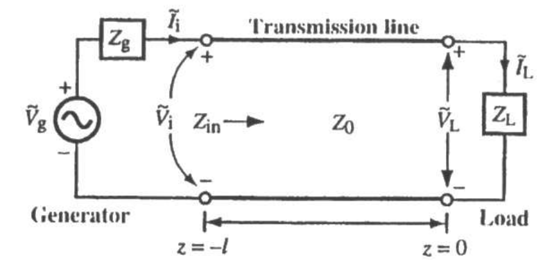
Question 1.



Consider the lossless transmission line shown above. The following values are given:

$\tilde{V}_g = 100\text{V}\angle 0°$ $\quad$ f = 100 MHz $\quad$ $u_p = c = 3.0\times 10^8$ m/s $\quad$ $l = 2$ m

$Z_g = 40\ \Omega$ $\quad$ $Z_0 = 50\ \Omega$ $\quad$ $Z_L = 30\ \Omega - j40\ \Omega$

Calculate:

(a) the voltage standing wave ratio (S);
(b) the input impedance (Z_{in});
(c) the voltage at the source plane ($\tilde{V}_i$);
(d) the average power absorbed in the load (P_{av});
(e) the load current ($\tilde{I}_L$).

Question 2.

Figure 1 to the right shows a microstrip line. Formulas for the wavelength (λ_m) and characteristic impedance (Z_0) of microstrip transmission lines are complicated due to the fact that the dielectric constants above and below the line are different. As a result, the design of microstrip transmission lines is usually done graphically with the aid of design graphs. Figure 2 below shows the characteristic impedance (Z_0) of the microstrip line as a function of line width (W) to dielectric support thickness (H) ratio for different values of support material dielectric constant (ε).
Figure 3 below shows the reduction of the free space wavelength (λ_0) in the microstrip line as a function of the width-to-thickness ratio (W/H) for different substrate dielectric constants (ε).

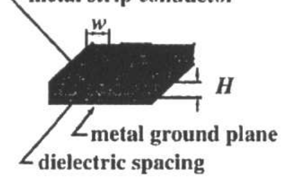


Figure 1

<u>Design</u> a 30 Ω microstrip line on a 0.635 mm thick dielectric support made of alumina (ε = 9.6) to operate at 10 GHz. *In other words*, find the line width W and the operating wavelength λ_m of the microstrip transmission line.

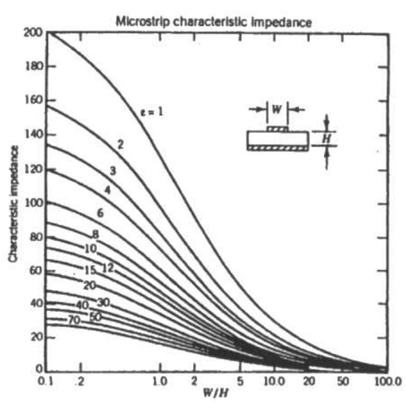


Figure 2

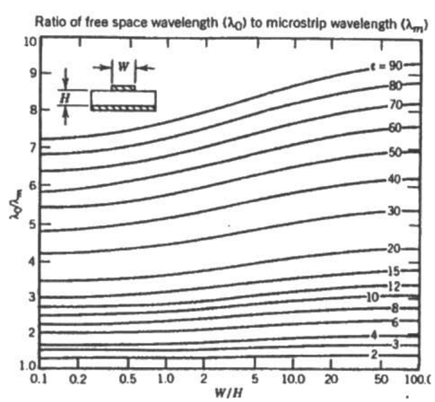


Figure 3

Question 3.

A cylindrical chamber consists of an inner solid cylinder of radius *a* and an outer cylindrical shell of inner radius *b* and outer radius *c*. The inner cylinder and the outer cylindrical shell have a length *l* and both are perfect conductors. The potential difference between the inner and outer conductors is V. The region between the inner and outer conductors is filled with a dielectric material having a relative permittivity ε_r.

a. Sketch the configuration described above and the charge distribution in/on the inner conductor, the outer conducting cylindrical shell and the dielectric medium.

b. Derive an expression for the surface charge density on the inner conducting cylinder and state the units for the surface charge density.

Question 4.

A cylindrical lightning rod of radius *a* is placed into a bore hole. The depth of the hole is *d* and let σ be the electrical conductivity of the earth. A current of amplitude *I* flows through the rod when the rod is struck by lightning. A person happens to stand a distance *C* from the rod. The person's right foot is placed at position *C* and the left foot is at a distance *C* + *ΔC* from the rod.

a. Sketch the configuration described above.

b. Calculate the potential difference between the person's two feet and describe what the consequences of this are. (Make any reasonable assumptions.)

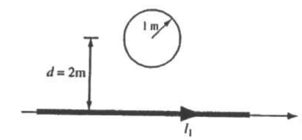
c. Stae three ways in which the person could have reduced the level of current passing through his/her body.

<u>Additional Hint for Question 4:</u>

Assume that you are dealing with a cylindrical geometry and the outer conductor is placed at infinity.

Question 5. (NOTE: <u>This question is worth 20 marks</u>. Part A is on this page; Part B is on p. 9)

Part A. (10 marks)
An infinitely long wire carrying a 50 A DC current in the positive *x*-direction is placed along the *x*-axis in the vicinity of a 10-turn circular loop located in the *x-y* plane, as shown in the figure to the right.



If the magnetic field at the center of the loop is zero, determine is the <u>magnitude</u> and <u>direction</u> of the current flowing in the loop.

Question 5. (NOTE: <u>This question is worth 20 marks</u>. Part B is on this page; Part A is on p. 8)

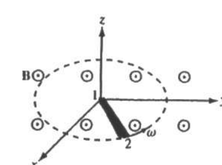
Part B. (10 marks)
A co-axial transmission line consists of an inner solid conductor of radius *a* and an outer conducting shell having an inner radius *b* and outer radius *c*. The region $a \le r \le b$ is filled with a material having a relative permeability μ_r and a relative permittivity ε_r. The line has a total length *h*.

a. Derive an expression for the L′, the inductance per meter of the line. Consider only the region $a \le r \le b$. (**NOTE**: A derivation must be provided; minimal marks will be given if the final expression for L′is given without a derivation.)

b. A co-axial line of the type considered in (a) is to have an inductive reactance of 50 Ω/m at 10 MHz. The radius of the inner conductor is 5 cm. Determine the inner radius *b* of the outer conductor.

Question 6. (NOTE: <u>This question is worth 10 marks</u>.)

The 40 cm long rod rotates about the z-axis at 180 revolutions per minute, with end 1 fixed at the origin, as shown in the figure to the right.



Determine the <u>induced emf</u> V_{12} if the flux density **B** = **z**400 μT (i.e. the magnetic field is constant and is oriented in the positive **z**-direction).7