CMPE 330 **Spring 2017** **Problem Set #1**

NOTE: Solutions are available for many of the problems. You must show complete work for full credit.

When nothing else is stated, carry out calculations to at least four significant figures and report three.

1. Determine the wavelength at the following frequencies in the SI and English units that are requested. The speed of light in a vacuum is 2.9979×10^8 m/s, but the speed of light in air differs from that in the vacuum in the fifth digit. In general, it makes no sense to report more significant digits than the accuracy of your starting data (in this case the speed of light). [based on Paul 1.2.1, p. 23].
   a. Long-range navigation 150 Hz (km, mi)
   b. Submarine communication 2.5 kHz (km, mi)
   c. Automatic detection finder in aircraft 350 kHz (km, mi)
   d. AM radio transmission 2.0 MHz (m, ft)
   e. Amateur radio 55 MHz (m, ft)
   f. FM radio transmission 125 MHz (m, ft)
   g. Instrument landing system 300 MHz (cm, ft)
   h. Satellite 6.75 GHz (cm, in)
   i. Remote sensing 45 GHz (mm, mils)
2. A sinusoidal current wave is described. Determine the velocity of propagation and the wavelength. From the distance d that the wave travels, determine the time delay and the phase shift. Report results to two significant figures. Note that t and z in the formulae are in seconds and meters respectively. [based on Paul 1.2.3, p. 23].
   a. $i(t, z) = I_0 \cos(4\pi \times 10^6 t - 4.5 \times 10^{-2} z)$, $d = 4$ km.
   b. $i(t, z) = I_0 \cos(10\pi \times 10^9 t - 200z)$, $d = 3$ in.
   c. $i(t, z) = I_0 \cos(20\pi \times 10^7 t - 3.5z)$, $d = 10$ ft.
   d. $i(t, z) = I_0 \cos(3\pi \times 10^3 t - 32 \times 10^{-6} z)$, $d = 50$ mi.

3. A current wave traveling along a transmission line in the $+x$-direction is given by [based on Ulaby and Ravaioli 1.7 p. 45]

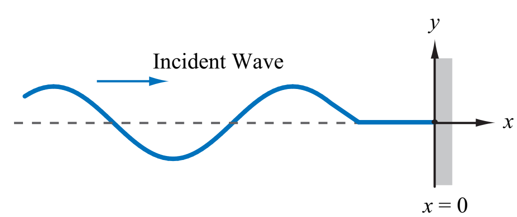
$$y_1(x,t) = A\cos(\omega t - \beta x)$$

where $x = 0$ is the end of the transmission line. At that point, the current is shorted and must equal zero, as shown in the attached figure [Ulaby and Ravaioli, Fig. P1.7]. When the wave $y_1(x,t)$ arrives at the wall, a reflected wave $y_2(x,t)$ is generated. Hence, at any location on the string, the vertical displacement y_s is the sum of the incident and reflected waves:

$$y_\mathrm{s}(x,t) = y_1(x,t) + y_2(x,t)$$

a. Write an expression for $y_2(x,t)$, keeping in mind its direction of travel and the fact that the current must be zero at $x = 0$.

b. Generate plots of $y_1(x,t)$, $y_2(x,t)$, and $y_\mathrm{s}(x,t)$ versus x over the range $-2\lambda \leq x \leq 0$ at $\omega t = \pi/4$ and at $\omega t = \pi/2$. Show the detailed calculations or MATLAB code that you used to generate the plots



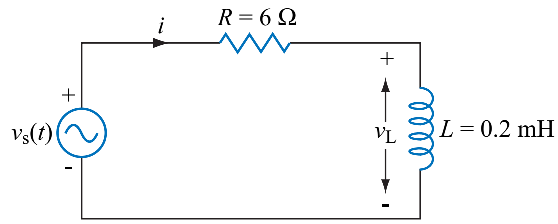
4. A certain electromagnetic wave traveling in seawater was observed to have an amplitude of 196.04 (V/m) at a depth of 10 m, and an amplitude of 163.74 (V/m) at a depth of 100 m. What is the attenuation coefficient of seawater? You should report five significant figures in your answer. Why? [modified from Ulaby and Ravaioli 1.14, p. 45]

5. If $z = -2 + j2$, determine the following quantities in polar form [modified from Ulaby and Ravaioli 1.19, p. 45]: (a) $1/z$, (b) z^3, (c) $|z|^2$, (d) $\mathrm{Im}(z)$, (e) $\mathrm{Im}(z^*)$, (f) $\sqrt{z}$

6. Find the following [modified from Ulaby and Ravaioli 1.22–1.24, p. 45]: (a) $\ln(3 - j5)$, (b) $\exp(3 - j4)$, (c) $\exp[3\exp(j\pi/6)]$. Use both a hand calculator and MATLAB. For the hand calculator, show your work. For MATLAB, show the input and output lines.

7. Consider the RL circuit in Ulaby's example 1-4 [pp. 33–34], shown in the attached figure [Ulaby and Ravaioli fig. 1-21]. Given an input voltage,

$$v_s(t) = 5\sin(4\times 10^4 t - 30°)$$



show without using phasors that the voltage across the inductor is given by

$$v_L(t) = 4\cos(4\times 10^4 t - 83.1°)$$

[Hint: You will have to begin by assuming that $i(t)$ has the form $i(t) = A\cos(\omega t + \phi_0 - \phi_1)$. The task is to determine A and ϕ_1. After substitution into the time domain equation, Eq. 1.70, you will have to use the difference formulae for the cosine and sine functions, $\cos(A - B) = \cos A\cos B + \sin A \sin B$ and $\sin(A - B) = \sin A\cos B - \cos A\sin B$, to find the coefficients of $\cos(\omega t + \phi_0)$ and $\sin(\omega t + \phi_0)$. That will give you two equations for two unknowns, $A\cos\phi_1$ and $A\sin\phi_1$. After solving those equations, you can solve the problem by using the relation $v_L = LdI/dt$.]

8. Find the phasors of the following time functions [Ulaby, et al. 1.26, p. 46]:

   (a) $v(t) = 9\cos(\omega t - \pi/3)\ (V)$,

   (b) $v(t) = 12\sin(\omega t + \pi/4)\ (V)$,

   (c) $i(x,t) = 5\exp(-3x)\sin(\omega t + \pi/6)\ (A)$,

   (d) $i(t) = -2\cos(\omega t + 3\pi/4)\ (A)$,

   (e) $i(t) = 4\sin(\omega t + \pi/3) + 3\cos(\omega t - \pi/6)\ (A)$