Problems

1. The dimensions of an X-band WR90 rectangular waveguide used for the feed of airport radars are $a = 0.9\text{in}$ and $b = 0.4\text{in}$. Assuming free space within the waveguide, determine in GHz the cutoff frequencies in ascending order of the first 10 $TE_{2}$ and/or $TM_{2}$ modes.

2. A rectangular air-filled waveguide WR510 used for cellular communications base stations has a cross-section $5.1in \times 2.55in$.
   (a) Calculate the cutoff wavelength $\lambda_{oc}$ and the cutoff frequency $f_{oc}$ for the dominant TE mode.
   (b) Determine the propagation constant and the transverse-wave impedance for this mode at $f = 10GHz$.
   (c) How close are the values of (b) to the TEM values?

3. Repeat the analysis of Problem (2) for the dominant TM mode.

4. If the amplitude of the $H_{x}$ field for the dominant TE mode of Problem (2) is $10A/m$, derive expressions for the spatial distributions of the EM components of this mode.

5. The inside dimensions of an X-band WR75 waveguide are $a=0.75\text{in}$ and $b=0.375\text{in}$. Assume that the waveguide is air-filled and operates in the dominant $TE_{30}$ mode, and that is used for a Meteorological Sensor feed. The air will break down when the maximum electric field intensity is $2 \times 10^{6} \text{V/m}$ (common when lightning occurs nearby). Find the maximum power that can be transmitted at $f=12 \text{GHz}$ in the waveguide before the sensor gets destroyed (air breakdown occurs).

6. What is the Conductor and the Dielectric Loss for the Waveguide of Problem (5) if the dielectric filling is Teflon, the Conductors are made from Copper and the frequency is 12 GHz.
   Teflon: $\tan \delta = \epsilon' / \epsilon'' = 5 \times 10^{-4}$ (@12 GHz), $\epsilon_{r}=2.1$
   Copper Cu: $\sigma=5.8 \times 10^{7} \text{ S/m}$