Static Fields Homework 1

Due 4/4/18 @ 4:00 pm

Start your homework early and submit a question about it on Canvas before class on Tuesday!

Remember that you should do some sense-making about every problem and result (*e.g.,* describe how you know a result is correct, interpret your answer non-symbolically, or describe new physics insight you gained). Solutions that contain exceptional sense-making will receive bonus points.

PRACTICE:

1. If you are unfamiliar with Mathematica and you have not already done so, go through the following tutorials:

   http://www.wolfram.com/broadcast/screencasts/handsonstart/

   More detailed information can be found at:

   http://www.wolfram.com/support/learn/

   WolframAlpha - a Mathematica-based computation engine. Enter equations into the box in the window and get instant results. A remarkably powerful piece of software. Can be found at:

   http://www.wolframalpha.com/

   Note that it is acceptable to use non-Mathematica computer programs if you are more comfortable with a different program.

REQUIRED:

2. Find the course website at http://physics.oregonstate.edu/˜ emighp/COURSES/ph422. Read through it carefully and bring your questions to class. Don't forget to check out the Syllabus.

   Find the paradigms website at http://physics.oregonstate.edu/paradigms. Read through it carefully and bring your questions to class.

3. Use Mathematica to plot (and print out) each of the following functions:

$$\begin{aligned} f_1(x) &= \sin\left(x^3\right) \\ f_2(x) &= \frac{e^x}{x^3} \\ f_3(x,y) &= \sinh(y) \\ f_4(x,y) &= \sin(x+y)^3 \end{aligned}$$

   Make sure you use best practices for creating plots: all plots should have a title, labeled axes (with units, when appropriate), and a domain and range that include the interesting behaviors of the function.

4. Use Mathematica to make a *contour plot* of the electric potential in the xy-plane due to a single point charge located at the origin.

   Make sure to label your plot in a sensible way, including indicating the values you used for any unknown parameters (make sure you choose reasonable values).

   This problem is a great chance to practice *sense-making* about your result. Is the answer what you expect? What interesting properties do you observe? How would you interpret your result physically? Can you push beyond what the question is asking literally and discover something interesting?

5. Use Mathematica to find the following integrals.

$$
\begin{aligned}
I_1 &= \int_0^{\sqrt{2\pi}} \sin\left(x^2\right) dx \\
I_2 &= \int_{-1}^{1} \int_0^{1-x^2} \sin\left(xy\right) dy dx \\
I_3 &= \int \sinh\left(kx\right) dx \\
I_4 &= \int_0^{2\pi} \frac{dx}{\sqrt{1 - A\cos\left(x\right)}}
\end{aligned}
$$

   When you do calculations using a computer program, make sure you: cite the program you used, include the relevant code (with attribution), cite any collaborators, and clearly organize your work so that the grader can understand what you have done.

   This is another great place to try out your own sense-making. In particular, think about what you can learn from each integral.

6. Four point charges sit at the corners of a square in the xy-plane. A positive point charge is located at $(a, a, 0)$ and another is located at $(-a, a, 0)$. A negative charge is located at $(-a, -a, 0)$ and another is located at $(a, -a, 0)$.

   (a) Find the electric potential at any point (x, y, z).

   (b) Is the yz-plane an equipotential surface? Explain. If so, what is the value of the potential?

   (c) Is the xz-plane an equipotential surface? Explain. If so, what is the value of the potential?

   (d) Do you expect any other equipotential surfaces to exist? Explain. If you do expect one or more equipotential surfaces, use the Mathematica function ContourPlot3D to plot one. All plots should include a title, axis labels and a legend if appropriate. Note: providing a plot does not count as an explanation for why you would expect an equipotential surface to exist.