Homework Problems VI
Accelerator Physics

1. Assuming a charged particle moves only in the *x*-direction as in the beginning of Lecture 10, verify the "Jackson" formula

$$\frac{d^2E}{d\omega d\Omega} = \frac{e^2\omega^2}{32\pi^3\varepsilon_0 c}\left|\int_{-\infty}^{\infty} \vec{n}\times\left(\vec{n}\times\vec{\beta}(t)\right)e^{i\omega\left(t-\vec{n}\cdot\vec{r}(t)/c\right)}dt\right|^2$$

leads directly to the result

$$\frac{d^2E}{d\omega d\Omega} = \frac{e^2\omega^4}{32\pi^3\varepsilon_0 c^3}\left|\tilde{d}(\omega)\right|^2 \sin^2\Theta$$

(the units in Lecture 10 are CGS) for non-relativistic motions. The angle Θ is the angle the emission direction makes with the *x*-axis. Note also the formula for general 3-dimensional motions is correct by the same argument.

2. Assuming no microphonics, plot β_{opt} and $P^{opt}{}_g$ as function of *b* (beam loading), *b* = -5 to 5, and explain the results.

   How do the results change if microphonics is present?

3. Show that in the Lorentz boosted frame the spin 4-vector becomes

$$S^i = \left(S_{0L}, \vec{S}_L\right) = \left(\gamma\vec{\beta}\cdot\vec{S}_R, \vec{S}_R + \frac{\gamma^2}{\gamma+1}\vec{\beta}\left(\vec{\beta}\cdot\vec{S}_R\right)\right)$$

4. Consider an electron storage ring of energy 30 GeV and a bending radius of $\rho = 500$ m. Calculate the polarization time.