Physics 514, Winter Quarter 2018
Electrodynamics: Homework Assignment 7
Due Feb. 23, either 11:00am in class or 10:45am in the instructor's mailbox.

1. Last week in class I showed a WR-187 waveguide. It's rectangular, brass, filled with polyethylene, with inside dimensions 4.76 cm and 2.22 cm. By adding brass end-caps at z=0 and z=d you can make it into a resonant cavity of length d and resonant at 5 GHz. The mode of interest is the lowest mode with longitudinal wave number p (in the z-direction) of 1. Polyethylene at room temperature has relative permittivity in the neighborhood of 2.2 and loss tangent in the neighborhood of 4×10^{-4}. Brass at room temperature has conductivity in the neighborhood of 5.8×10^{7} S/m.
b. Find the length d for resonance at 5 GHz.
c. Find the Q due solely to conductor loss. You might recall from class the result from circuit theory $Q = \frac{2\omega_0 W_e}{P_c}$, where W_e is the time-average stored electric energy, and P_c is the power dissipated in the conductor. You might also want to look at Jackson chapter 8.1.
d. Find the Q due solely to losses in the dielectric. This is not hard: In principle one determines the loss tangent of a material by completely filling a bare, very high Q cavity with a material under study and equating the loss tangent to the resulting 1/Q. In practice the bare-cavity Q is not infinite and the determination of loss tangent is more involved.

2. Consider a rectangular wave guide.
a. Find the shape of the fields for the (non existent) TE_{00} mode.
b. In class we asserted this mode does not exist. Argue why this is so.

3. The half-circle waveguide (done is several texts). Many waveguide problems involve starting with rectangular or circular guides, then inserting conducting planes. For this problem, consider a waveguide with cross-section a half-circle of radius R.
a. In the mode terminology of the corresponding circular waveguide, what modes exist in the half-circle guide? You can argue this based on the boundary condition imposed by the flat section of the guide.
b. What are the cutoff angular frequencies?

4. The application of Fresnel's equations to find the reflection of a wave from a plane metal surface leads to complicated expressions. However, in the "good conductor:" (or "optical") region there's a simplification. In this region, find an approximate expression for the "reflecting power" (the ratio of the reflected energy to the normal-incidence incident energy) in terms of the conductivity σ and frequency.

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