences, but it is becoming much used in physics, so learning it will serve you well in your future work.

Download and install Python using the Anaconda distribution. Write a Python script to display the string "Hello World" ten times using a for loop. The output of your script should look like this:

1 Hello World
2 Hello World
3 Hello World
4 Hello World
5 Hello World
6 Hello World
7 Hello World
8 Hello World
9 Hello World
10 Hello World

Submit a copy of your script via D2L $>$ Assessments $>$ Assignments $>$ Homework 01. Please name your script
$\langle YourLastName \rangle, \langle YourFirstName \rangle - HW01$