Homework Problems
Physics 854
Due September 10, 2015

1. Our definition of the energy gain is in terms of the full Fourier integral of the electric field pattern of the cavity. Sometimes, particularly for acceleration through a gap, the Fourier integral is divided into two terms: the gap voltage and the transit time factor. Assume a time dependent voltage $V(t) = V_0 \cos \omega t$ across an accelerating gap of length L and a particle orbit $z(t) = \beta c t$. Show

$$|V_c| = V_0 \frac{\sin(\omega L / 2\beta c)}{\omega L / 2\beta c}$$

$\frac{\sin(\omega L / 2\beta c)}{\omega L / 2\beta c}$ is called the transit time factor, and quantifies the effective voltage reduction because as the particle transits the gap, the voltage (and hence the electric field) is not always at the maximum value.

2. Suppose a transmission line of characteristic impedance Z_0 is terminated with a resistive impedance Z.
   a. With the sign conventions in the lectures show the reflected wave has amplitude

$$V^- = \frac{Z - Z_0}{Z + Z_0} V^+.$$

   b. Show the voltage standing wave ratio $\frac{|V^+| + |V^-|}{|V^+| - |V^-|}$ is

$$VSWR = \left(\frac{Z}{Z_0} \right)^{\pm 1},$$

   the sign chosen so $VSWR > 1$.
   https://en.wikipedia.org/wiki/Standing_wave_ratio

   c. What is the termination impedance, and what are the answers to a. and b. when the impedance is matched to the transmission line.

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

   How do the results change if microphonics is present?