Physics 515, Spring Quarter 2018
Electrodynamics: Homework Assignment 2
Due April 13, either 11:00am in class or 10:45am in the instructor's mailbox.

1. A diffraction problem that looks like a radiation problem. Consider a small circular aperture of radius R in a thin sheet of good conductor. The electromagnetic fields at the incident side of the sheet have electric field $\mathbf{E}_0$ normal to the aperture and magnetic field $\mathbf{B}_0$ parallel to the aperture and wave number k. Such fields are, e.g, found at the walls of wave guides.

Show that the diffracted electric field in the Fraunhofer (far) region is $\frac{1}{3\pi}\frac{e^{ikr}}{r}k^2a^3\{\hat{\mathbf{k}}\times(\boldsymbol{E_0}\times\hat{\mathbf{k}}) + 2c\hat{\mathbf{k}}\times\mathbf{B_0}\}$. Hint: This could be considered an aperture in the side of a waveguide with effective radiating electric and magnetic dipole moments.

2. For the physical system in problem 1. Find the angular distribution of the diffracted radiation.

3. A problem using the tools of vector-diffraction. A linearly-polarized plane wave with electric field $\mathbf{E}_0$ is normally incident on a circular aperture of radius R in a thin sheet of good conductor. Find the diffracted fields *in the far region* using the vector-diffraction formalism of Jackson section 10.7 with equation 10.101. Hint: You may see something like the integral equation 10.112, with result equation 10.113.

4. Spacetime. A classic problem recast into Star Trek by Prof. Miguel Morales. A Federation spaceship is in Federation territory at rest with respect to the border between Federation and Klingon space. According to instruments on the Federation spaceship, the border is 6 light minutes distant. A Klingon spaceship flies close by the Federation ship directly towards the border at speed β=0.6. Just 5 minutes later according to the clock on the Federation spaceship, the Klingon emits a photon torpedo that eventually hits the Federation

spaceship. Then a short time later, according to the instruments on the Federation spaceship, the Klingons cross back into their own space. I'm told a photon torpedo travel at the speed of light.

a. Make a Federation-spaceship-based spacetime drawing of these events, including the Federation spaceship, the Klingon spaceship, the photon torpedo, and the boundary.

b. According to instruments on the Federation spaceship, how long after the Klingon flies by the Federation spaceship does the photon torpedo hit the Federation spaceship? Hint: you can infer this from the spacetime diagram.

c. Also according to instruments on the Federation spaceship, how long after the Klingon flies by the Federation spaceship does the Klingon spaceship cross the border? Hint: This can also be inferred from the spacetime diagram.

d. An interstellar war is at stake in the answer to this question. The Klingon commander claims that the Federation is wrong: according to instruments on the Klingon spaceship, the Federation spaceship was hit when the Klingon spaceship was in Klingon territory. According to instruments on the Klingon spaceship, when the Federation spaceship was hit, was the Klingon spaceship on its own side of the border? Hint: This can also be inferred from the spacetime diagram.

[ver 13apr18 16:00]