HW #2

All are at the end of Chapter 2.

P1. Problem 2.1 in 7/E (i.e. Problem 2.1 in 6/E)

Problem 2.1 A transmission line of length \( l \) connects a load to a sinusoidal voltage source with an oscillation frequency \( f \). Assuming the velocity of wave propagation on the line is \( c \), for which of the following situations is it reasonable to ignore the presence of the transmission line in the solution of the circuit:

(a) \( l = 20 \text{ cm}, f = 20 \text{ kHz} \),
(b) \( l = 50 \text{ km}, f = 60 \text{ Hz} \),
(c) \( l = 20 \text{ cm}, f = 600 \text{ MHz} \),
(d) \( l = 1 \text{ mm}, f = 100 \text{ GHz} \).

P2. Problem 2.3 in 7/E (i.e. Problem 2.3 in 6/E; 2.4 in Answer Sheet).

Problem 2.4 Show that the transmission line model shown in Fig. 2-37 (P2.4) yields the same telegrapher’s equations given by Eqs. (2.14) and (2.16).

P3. Problem 2.4 in 7/E (i.e. Problem 2.4 in 6/E; 2.3 in Answer Sheet). Read Section 2.2 before working on this problem. Use formulas given in Table 2.1, which we do not cover in class. The purpose of this homework problem is for you to learn about transmission lines other than co-ax cables.

Problem 2.3 A 1-GHz parallel-plate transmission line consists of 1.2-cm-wide copper strips separated by a 0.15-cm-thick layer of polystyrene. Appendix B gives \( \mu_c = \mu_0 = 4\pi \times 10^{-7} \text{ (H/m)} \) and \( \sigma_c = 5.8 \times 10^7 \text{ (S/m)} \) for copper, and \( \varepsilon_r = 2.6 \) for polystyrene. Use Table 2-1 to determine the line parameters of the transmission line. Assume \( \mu = \mu_0 \) and \( \sigma \approx 0 \) for polystyrene.

P4. Problems 2.6 & 2.8 (same problems #‘s in 7/E & 6/E; Problems 2.2 & 2.5 in Answer Sheet). Read Section 2.2 before working on this problem. Use formulas given in Table 2.1, which we do not cover in class. Find properties of copper from the above problem or in Table B2 in Appendix B of the textbook. The purpose of this homework problem is for you to learn about actual (not ideal) co-ax cables.
Problem 2.2  Calculate the line parameters $R', L', G'$, and $C'$ for a coaxial line with an inner conductor diameter of 0.5 cm and an outer conductor diameter of 1 cm, filled with an insulating material where $\mu = \mu_0$, $\varepsilon_r = 4.5$, and $\sigma = 10^{-3}$ S/m. The conductors are made of copper with $\mu_c = \mu_0$ and $\sigma_c = 5.8 \times 10^7$ S/m. The operating frequency is 1 GHz.

Problem 2.5  Find $\alpha, \beta, \nu$, and $Z_0$ for the coaxial line of Problem 2.2.

P5. Problem 2.13 in 7/E (same # in 6/E; Problem 2.6 in Answer Sheet).

Problem 2.6  In addition to not dissipating power, a lossless line has two important features: (1) it is dispersionless ($\mu_p$ is independent of frequency) and (2) its characteristic impedance $Z_0$ is purely real. Sometimes, it is not possible to design a transmission line such that $R' \ll \omega L'$ and $G' \ll \omega C'$, but it is possible to choose the dimensions of the line and its material properties so as to satisfy the condition

$$R' C' = L' G' \quad \text{(distortionless line)}.$$

Such a line is called a distortionless line because despite the fact that it is not lossless, it does nonetheless possess the previously mentioned features of the loss line. Show that for a distortionless line,

$$\alpha = R' \sqrt{\frac{C'}{L'}} = \sqrt{R' G'}, \quad \beta = \omega \sqrt{L' C'}, \quad Z_0 = \sqrt{\frac{L'}{C'}}.$$

P6. Problem 2.16 in 7/E (same # in 6/E; Problem 2.9 in Answer Sheet).

Problem 2.9  A transmission line operating at 125 MHz has $Z_0 = 40 \ \Omega$, $\alpha = 0.02$ (Np/m), and $\beta = 0.75$ rad/m. Find the line parameters $R', L', G'$, and $C'$.

Hint: This is a lossy transmission line since $\alpha \neq 0$, but $Z_0$ is purely resistive.

P7. Problem 2.19 in 7/E (i.e. Problem 2.19 in 6/E; Problem 2.12 in Answer Sheet).

P8. Problem 2.21 in 7/E (i.e. Problem 2.21 in 6/E; Problem 2.13 in Answer Sheet).

P9. Problem 2.31 in 7/E (i.e. Problem 2.31 in 6/E; Problem 2.21 in Answer Sheet).

P10. Problem 2.17 in 7/E (i.e. Problem 2.17 in 6/E; Problem 2.10 in Answer Sheet).