

ECEn 462 (Block 1)
Electromagnetic Radiation and Propagation
Homework #3

1. Book problem 7.1.3 (only part a and b)
2. Book problem 7.3.1
3. For an air filled rectangular metallic waveguide of dimensions $a=3\text{cm}$ and $b=1\text{cm}$, compute the cutoff frequencies of the first 4 modes and give the operating bandwidth of the dominant mode.
4. For the waveguide of the previous problem, suppose that the operating frequency is $1.5 f_{c,10}$. An imperfect probe setup excites the TE_{11} mode. How far down the waveguide from the probe has the amplitude of this mode fallen by 100dB?
5. A rectangular metallic waveguide is to be designed to have the following design parameters:
 - Single mode operation for $f < 10\text{GHz}$
 - Air filled metallic waveguide
 - Choose the waveguide dimensions (a and b) to be as large as possible.
 - A. What are the dimensions of the waveguide?
 - B. What is the waveguide cutoff frequency (below which the waveguide does not support any modes)?
 - C. What is the electric field phasor of the lowest waveguide mode?
 - D. What is the time average power density, S_{av} of the lowest waveguide mode?

$$\left(\bar{S}_{av} = \frac{1}{2} \text{Re} \{ \bar{E} \times \bar{H}^* \} \right)$$
6. Sketch the location of a waveguide probe or probes that would excite the TE_{02} mode but not the TE_{01} mode. How would you drive each probe to accomplish this?
7. Derive $E_\phi = \frac{-j}{k^2 - \beta^2} \left(\frac{\beta}{\rho} \frac{\partial E_z}{\partial \phi} - \omega\mu \frac{\partial H_z}{\partial \rho} \right)$ from Maxwell's equations.
8. An air filled circular metallic waveguide is to be single mode for operating frequencies of $f < 10\text{GHz}$.
 - a. What is the radius of the waveguide?
 - b. What is the electric field of the dominant mode?
 - c. What is the cut-off frequency of the dominant mode?
 - d. How many modes propagate in the waveguide if the operating frequency is 20 GHz?
9. Find the phase and group velocity for the TE_{13} mode in a circular waveguide if the waveguide radius is $a=10\mu\text{m}$ and the wavelength of the signal is $\lambda=3\mu\text{m}$.