

PHYS 1512: Week 7

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Equations

$$c = \frac{1}{\sqrt{\mu_o \epsilon_o}} = \lambda f \quad (\text{speed of light}) \quad (1)$$

$$u = \frac{1}{2} \epsilon_o E^2 + \frac{1}{2 \mu_o} B^2 \quad (\text{Energy Density}) \quad (2)$$

$$u = \epsilon_o E^2 = \frac{1}{\mu_o} B^2 \quad (\text{In Vacuum/Air}) \quad (3)$$

$$c = \frac{E}{B} \quad (4)$$

$$E_{rms} = \frac{E_o}{\sqrt{2}}, B_{rms} = \frac{B_o}{\sqrt{2}} \quad (5)$$

$$S = cu \quad (\text{Intensity}) \quad (6)$$

$$\bar{S} = \bar{S}_o \cos^2(\theta) \quad (7)$$

$$f_o = f_s \left(1 \pm \frac{v_{rel}}{c}\right) \quad (8)$$

Some notes

$$1) f_o = f_s(1 \pm \frac{v_{rel}}{c})$$

(+) : Source and Observer are moving towards one another

(-) : Source and Observer are moving away from one another

$$2) \bar{S} = \bar{S}_o \cos^2(\theta)$$

This works for polarized light, but won't be applied to unpolarized.

$$\epsilon_o = 8.854 * 10^{-12}$$

$$\mu_o = 4\pi * 10^{-7}$$

Question #1

Ride the wave....dude

A certain type of laser emits light that has a frequency of $5.2 * 10^{14} \text{Hz}$. The light however occurs as a series of short pulses, each lasting for a time of $2.7 * 10^{-11} \text{s}$.

- a) How many wavelengths are there in one pulse?
- b) The light enters a pool of water. The frequency of light will remain the same but the speed of light slows to $2.3 * 10^8 \frac{\text{m}}{\text{s}}$. How many wavelengths are these now in one pulse?

Question #2

Astronauts

Two astronauts are 1.5m apart in their spaceship. One speaks to the other. The conversation is transmitted to earth via electromagnetic waves. The time it takes for sound waves to travel at $343 \frac{m}{s}$ through the air between the astronauts equals the time it takes for the electromagnetic waves to travel to the earth. How far away from the earth is the spaceship?

Question #3

Big "Bang" Theory

The microwave radiation left over from the Big Bang explosion of the universe has an average energy density of $4 * 10^{-14} \frac{J}{m^3}$. What is the rms value of the electric field of this radiation?

Question #4

Spicy Light

An electromagnetic wave strikes a 1.30 cm^2 section of wall perpendicularly. The rms value of the wave's magnetic field is determined to be $6.80 \times 10^{-4} \text{ T}$. How long does it take for the wave to deliver 1850J of energy to the wall?

Question # 5

Malus' Law

Unpolarized light with an intensity of $\bar{S}_o = 16 \frac{W}{m^2}$ is incident on a pair of polarizers. The first polarizer has its transmission axis aligned at 50° from the vertical. The second polarizer has its transmission axis aligned at 20° from the vertical.

- a) What is the intensity of the light when it emerges from the first polarizer?
- b) What is the intensity of the light when it emerges from the second polarizer?
- c) Repeat parts a) and b) if the incident light was 20° from the vertical.

Question # 6

Doppler-gangster

A distant galaxy emits light that has a wavelength of 434.1nm. On earth, the wavelength of this light is measured to be 438.6nm.

- Decide whether this galaxy is approaching or receding from the earth.
- Find the speed of the galaxy relative to earth.