Physics 515, Spring Quarter 2018
Electrodynamics: Homework Assignment 6
Due May 18 either 11:00am in class or 10:45am in the instructor's mailbox.

1. A variant of Jackson problem 14.5. A nonrelativistic particle of charge *ze*, mass *m*, and kinetic energy *E* makes a head-on collision with a fixed, repulsive, central force of finite range having potential *V(r)*, which becomes greater than *E* for some sufficiently small *r*. Show that the total radiated energy is

$$W = \frac{4}{3}\frac{(ze)^2}{m^2c^3}\sqrt{\frac{m}{2}}\int_{r_{min}}^{\infty}\left|\frac{dV}{dr}\right|^2 \frac{dr}{\sqrt{V(r_{min}-V(r))}} \text{ (CGS)}$$

where r_{min} is the distance of closest approach. This is the starting point for a number of problems where *V(r)* is specified. Also, there are interesting consequences when the nonrelativistic condition is relaxed.

2. The proposed Next Linear Collider (a type of 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 process.

3. Suppose electrons of energy 500 GeV are circulating in a 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 problems 1 and 2 should make clear why very-high-energy electron accelerators are linear accelerators.

4. The Thomson polarimeter, studied in several texts. A monochromatic linearly-polarized plane wave travelling in the z-direction Thomson-scatters from a possibly-moving electron. The amount of polarization of the scattered field is given by $p(\boldsymbol{\epsilon}_i, \boldsymbol{\epsilon}_f) = \frac{|\epsilon_f \cdot \mathrm{E}_f|^2}{|\epsilon_i \cdot \mathrm{E}_f|^2}$ where $\boldsymbol{\varepsilon}_i$ ($\boldsymbol{\varepsilon}_f$) is the incident (scattered) polarization and $\mathbf{E}_i$ ($\mathbf{E}_f$) is the incident (scattered) field.

Find an expression for backscattered (backward-going) *p* in terms of the final velocity (β) and polar coordinates θ and ϕ of the scattered electron trajectory, for the initial polarization along the x-direction, and the scattered polarization along the y-direction. It is possible to write p without the electron acceleration appearing by applying the Liénard-Wichert fields plus relativistic kinematics. You can assume the polarimeter is far from the scatterer. This measurement finds utility when the scattered electron moves off relativistically. This coordinate system and nomenclature are the convention for these polarimeters.