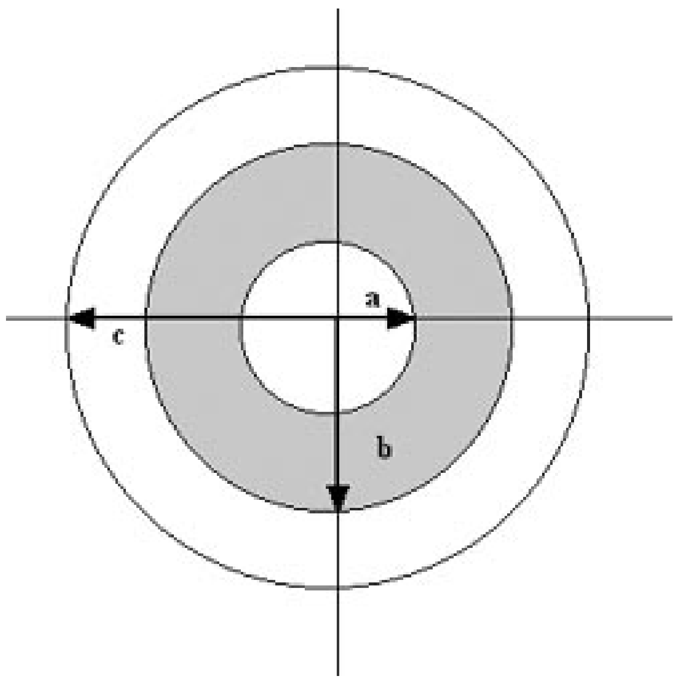
EECS 117A, Fall 1995
Final Exam
Professor A.R. Neureuther

Problem #1 (70 Points) Concepts from Electrostatics, Magnetostatics and Maxwell's Equations

A coaxial transmission line consists of an inner perfect electric conductor of radius **a**, a material inner lining from **a** < **r** < **b**, and an outer perfect electrical conductor of radius **c**. The material lining has U_r = 10 and E_r = 4. The dimensions **a**, **b**, and **c** are 2, 4, and 6 mm respectively.

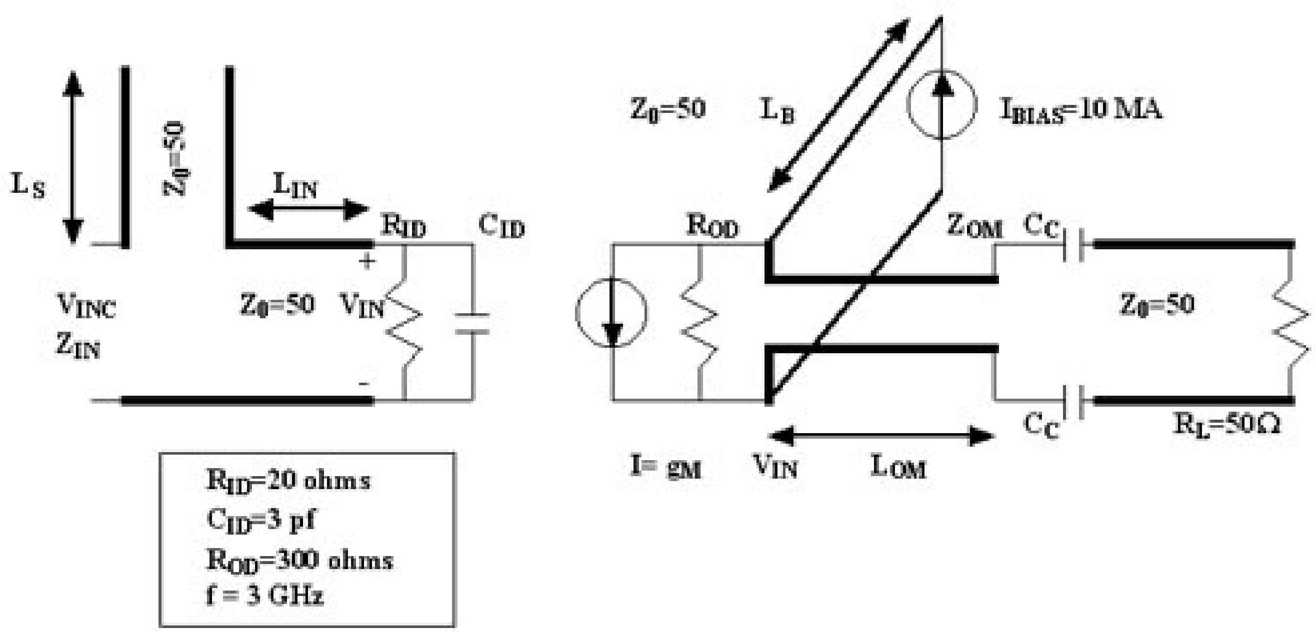


I.a. (20 Points) Find the magnetic flux density vector **B** at the radius **r** of 3 mm and 8 mm when a current of 1 mA flows in the inner conductor and a current of 0.5 mA flows in the opposite direction in the outer conductor.

I.b. (25 Points) Using Stoke's Theorem show how to derive an equation for the change in voltage with position down the transmission line as a function of the change in current with time. Identify in your derivation and algebraic expression for the inductance per unit length. Hint: Start with a sketch of the geometry and mathematical construct.

I.c. (25 Points) State if the line is despersive and or lossy and give an expression for the phase velocity as a function of the angular frequency w, radial dimensions and material properties.

Problem #2 (80 Points) Transmission Lines Time-Harmonic



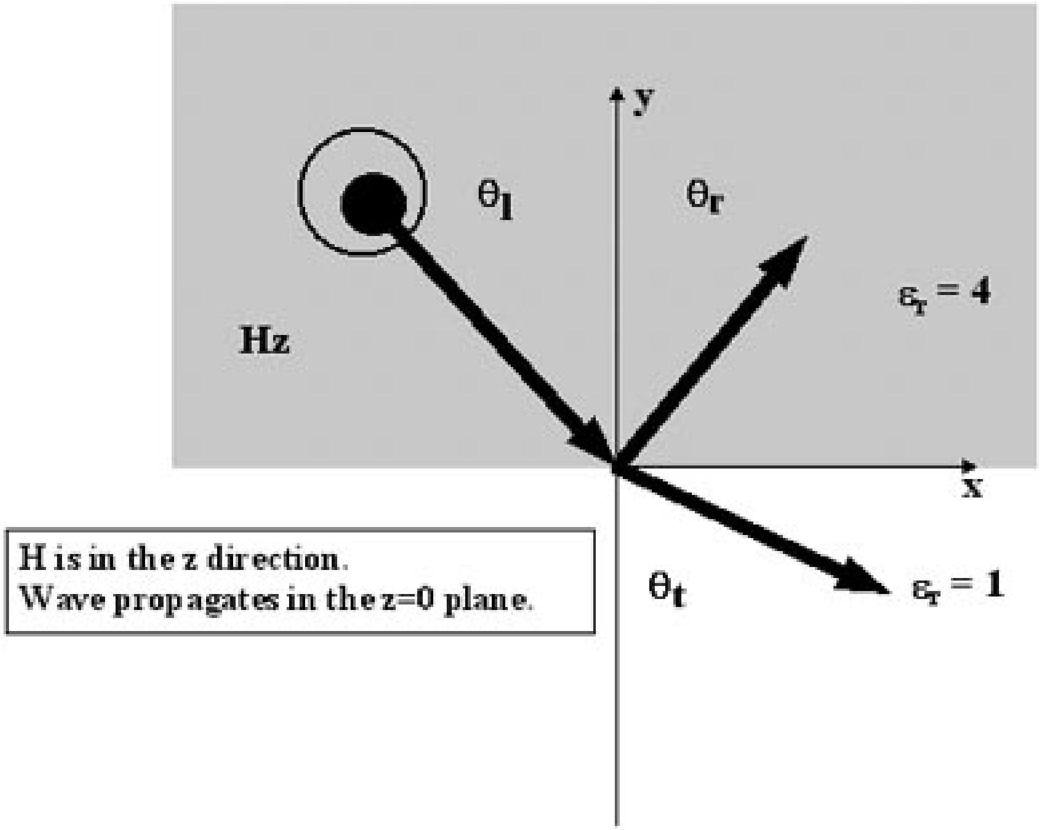
II.a. (15 Points) The output circuit consists of a bias line of length $\mathbf{L_B}$ and a quarter wave matching line with impedance $\mathbf{Z_{OM}}$. Explain how the length $\mathbf{L_B}$ can be chosen such that the current source does not load the a.c. circuit and specify the impedance $\mathbf{Z_{OM}}$ to match $\mathbf{R_{OD}}$ to a 50 ohm output.

II.b. (15 Points) Design the coupling capcitors $\mathbf{C_C}$ such that the voltage reflection back toward the device is **0.01**.

II.c. (25 Points) Design the length of the stub $\mathbf{L_s}$ and the length of the line $\mathbf{L_{IN}}$ to make $\mathbf{Z_{IN}}$ = 50 ohms. Do your work on the Smith Chart on the following page.

II.d. (25 Points) Assuming the input has been matched as in part b) find and algebraic expression for the ratio $\mathbf{V_{IN}/V_{INC}}$ in terms of $\mathbf{Z_{STUB}}$ and the input impedance to the device $\mathbf{Z_{ID}}$ (which is $\mathbf{R_{ID}}$ and $\mathbf{C_{ID}}$ in parallel).

Problem #3 (65 Points) Plane Waves



III.a. (15 Points) Write out expressions for the z component of the magnetic field **H** as a function of spatial location for the incident, reflected and transmitted plane waves using a single phasor for each as well as $\mathbf{k_O}$, $\mathbf{E_r}$, $\mathbf{O_l}$, and $\mathbf{O_t}$.

III.b. (15 Points) Using your representation from a) determine the electric field associated with the incident wave as a function of spatial location.

III.c. (20 Points) Explain why making the tangential components of the magnetic field plane waves continuous at a boundary in a problem such as in the above geometry automatically guarantees that the normal component of the D field is also continuous.

III.d. (15 Points) Is it possible to find a material for which the total internal reflection and the Brewster angle effect occur at the same angle of incidence?.

Problem #4 (45 Points) Antennas and Radiation Systems Aspects

The navigation radar on a small boat operates at 10 GHz with a 7 Mhz bandwidth, peak power of 1.5 kW and Noise Figure of 9 db. The antenna is housed in a plastic circular disk 40 cm in diameter by 15 cm high and rotates. The target is a 20 cm diameter corner reflector on the mast of a sailboat. For convenience neglect any effects of and waves which reflect from the ocean surface.

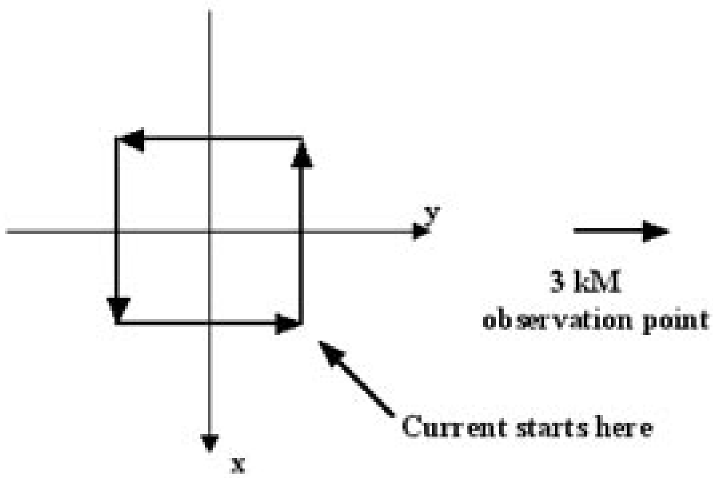
IV.a. (20 Points) Estimate 1) the horizontal full-width half-power beamwidth in degrees, 2) the distance resolution in meters, and 3) the gain.

IV.b. (25 Points) Estimate the maximum range to have 15 db S/N ratio.

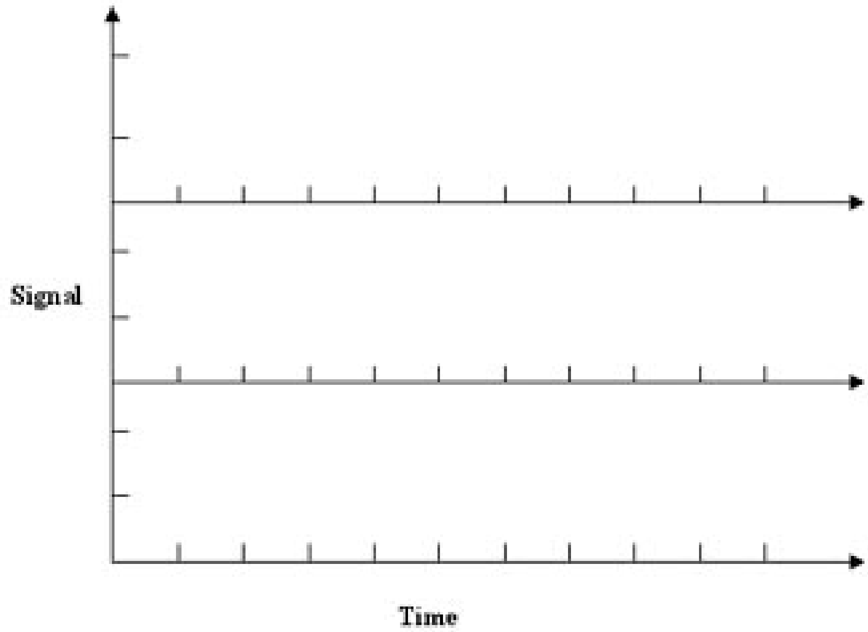
Problem #5 (40 Points) Antennas and Radiation Concepts Including Time-Domain

A radiating system consists of a very short (30 ps) duration square pulse of 10 mA current which travels around a square loop 60 cm on a side at the speed of light. The rectangle lies in the z=0 plane and the direction vectors along the sides are in the x and y directions. The pulse starts at (x,y) of (30cm, 30cm) and propagates in the -x direction. The observation point is at (x,y) of (0, 3km).

V.a. (15 Points) What is the approximate delay from the signal source to the observation point and at the observation point which far field spherical coordinate system components of the vectors **A**, **B**, and **E** will be present?. Explain your answers.



V.b. (25 Points) For each of the components of the vector **A** sketch the behavior as a function of time once the pulse begins to arrive and label the sketch with a quantitative value of one of the nonzero levels.


Signal
Time
