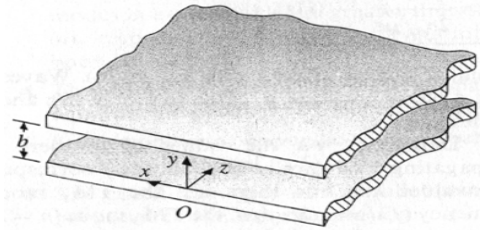**HW#6**

9-2. For uniform waveguides, use appropriate relations in Section 9-2 to:
   a) Prove that the universal diagram relating u_g/u and f_c/f is a quarter-circle with a unity radius,
   b) Plot the universal graph of λ_g/λ cursus f/f_c.

9-3. Assume that a TE wave of a frequency f is launched along the z-direction in the parallel-plate waveguide in following figure. The dielectric medium between the plates has constitutive parameters ϵ and μ. (a) Find the phasor expression for $H_z^0(y)$. (b) Find the cutoff frequency for the TE_1 mode. (c) Write the instantaneous expression for all the field components of the TE_1 mode.

9-7. A standard air-filled S-band rectangular waveguide has dimensions $a = 7.21(cm)$ and $b = 3.40(cm)$. What mode types can be used to transmit electromagnetic waves having the following wavelengths?
   a) $\lambda = 10$ (cm)   b) $\lambda = 5$ (cm)

9-9. An air-filled $a \times b$ $(b < a < 2b)$ rectangular waveguide is to be constructed to operate at 3 (GHz) in the dominant mode. We desire the operating frequency to be at least 20% higher than the cutoff frequency of the dominant mode and also at least 20% below the cutoff frequency of the next higher-order mode.
   c) Give a typical design for the dimensions a and b.
   d) Calculate for your design β, u_p, λ_g, and the wave impedance at the operating frequency.

9-11. Starting from $E_z^0(x,y) = E_0 \sin\left(\frac{m\pi}{a}x\right) \sin\left(\frac{n\pi}{b}y\right)$ (V/m),
   a) Obtain the expressions of $E_x^0(x,y)$, $E_y^0(x,y)$, $H_x^0(x,y)$, and $H_y^0(x,y)$ for the TM_{11} mode, and
   b) Obtain a formula for the average power P_{av} transmitted along an $a \times b$ waveguide.

9-15. An electromagnetic wave is to propagate along an air-filled $a \times b$ rectangular waveguide at the dominant mode. Assume $a = 2.50(cm)$ and the usable bandwidth to be between $1.15(f_c)_{10}$ and 15% below the cutoff frequency of the next higher mode.

a) Calculate and compare the permissible bandwidth for $b = 0.25a$, $b = 0.50a$, and $b = 0.75a$.

b) Calculate and compare the average powers transmitted along the three guides in part (a) at 7 (GHz) if the maximum electric intensity is 10 (kV/m). Neglect the losses.