University of Washington
Physics 513
Graduate Electrodynamics I

Autumn Quarter 2020
December 10-11, 2020

Mid-Term Exam II

- The exam is due via email by Friday, December 11, at 4 pm PST. Points will be deducted for a late submission.

- Use a separate sheet of paper for each problem solution; you will therefore have a minimum of 3 pages in your submitted PDF file. Assemble the PDF pages in problem-order (1, 2, 3).

- This is an open-book exam; you may refer to the Jackson textbook, your lecture notes and anything on the course web site.

- Show your work in enough detail so the grader can follow your reasoning and your method of solution.

- Take up to an hour and 20 minutes to complete the exam, please don't continue beyond that.

- Feel free to contact me with questions.

- Email-submission instructions:
  1. Scan your solutions as a single PDF file
  2. Name your file `midterm2-`*lastname*`.pdf`
  3. Attach your file to an email
  4. ... with subject line `midterm2-`*lastname*
  5. Send that email to `ljrosenberg@phys.washington.edu`

I. (35 points) Dipole magnetic field.
Consider a spherical surface of radius R with a point dipole of magnetic moment **m** at its center. Find the average magnetic field <**B**> within the sphere.

II. (35 points) Solution to Poisson and Laplace equations.
Consider a long straight wire (in the z-direction) of radius R carrying a uniform current density J. Use the magnetic Poisson equation in Coulomb gauge (Jackson eqn. 5.101) to find the vector potential and magnetic field everywhere.

III. (30 points) Gauge transformations.
Consider a static point charge e at r=0. We started this quarter by using for its potentials $\Phi = \frac{1}{4\pi\epsilon_0}\frac{e}{r}$ and $\mathbf{A} = 0$. (a) Are these in either Coulomb or Lorentz gauge? Explain. (b) Show that these familiar potentials are related to less-familiar ("Hamiltonian" or "Weyl" gauge) potentials $\Phi = 0$ and $\mathbf{A} = -\frac{1}{4\pi\epsilon_0}\frac{et}{r^2}\hat{\boldsymbol{r}}$ by a gauge transformation. (c) What is a suitable scalar gauge function for this gauge transformation? (d) Are these less-familiar potentials in either Coulomb or Lorentz gauge? Explain.