

## Electrodynamics III: Assignment 4

Due May 1 at 11:00 am.

1. Scan your solutions as a single PDF file
2. Name your file **HW4-*lastname*.pdf**
3. Attach your file to an email...
4. ... with subject line **HW4-*lastname* ...**
5. ... and send the email to **ljrosenberg@phys.washington.edu**

1. Plane waves are normally incident on a long slit of width  $d$  in an absorbing screen. In the Fraunhofer region, show that scalar diffraction yields the single-slit diffraction result from first-year physics

$$I = I_0 \left( \frac{\sin \theta}{\theta} \right)^2, \text{ where } \theta \text{ is an "effective" angle; what is } \theta?$$

2. Show Arago and Fresnel's 1816 interference claim: Two beams polarized at right angles to each other cannot interfere.

3. "Drag". A medium has index of refraction  $n$ . An observer sees the medium moving with speed  $v$  in the same direction as a light ray moving through the medium. Show that for non-relativistic  $v$ , the observer sees the ray moving at speed  $\frac{c}{n} + \left(1 - \frac{1}{n^2}\right)v$ .

4. Spacetime. A classic relativity 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  $\beta=0.6$ . 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 travels 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.