Physics 515, Spring Quarter 2018 Electrodynamics: Homework Assignment 7 Due May 25 either 11:00am in class or 10:45am in the instructor's mailbox.

1. Cerenkov radiation. Recall that a charged particle moving at a constant velocity greater than the phase velocity in some medium produces Cerenkov radiation in the form of a cone. Find the electric field in the region between the shock front (the cone surface) and the particle trajectory (outside the cone the field is obviously zero) in terms of the cone angle θ_0 and the angle θ between the velocity and the vector from the actual position of the particle to the field point. You may find this result troubling in the context of Gauss's law: explain how to resolve this.

2. Consider a particle moving at a non-relativistic speed in a straight line. This particle of charge *e* starts a rest, moves out on the line, then returns to rest. The particle travels a total distance *d* taking time τ. (a) Suppose on each leg, the particle accelerates at a constant rate for the first half of the leg, then deaccelerates for the second half of the leg. Find the total radiated energy over the total path *d*. (b) Find the (non-constant) acceleration that minimizes the radiated energy. This is one of Kirk McDonald's challenge problems.

3. Suppose a particle of mass *m* and charge *e* moves in quasi-circular orbit at a speed *v,* held in the orbit by a uniform magnetic field B. "Quasi" means that the radius changes slightly as the particle loses energy. (a) What is the radius and angular frequency of the orbit? (b) What is the total radiated power? (c) Find the total particle energy versus time. Does the large-time limit make sense?

4. Bremsstrahlung during collisions. A variant of Jackson problem 15.9. A particle of charge *ze* and mass *m* moves at impact parameter *b* past a screened Coulomb field from charge *Z*. Assume the screening length is α (per the form suggested in Jackson's discussion in the first paragraph of section 15.3; as we discussed this is

screening from the Fermi-Thomas model of the atom). Assume the particle moves non-relativistically and the particle trajectory is a straight line. Show that the radiated energy per bandwidth dω is $\frac{dI}{d\omega}(\omega, b) = \alpha^2 \frac{8}{3\pi} \frac{(Ze)^2}{c} \left(\frac{z^2 e^2}{mc^2}\right)^2 \left(\frac{c}{v}\right)^2 K_1^2(\alpha b)$, where K_1 is a modified Bessel function of the 2nd kind. In class we discussed how such Bessel functions arise in this class of problem.

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