1. The amplitude of an FM Radio Wave is described by the function:

\[ y(x,t) = 1.5 \cos(2 \times 10^8 \pi t - \frac{2}{3} \pi x + \frac{\pi}{3}) \ e^{-0.0005x} \ \text{(Volts)} \]  \hspace{1cm} (1)

(a) What is the amplitude \( A \), the period \( T \), the frequency \( f \), the wavelength \( \lambda \), the reference phase \( \phi_0 \) and the attenuation factor \( \alpha \)? The velocity of light in the air is \( c = 3 \times 10^8 \text{ m/sec} \). The propagation constant is given by \( \beta = \frac{2\pi}{\lambda} \) and \( \omega = 2\pi f \) is the radial frequency. What is the value of \( \beta \) and \( \omega \)? DO NOT FORGET THE UNITS!!

(b) Is the wave propagating to the positive or to the negative \( x \)-direction and why?

(c) What will be the amplitude of the FM wave for \( t = 10^{-5} \) sec and \( x = 3 \) km? Supposing that a Radio receiver can pick up FM waves with amplitude larger than 0.1 V without deterioration of the quality of reception, could a radio placed at \( x = 3 \) km receive efficiently this FM wave at \( t = 10^{-5} \) sec ?

2. A transmission line of length \( l \) connects a wireless communication antenna to a voltage source with frequency \( f \). Assuming that the velocity of wave propagation on the line is \( c = 3 \times 10^8 \text{ m/sec} \), for which of the following situations is it reasonable to ignore the presence of the transmission line in the solution of the circuit:

(a) \( l = 0.1 \text{ m}, \ f = 1 \text{ GHz} \)

(b) \( l = 1 \text{ m}, \ f = 1.8 \text{ GHz} \)

(c) \( l = 0.01 \text{ m}, \ f = 0.9 \text{ GHz} \)

(d) \( l = 5 \text{ cm}, \ f = 5.4 \text{ GHz} \)

3. A 50-Ω lossless coaxial transmission line is terminated in an antenna with impedance \( Z_L = (30 - j60)\Omega \). The wavelength is 5 cm. Find

(a) The reflection coefficient \( \Gamma \) at the load.

(b) The Standing Wave Ratio \( S \) on the line.

(c) If the electrical length of the coaxial line is \( l = 0.35\lambda \), what is the input impedance?

(d) If under matched conditions \( (Z_L) \) the transmitter can deliver 10 Watts to the load, how much power does it deliver to the antenna?

4. A 50Ω lossless line used in a Radar Filter:

(a) has electrical length \( l = \frac{1}{4} \) and is terminated with 60Ω resistive load. What is the reflection coefficient and the input impedance?

(b) has electrical length \( l = \frac{1}{8} \) and is terminated with an Open Circuit. What is the reflection coefficient and the input impedance? Does the Open Circuit behave as an inductor or as a capacitor?
(c) has electrical length \( l = \frac{\lambda}{2} \) and is terminated with a Short Circuit. What is the reflection coefficient and the input impedance? Does the Short Circuit behave as an inductor or as a capacitor?

5. A lossless 50 – \( \Omega \) transmission line is terminated at an VHF antenna load with \( Z_L = (50 + j25)\Omega \).
   Use the Smith chart to find:
   (a) the reflection coefficient \( \Gamma \),
   (b) the standing-wave ratio,
   (c) the input impedance at 0.35\( \lambda \) from the load,
   (d) the input admittance at 0.35\( \lambda \) from the load,
   (e) the shortest line length for which the input impedance is purely resistive (no imaginary part).
   (f) compare the results of the Smith Chart with those obtained by the theoretical formulas for the reflection coefficient, the standing-wave ratio and the input impedance. (DO NOT FORGET THE PHASE FOR THE REFLECTION COEFFICIENT AND FOR INPUT IMPEDANCE).

6. A lossless 50\( \Omega \) microstrip transmission line, that is used in a radar filter, is terminated in a short circuit. Use the Smith chart to find
   (a) the reflection coefficient \( \Gamma \),
   (b) the input impedance at a distance 2.3\( \lambda \) from the load,
   (c) the input admittance at a distance 2.3\( \lambda \) from the load.

7. A lossless 50\( \Omega \) coaxial transmission line is to be matched to a satellite parabolic antenna with \( Z_L = (75 – j20)\Omega \) using an open-circuited stub. Use the Smith chart to determine the stub length and the distance between the antenna and the stub. (There are two matching points with different stub lengths and distances).

8. A 100 – \( MHz \) FM broadcast station uses a 300 – \( \Omega \) transmission line between the transmitter and a tower-mounted half-wave dipole antenna. The antenna impedance is 73\( \Omega \). You are asked to design a quarter-wave transformer to match the antenna to the line.
   (a) Determine the electrical length and characteristic impedance of the quarter-wave section.
   (b) Determine the physical length of the quarter-wave section if it is made of polystyrene with \( \varepsilon_r = 2.56 \). (HINT: \( \lambda = c/f \) is the wavelength and \( c = 3.08/\sqrt{\varepsilon_r} \ m/sec \) is the velocity of the light in a material with \( \varepsilon_r \)).

9. An antenna with characteristic impedance \( Z_L = 100 + j20 \ \Omega \) has to be matched to a filter with \( Z_o = 50 \ \Omega \). There are two available options: matching with lumped elements (L,C) and quarter-wavelength transformer. Which one is preferable and how it can be implemented (find design values).

10.* Two cable TV lines of 50\( \Omega \) and 150\( \Omega \) have to get matched with maximum allowable reflection coefficient \( \Gamma_m = 5\% \). Design a three-section binomial transformer and a three-section Chebyshev transformer and compare the respective bandwidths.

(*) Non-graded (Practice) Problems.