ECE 341 Homework #1

P1. Problem 1.3 of 8/E of textbook (i.e. Problem 1.1 in 7/E or earlier as shown below):

1.1 A 2 kHz sound wave traveling in the x direction in air was observed to have a differential pressure \( p(x, t) = 10 \text{ N/m}^2 \) at \( x = 0 \) and \( t = 50 \mu \text{s} \). If the reference phase of \( p(x, t) \) is 36°, find a complete expression for \( p(x, t) \). The velocity of sound in air is 330 m/s.

P2. Problem 1.2 in Textbook 8/E or earlier versions (Example 1-1 refers to the Example in the text, not Problem 1.1 in PROBLEMS):

Problem 1.2 For the pressure wave described in Example 1-1, plot
(a) \( p(x,t) \) versus \( x \) at \( t = 0 \),
(b) \( p(x,t) \) versus \( t \) at \( x = 0 \).
Be sure to use appropriate scales for \( x \) and \( t \) so that each of your plots covers at least two cycles.

P3. Problem 1.1 in Textbook 8/E (i.e. Problem 1.3 in earlier versions as shown below):

Problem 1.3 A harmonic wave traveling along a string is generated by an oscillator that completes 180 vibrations per minute. If it is observed that a given crest, or maximum, travels 300 cm in 10 s, what is the wavelength?

P4. Problem 1.5 in Textbook 8/E:

Two waves, \( y_1(t) \) and \( y_2(t) \), have identical amplitudes and oscillate at the same frequency, but \( y_2(t) \) leads \( y_1(t) \) by a phase angle of 60°. If
\[
y_1(t) = 4\cos(2\pi \times 10^3 \, t),
\]
write down the expression appropriate for \( y_2(t) \) and plot both functions over the time span from 0 to 2 ms.

Note: We often call a sinusoidal function of time a "wave." This is not in a strict sense, as a wave is a function of both time and position. Better to say a "waveform" (as you can see with an oscilloscope) or a "signal."

Note: To "lead" means to be ahead of, thus the + sign. It is as if \( y_2 \) started earlier: At \( t = 0 \), \( y_1 \) is at phase zero while \( y_2 \) is already at phase 60°.
P5. Problem 1.6 in Textbook 8/E:

The height of an ocean wave is described by the function

\[ y(x,t) = 1.5 \sin(0.5t - 0.6x) \text{ (m).} \]

Determine the phase velocity and the wavelength and then sketch \( y(x,t) \) at \( t = 2 \text{ s} \) over the range from \( x = 0 \) to \( x = 2\lambda \).

P6. Problem 1.7 in Textbook 8/E:

A wave traveling along a string in the \(+x\)-direction is given by

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

where \( x = 0 \) is the end of the string, which is tied rigidly to a wall, as shown in Fig. 1-21 (P1.6). When 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 \( y_s \) will be the sum of the incident and reflected waves:

\[ y_s(x,t) = y_1(x,t) + y_2(x,t). \]

(a) Write an expression for \( y_2(x,t) \), keeping in mind its direction of travel and the fact that the end of the string cannot move.

(b) Generate plots of \( y_1(x,t) \), \( y_2(x,t) \) and \( y_s(x,t) \) versus \( x \) over the range \(-2\lambda \leq x \leq 0\) at \( \omega t = \pi/4 \) and at \( \omega t = \pi/2 \).
P7. Problem 1.8 in Textbook 8/E:
Two waves on a string are given by the following functions:

\[ y_1(x,t) = 4 \cos(20t - 30x) \quad \text{(cm)}, \]
\[ y_2(x,t) = -4 \cos(20t + 30x) \quad \text{(cm)}, \]

where \( x \) is in centimeters. The waves are said to interfere constructively when their superposition \( |y_s| = |y_1 + y_2| \) is a maximum and they interfere destructively when \( |y_s| \) is a minimum.

(a) What are the directions of propagation of waves \( y_1(x,t) \) and \( y_2(x,t) \)?
(b) At \( t = (\pi/50) \) s, at what location \( x \) do the two waves interfere constructively, and what is the corresponding value of \( |y_s| \)?
(c) At \( t = (\pi/50) \) s, at what location \( x \) do the two waves interfere destructively, and what is the corresponding value of \( |y_s| \)?

P8. Similar to but different from Problem 1.9 in Textbook 8/E:

\[ \text{HW1:P8} \]
\[ (1.9 \text{ in } 8/E) \]

Give expressions for \( y(x,t) \) for a sinusoidal wave traveling along a string in the negative \( x \)-direction, given that \( y_{\max} = 40 \text{ cm}, \lambda = 30 \text{ cm}, f = 10 \text{ Hz}, \)

(a) \( y(x,0) = 0 \) at \( x = 0 \),
(b) \( y(x,0) = 0 \) at \( x = 7.5 \text{ cm} \). Notice difference from problem in textbook

P9. Problem 1.14 in Textbook 8/E:

A certain electromagnetic wave traveling in sea water was observed to have an amplitude of 98.02 (V/m) at a depth of 10 m and an amplitude of 81.87 (V/m) at a depth of 100 m. What is the attenuation constant of sea water?

Note: Assume the wave travels downwards.

P10. Problem 1.28 in Textbook 8/E:

Find the phasors of the following time functions:
(a) \( v(t) = 3 \cos(\omega t - \pi/3) \) (V),  \( \text{Amplitude is 9 in 7/E and 8/E of textbook} \)
(b) \( v(t) = 12 \sin(\omega t + \pi/4) \) (V),
(c) \( i(x,t) = 3e^{-3x} \sin(\omega t + \pi/6) \) (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).  \( \text{Again, amplitude different in newer versions} \)
Problem 1.27 in Textbook 8/E:

Find the instantaneous time sinusoidal functions corresponding to the following phasors:

(a) \( V = -5e^{j\pi/3} \) (V),
(b) \( V = j6e^{-j\pi/4} \) (V),
(c) \( I = (6 + j8) \) (A),
(d) \( I = -3 + j2 \) (A),
(e) \( I = j \) (A),
(f) \( I = 2e^{j\pi/6} \) (A).