1. (15%) The electric field of a uniform plane wave is given by

$$\mathbf{E} = 10\sin(3\pi \times 10^8 t - \pi z)\,\mathbf{a}_x + 10\cos(3\pi \times 10^8 t - \pi z)\,\mathbf{a}_y \text{ V/m}$$

Let us find

(a) the various parameters $\omega, \beta, \lambda, f, v_p$ associated with the wave;

(b) the polarization of the uniform plane wave;

(c) the corresponding magnetic field **H**.

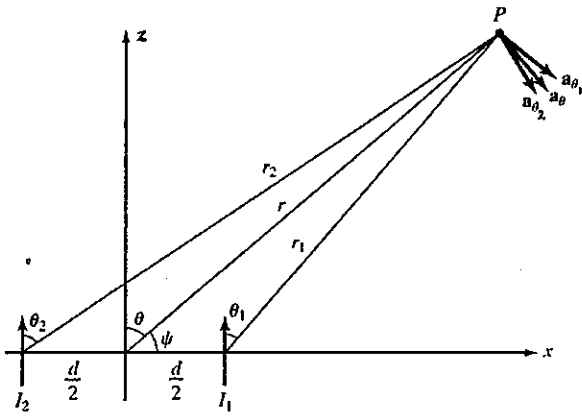
2. (20%) The region between the two parallel plates $0<x<d$ is filled with two perfect dielectric media having permittivities ε_1 for $0<x<t$ (region 1) and ε_2 for $t<x<d$ (region 2). The two parallel plates are applied by potential V_0 and 0, respectively.

(a) What are the boundary conditions to be satisfied at $x=t$. (4%)

(b) Find the solutions for the potentials in the two regions $0<x<t$ and $t<x<d$. (8%)

(c) Find the capacitance per unit area of the plates. (8%)

3. (15%) For the radiation field of two Hertzian dipoles, the electric fields of the individual dipoles are



$$\mathbf{E}_1 = -\frac{\eta\beta I_0\, dl \sin\theta_1}{4\pi r_1}\sin\left(\omega t - \beta r_1 + \frac{\alpha}{2}\right)\mathbf{a}_{\theta_1}$$

$$\mathbf{E}_2 = -\frac{\eta\beta I_0\, dl \sin\theta_2}{4\pi r_2}\sin\left(\omega t - \beta r_2 - \frac{\alpha}{2}\right)\mathbf{a}_{\theta_2}$$

For $r \gg d$, so that $\theta_1 \approx \theta_2 \approx \theta$ and $\mathbf{a}_{\theta_1} \approx \mathbf{a}_{\theta_2} \approx \mathbf{a}_\theta$

$$r_1 \approx r - \frac{d}{2}\cos\psi$$

$$r_2 \approx r + \frac{d}{2}\cos\psi$$

(a) (3%) Please show that the total field $\mathbf{E} = \mathbf{E}_1 + \mathbf{E}_2$ is equal to

$$-\frac{2\eta\beta I_0\, dl \sin\theta}{4\pi r}\cos\left(\frac{\beta d\cos\psi + \alpha}{2}\right)\sin(\omega t - \beta r)\,\mathbf{a}_\theta$$

(b) (12%) Please plot the group patterns for

(i) $d = \lambda,\ \alpha = 0$;

(ii) $d = \lambda/4,\ \alpha = -\pi/2$;

(iii) $d = \lambda/2,\ \alpha = 0$;

(iv) $d = \lambda/2,\ \alpha = \pi$.

4. (20%) The $\omega - \beta$ curve for a dispersive medium can be expressed by

$$\frac{1}{\omega^2} = \frac{1}{\omega_0^2} + \frac{\tau^2}{\beta^2}$$

where τ is a constant. Find

(a) the phase velocity for a signal of $0.8\omega_0$;

(b) the group velocity for a narrow-band signal having the center frequency of $0.8\omega_0$.

5. (20%) In the system shown in the following figure, find the values of **(a)** the reactance ***X*** and **(b)** the characteristic impedance Z_{02} of line 2 for which the power delivered to the load Z_R is a maximum.

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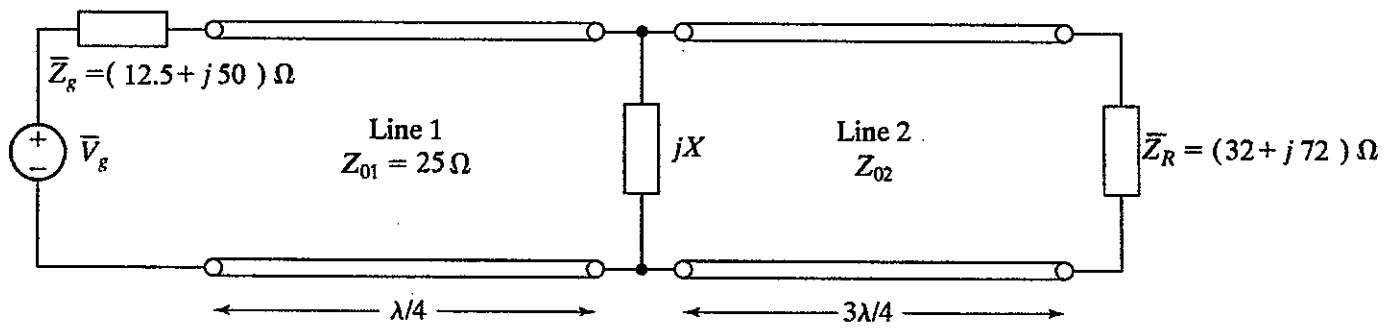
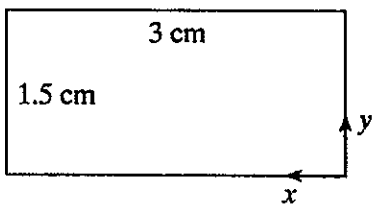
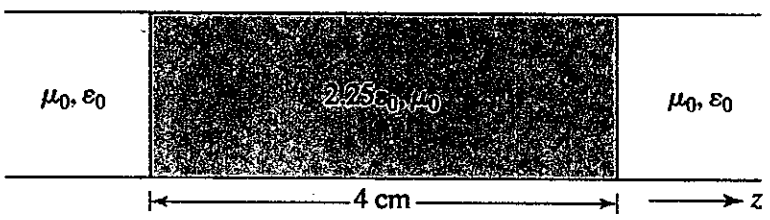


6. (10%) Transparency of dielectric slab in an air–dielectric rectangular waveguide. A dielectric slab of thickness 4 cm and permittivity exists in an air-dielectric rectangular waveguide of dimensions and as shown in the following figure. Find **the lowest frequency** for which the dielectric slab is transparent (*i.e.*, allows complete transmission) for mode propagation in the waveguide.





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