Electrodynamics III: Assignment 8

Due May 29 at 11:00 am.

1. **Scan your solutions as a single PDF file**
2. **Name your file HW8-*Lastname*.pdf**
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ljrosenberg@phys.washington.edu

1. Consider a non-relativistic particle of charge *e* moving in a straight line. This particle starts a rest, moves outwards on the line, then returns to the starting position at 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.

2. Cerenkov radiation. A charged particle moving at constant velocity greater than the phase velocity in a medium produces a cone of Cerenkov radiation. 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. This is a tricky problem and it's outlined in several texts; you may want to refer to those texts. You may find this result troubling in the context of Gauss's law: explain how to resolve this.

3. Transition radiation. A proton with energy 1 TeV enters a tungsten block.

a. Estimate the energy released as transition radiation.
b. What's the characteristic photon energy?
c. Approximately how many photons are emitted?

4. Linear versus circular particle accelerators.

a. The proposed Next Linear Collider (a linear accelerator) has accelerating RF cavities that increase the electron energy (in the laboratory frame) by around 50 GeV/meter. Find the radiated power per electron during this acceleration.

b. Suppose electrons of energy 500 GeV are circulating in a future circular storage ring of radius 1 km; presume there are accelerating RF cavities spaced along the ring circumference to maintain the fixed electron energy. Find the radiated power per electron during this storage process. The results of parts a and b should make clear why very-high-energy electron accelerators are linear accelerators.