Electricity and Magnetism II (PHY 322)

3D EM Wave Animation Homework

This homework is all about animating EM waves in three spatial dimensions. Download the files `MaxwellGIF.hs` and `GIF.hs` from the course website.

This code solves the full three-dimensional Maxwell equations for a given current density $\mathbf{J}(\mathbf{r}, t)$. It animates the components of the electric and magnetic fields that are found in solving the equations. The animation has two rows and three columns. The top row animates the x, y, and z components of electric field. The bottom row animates the x, y, and z components of magnetic field.

Because these animations are computationally intensive, I recommend starting with a small grid, say

```
spaceStepsCE = 10
```

which specifies a $20 \times 20 \times 20$ grid. (The CE at the end stands for "center to edge".) I also recommend starting with a smaller number of time steps, say

```
numTimeSteps = 180
```

in the `animation` function. This "small" animation takes about a minute to run on my computer. If it looks like things are working, you can try a full-size animation, which takes several hours to run. The full-size animation uses an $80 \times 80 \times 80$ grid, and runs for 720 time steps. Since $80 \times 80 \times 80 = 512000$, and we are keeping track of six components, we have over 3 million numbers for each time step. In doing 720 time steps, we are asking the computer to do over 2 billion calculations for us.

The current code is written to simulate electric dipole radiation and to show the results in the xz plane.

Look at Table 29-2 in LPFP to see where the different components of the fields are being stored.

Problem 1 (16 points) The function `frameXZFromStateFDTD` collects the information we want to show in the animation for a single time step. The current code shows the components in the xz plane. Change the code to make the animation for the

xy plane. Then compare the results of the animation to the analytical equations we have for electric dipole radiation (in which we assumed that $r >> \lambda >> d$). Make a list of features that the animation and the equations have in common. Make a list of features in which the animation and the equations differ.

Problem 2 (16 points) Change the code to produce magnetic dipole radiation by changing the unit vector in `jGaussian` from $\hat{\mathbf{k}}$ to $\hat{\phi}$. Change the code to make the animation for the yz plane. Then compare the results of the animation to the analytical equations we have for magnetic dipole radiation (in which we assumed that $r >> \lambda >> d$). Make a list of features that the animation and the equations have in common. Make a list of features in which the animation and the equations differ.

Problem 3 (16 points) Change the code to produce magnetic dipole radiation by changing the unit vector in `jGaussian` from $\hat{\mathbf{k}}$ to $\hat{\phi}$. Change the code to make the animation for the xy plane. Then compare the results of the animation to the analytical equations we have for magnetic dipole radiation (in which we assumed that $r >> \lambda >> d$). Make a list of features that the animation and the equations have in common. Make a list of features in which the animation and the equations differ.