The amplitude of an FM Radio Wave is described by the function
\[ Y(x,t) = 1.5\cos(2\times10^8 \pi t - 2/3 \pi x + \pi/3) e^{-0.0005x} \text{ (Volts)} \]

(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 \( c=3\times10^8 \) m/sec.

(b) What are the values of the propagation constant \( \beta \) and of the radial frequency \( \omega \)? Do not forget the units!

(c) What is the propagation direction and why?

(d) What will be the amplitude of the FM wave for \( t=10^{-5} \) sec and \( x=3\text{km} \)? Supposing that a Radio receiver can pick up FM waves with amplitude larger than 0.1V without deterioration of the quality of reception, could a radio placed at the above distance 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 is \( c=3\times10^8 \) m/sec, for which of the following situations it is reasonable to ignore the presence of the transmission line in the analysis 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) \( L=5\text{cm} \), \( f=60 \text{ GHz} \)

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

(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, the transmitter can deliver 10 Watts to the load, how much power does it deliver to this antenna?

4. A 50W lossless line used in a Radar filter:

(a) has electrical length \( L=\lambda/4 \) and is terminated with a 60\( \Omega \) resistive load. What is the reflection coefficient and the input impedance?

(b) has electrical length \( L=\lambda/8 \) 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 and why?

(c) Has electrical length \( L=\lambda/6 \) and is terminated with a Short Circuit? What is the reflection coefficient and the input impedance? Does the Short Circuit behave as and inductor or as a capacitor and why?

5. A lossless 50 \( \Omega \) microstrip transmission line, that is used in a nanosensor is terminated in a short circuit. Find:

(a) The reflection coefficient \( \Gamma \)
(b) The input impedance at a distance 2.3λ from the load
(c) The input admittance at a distance 2.3λ from the load

6. A lossless 50Ω coaxial transmission line is to be matched to a satellite parabolic antenna with \( Z_L = (75-j20)\Omega \) using an L,C matching network around the center frequency of 6GHz.
(a) Calculate the TWO solutions and their respective bandwidth for \( \Gamma_M=0.05 \).
(b) How would the matching circuit get modified if we used a different antenna with \( Z_L=(25-j20)\Omega \). Calculate the new TWO solutions and their respective bandwidth for \( \Gamma_M=0.05 \).

7. A 100 MHz FM broadcast station uses a 300Ω transmission line between the transmitter and a tower-mounted half-wave dipole antenna with impedance equal to 73Ω. You are asked to match the antenna to the line.
(a) Using a quarter-wave section, determine the electrical length and the characteristic impedance of the quarter-wave section.
(b) Determine the physical length of the quarter-wave section if it is made of polyesterene with \( \varepsilon_r=2.56 \).
(c) What is the bandwidth of the transformer for \( \Gamma_M=5\% \)?
(d) Using a 3-stage binomial transformer, determine the characteristic impedance and the electrical length of each section
(e) What is the bandwidth of the binomial transformer for \( \Gamma_M=5\% \)?