Homework 9

You may either submit this page with your homework or copy the information in this box to your handwritten solutions.

An Aggie does not lie, cheat or steal or tolerate those who do.

Please acknowledge your adherence to the honor code by printing and signing your name below.

This work is the product of my effort and was completed either through my sole effort or with collaborations as permitted by the syllabus. All collaboration, team effort, and sources are disclosed below. I have complied with the requirements of this homework to the best of my knowledge.

JOAQUIN SALAS
Printed Name

Signature

Disclosure of Sources and Collaborators:

OTABEK MANOOLOV

Note: This homework assignment is worth a total of 120 Points.

PART 1: Individual Homework (120 Points)

1. **10 Points** A 2-kHz sound wave traveling in the x-direction in air was observed to have a differential pressure $p(x, t) = 10$ N/m² at $x = 0$ and $t = 50$ μs. If the reference phase of $p(x, t)$ is 36 degrees, find a complete expression for $p(x, t)$. The phase velocity of sound in air is 330 m/s.
2. **10 Points** The height of an ocean wave is described by the function $y(x, t) = 1.5\sin(0.5t - 0.6x)$ (m). Determine the phase velocity and the wavelength λ. Using MATLAB, plot $y(x, t)$ at $t = 2$ s over the range from $x = 0$ to $x = 2\lambda$. The x-axis must be in meters. The place a marker at $x = \lambda/3$. Submit a copy of your code and screenshot of the plot.
3. **20 Points** The electric field of a plane wave propagating in a nonmagnetic medium is given by $\bar{E} = 25e^{-30x}cos(2\pi * 10^9 t - 40x)\, e_z$ (V/m). Find the expression for the magnetic field intensity of the plane wave.
4. **80 Points** Read all instructions outlined here before starting this section of the homework. Download the article – *Homework9-Reading Assignment-Exploiting the Electromagnetic Spectrum – State of the Science Overviews* from canvas. The article was written in 2004 by a group of experts as a vision for what the research community should focus on over the next 20 years.
   a. Notice from the contents page that the article is divided into four main sections plus the introduction. Read the introduction to the article and the introductions of each of the four sections.
   b. You will write a one-page essay based on this article. Page formatting: 1inch margins, single spacing, Times New Roman 12point font or equivalent.

c. First paragraph (you may refer to any source(s)): Introduction - *What is the electromagnetic spectrum? How is the spectrum divided? What are some everyday applications that use the electromagnetic spectrum (that are not covered by the assigned article? Summarize the introduction of the assigned article.*
d. Second Paragraph: *Summarize the four sections of the article based on your readings of the respective introductions. Which section interested you the most and why?*
e. Third Paragraph: Read the section that interested you the most carefully. Then complete the third paragraph using the following prompts and other sources. *What were the technological advancements proposed in the section nearly 20 years ago? What were key issues at that time and research directions that were identified by the article? Try to find out what advancements have been made in this topic over the past 20 years since the assigned article was written? Have scientists solved the problems outlined in the article? Are these technologies available in the commercial space now? If so, include pictures in your essay. Did you find anything interesting while doing your research?*

Grading scheme:

First paragraph (15 points), second paragraph (20 points), third paragraph (35 points), quality of work – cohesiveness in writing, formatting, appropriate citations, etc. (10 points).

Penalties:

- Inappropriate length (less than ¾ of a page or more than 1.5 pages): 50% penalty on overall score
- Plagiarism: Up to 100% penalty depending on the severity of the offense. Your essay will be checked using a plagiarism software. Copying sentences directly from a source or the assigned article is considered plagiarism even if you cite the source.
- Inadequate / inappropriate citations: 50% penalty. Any information outside the assigned article must contain a citation/source. The grader must be able to find this source without much effort. For instance, citing "Wikipedia" as a source without the title of the Wikipedia page and a link to the same would be considered an inadequate citation. An adequate citation would be something as follows: Wikipedia article on Maxwell's Equations - https://en.wikipedia.org/wiki/Maxwell%27s_equations (accessed on October 22, 2023).
- Citing generative AI tools as a source for your essay: 100% penalty (no exceptions). I would recommend not asking a generative AI tool to write your essay and create citations. As I showed at the beginning of the semester, these tools can make up citations that don't exist.

PART 2: Team Homework (0 Points)

This homework does not have a team component.

1. **10 Points** A 2-kHz sound wave traveling in the x-direction in air was observed to have a differential pressure $p(x, t) = 10$ N/m² at $x = 0$ and $t = 50$ μs. If the reference phase of $p(x, t)$ is 36 degrees, find a complete expression for $p(x, t)$. The phase velocity of sound in air is 330 m/s.

$p(x=0, t=50\mu s) = 10\ N/m^2$

$f = 2kHz$

$v_p = 330\ m/s$

$\phi = 36^\circ$

$\omega = 2\pi f = 2\pi(2000) = 4000\pi\ \frac{rad}{s}$

Wave Number.

$k = \frac{\omega}{v_p} = \frac{4000\pi}{330} = 12.12\pi$

$p(x,t) = P\cos(\omega t - kx + \phi)$

$p(x,t) = A\cos\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} + \phi_0\right) \longleftrightarrow p(x,t) = 10\cos(4000\pi t - 12.12\pi x + 36^\circ)$

2. **10 Points** The height of an ocean wave is described by the function $y(x, t) = 1.5\sin(0.5t - 0.6x)$ (m). Determine the phase velocity and the wavelength λ. Using MATLAB, plot $y(x, t)$ at $t = 2$ s over the range from $x = 0$ to $x = 2\lambda$. The x-axis must be in meters. The place a marker at $x = \lambda/3$. Submit a copy of your code and screenshot of the plot.

$y(x,t) = A\cos(\omega t + \beta x + \phi_0)$

Convert to cosine.

$y(x,t) = 1.5\sin(0.5t - 0.6x)\ m$

$y(x,t) = 1.5\cos(\pi/2 - (0.5t - 0.6x))\ [m]$

$+0.5t \mp 0.6x \mp \pi/2$

$= 1.5\cos(0.5t - 0.6x - \pi/2)\ [m]$

PHASE VELOCITY

$v_p = \frac{\omega}{\beta} = \frac{2\pi f}{\frac{2\pi}{\lambda}} = f\lambda\ \left(\frac{m}{s}\right)$

1st: $\omega = 2\pi f \rightarrow f = \frac{\omega}{2\pi} = \frac{0.5}{2\pi} = 0.0796\ Hz$

2nd: $\beta = \frac{2\pi}{\lambda} \rightarrow \lambda = \frac{2\pi}{\beta} = \frac{2\pi}{0.6} = 10.5\ m$

$v_p = 0.8358\ m/s$

2. MATLAB CODE AND PLOT.

joaquinsalas ▸ Desktop ▸ ECEN420ExtraCred

Editor – /Users/joaquinsalas/Desktop/ECEN420ExtraCred/ECEN322HW7.m *

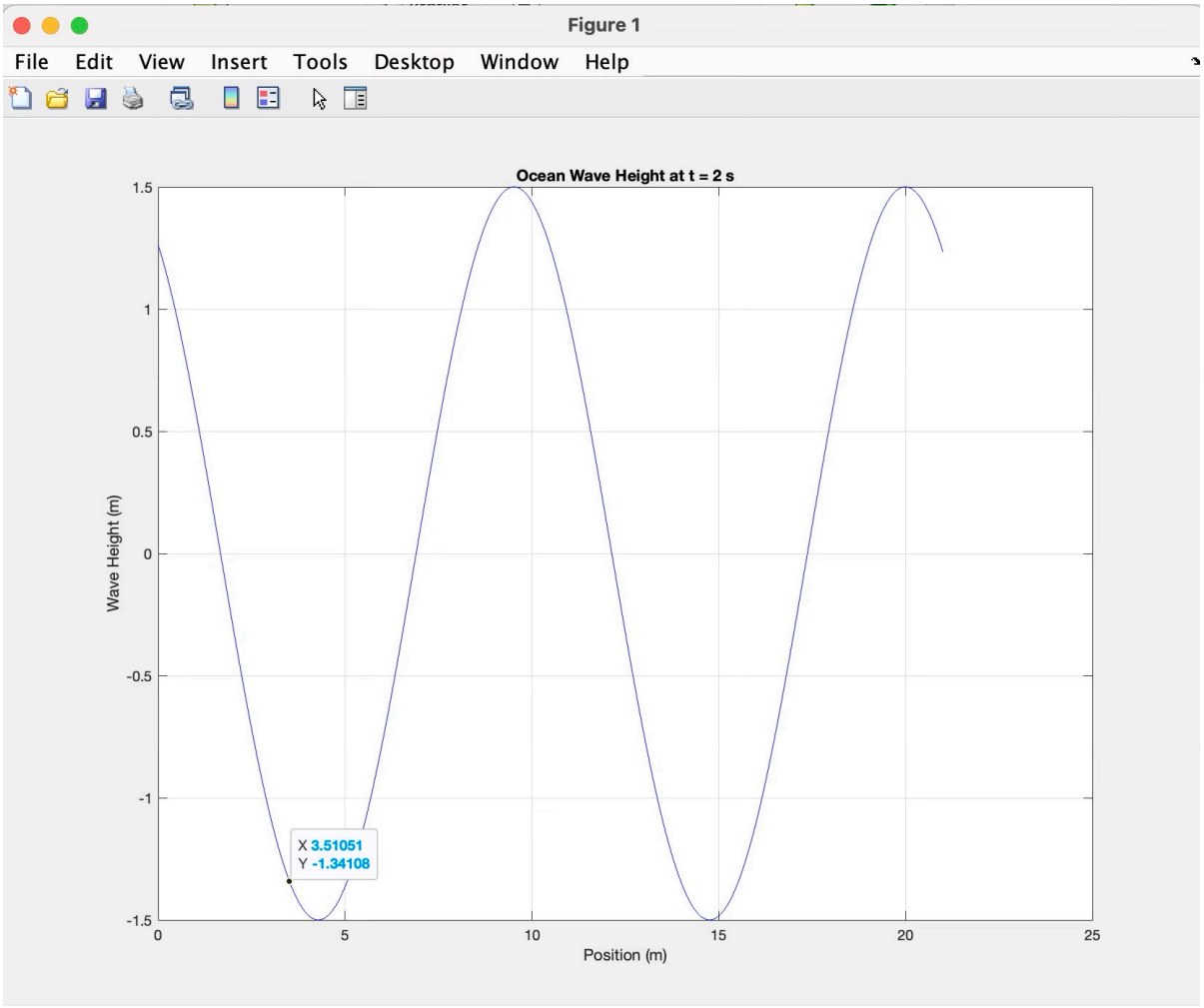
ECEN322HW7.m *

```
% parameters
lambda = 10.5; %lambda in meters
t = 2; %time in seconds

% x range
x = linspace(0, 2 * lambda, 1000);

% ocean wave function
Y = 1.5 * cos(0.5 * t - 0.6 * x - (pi/2));

% plot it
plot(x, Y, 'b');
xlabel('Position (m)');
ylabel('Wave Height (m)');
title('Ocean Wave Height at t = 2 s');
grid on;
hold on;
```



3. **20 Points** The electric field of a plane wave propagating in a nonmagnetic medium is given by $\bar{E} = 25e^{-30x}cos(2\pi * 10^9 t - 40x)\, e_z$ (V/m). Find the expression for the magnetic field intensity of the plane wave.

$\vec{E} = \eta \vec{H}$ $\quad \eta = \sqrt{\frac{\mu}{\epsilon}}$ $\quad \bar{E}(z,t) = E_0^+ \cos(\omega t - \beta z)\hat{e}_x \ (V/m)$

$$H_0^+ = \frac{E_0^+}{\mu} = \frac{25}{377} = 0.066 \ A/m$$

$$\bar{H} = 0.066 e^{-30x}\left(2\pi \times 10^9 t - 40x\right)\hat{e}_y \ (A/m)$$