

This print-out should have 10 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 (part 1 of 3) 10.0 points

A plane electromagnetic sinusoidal wave of frequency 13.3 MHz travels in free space.

The speed of light is 2.99792×10^8 m/s.

Determine the wavelength of the wave.

Correct answer: 22.5408 m.

Explanation:

$$\text{Let : } c = 2.99792 \times 10^8 \text{ m/s, and} \\ f = 13.3 \text{ MHz} = 1.33 \times 10^7 \text{ Hz.}$$

The speed of light is

$$c = \lambda f \\ \lambda = \frac{c}{f} \\ = \frac{2.99792 \times 10^8 \text{ m/s}}{1.33 \times 10^7 \text{ Hz}} \\ = \boxed{22.5408 \text{ m}}.$$

002 (part 2 of 3) 10.0 points

Find the period of the wave.

Correct answer: 7.5188×10^{-8} s.

Explanation:

The period T of the wave is the inverse of the frequency:

$$T = \frac{1}{f} \\ = \frac{1}{1.33 \times 10^7 \text{ Hz}} \\ = \boxed{7.5188 \times 10^{-8} \text{ s}}.$$

003 (part 3 of 3) 10.0 points

At some point and some instant, the electric field has a value of 958 N/C.

Calculate the magnitude of the magnetic field at this point and this instant.

Correct answer: 3.19554×10^{-6} T.

Explanation:

$$\text{Let : } E = 958 \text{ N/C.}$$

The magnitudes of the electric and the magnetic fields are related by $\frac{E}{B} = c$,

$$B = \frac{E}{c} \\ = \frac{958 \text{ N/C}}{2.99792 \times 10^8 \text{ m/s}} \\ = \boxed{3.19554 \times 10^{-6} \text{ T}}.$$

004 (part 1 of 2) 10.0 points

What is the wavelength corresponding to a frequency of 2×10^{19} Hz of electromagnetic wave in free space? The speed of light is 2.99792×10^8 m/s.

Correct answer: 1.49896×10^{-11} m.

Explanation:

$$\text{Let : } f = 2 \times 10^{19} \text{ Hz and} \\ c = 2.99792 \times 10^8 \text{ m/s.}$$

The relation between frequency and wavelength is given by

$$\lambda = \frac{c}{f} \\ = \frac{2.99792 \times 10^8 \text{ m/s}}{2 \times 10^{19} \text{ Hz}} \\ = \boxed{1.49896 \times 10^{-11} \text{ m}}.$$

005 (part 2 of 2) 10.0 points

What is the wavelength corresponding to a frequency of 6×10^9 Hz?

Correct answer: 0.0499654 m.

Explanation:

$$\text{Let : } f = 6 \times 10^9 \text{ Hz.}$$

$$\lambda = \frac{c}{f} \\ = \frac{2.99792 \times 10^8 \text{ m/s}}{6 \times 10^9 \text{ Hz}} \\ = \boxed{0.0499654 \text{ m}}.$$

006 (part 1 of 2) 10.0 points

The magnetic field amplitude of an electromagnetic wave is 7.7×10^{-6} T.

The speed of light is 2.99792×10^8 m/s.

Calculate the amplitude of the electric field if the wave is traveling in free space.

Correct answer: 2308.4 N/C.

Explanation:

$$\text{Let : } c = 2.99792 \times 10^8 \text{ m/s} \quad \text{and}$$

$$B = 7.7 \times 10^{-6} \text{ T}.$$

According to Maxwell's equations for an electromagnetic wave in vacuum the relation between the amplitude of the magnetic field and the amplitude of the electric field must be

$$\begin{aligned} E &= cB \\ &= (2.99792 \times 10^8 \text{ m/s}) (7.7 \times 10^{-6} \text{ T}) \\ &= \boxed{2308.4 \text{ N/C}}. \end{aligned}$$

The same relation applies even when the velocity of light in the medium is not c , in general,

$$E = vB$$

where v is the velocity of light in that medium.

007 (part 2 of 2) 10.0 points

Calculate the amplitude of the electric field if the wave is traveling in a medium in which the speed of the wave is $0.57c$.

Correct answer: 1315.79 N/C.

Explanation:

$$\text{Let : } v = 0.57c.$$

Amplitude of electric field when the wave is traveling in a medium is

$$E = vB = 0.57cB = \boxed{1315.79 \text{ N/C}}.$$

008 10.0 points

Calculate the magnitude of the magnetic field at a point 120 cm from a long, thin conductor carrying a current of 0.588 A. The permeability of free space is 1.25664×10^{-6} T · m/A.

Correct answer: 9.8×10^{-8} T.

Explanation:

$$\begin{aligned} \text{Let : } \mu_0 &= 1.25664 \times 10^{-6} \text{ T} \cdot \text{m/A}, \\ r &= 120 \text{ cm} = 1.2 \text{ m}, \quad \text{and} \\ I &= 0.588 \text{ A}. \end{aligned}$$

The magnetic field of the wire is

$$\begin{aligned} B &= \frac{\mu_0 I}{2\pi r} \\ &= \frac{(1.25664 \times 10^{-6} \text{ T} \cdot \text{m/A}) (0.588 \text{ A})}{2\pi (1.2 \text{ m})} \\ &= \boxed{9.8 \times 10^{-8} \text{ T}}. \end{aligned}$$

009 (part 1 of 2) 10.0 points

An AC generator consists of eight turns of wire, each of area 0.11 m^2 , and total resistance of 8.48Ω . The loop rotates in the external magnetic field of strength 0.587 T at a constant frequency of 66.4 Hz .

What is the maximum induced *emf*?

Correct answer: 215.511 V.

Explanation:

$$\begin{aligned} \text{Let : } N &= 8, \\ A &= 0.11 \text{ m}^2, \\ R &= 8.48 \Omega, \\ B &= 0.587 \text{ T}, \quad \text{and} \\ f &= 66.4 \text{ Hz}. \end{aligned}$$

Faraday's Law for solenoid:

$$\mathcal{E} = -N \frac{d\Phi_B}{dt}.$$

$$\text{Ohm's Law: } I = \frac{V}{R}.$$

First note that

$$\begin{aligned} \omega &= 2\pi f \\ &= 2\pi (66.4 \text{ Hz}) \\ &= 417.204 \text{ rad/s}. \end{aligned}$$

Using Faraday's Law (Equation above) with the appropriate numerical values gives

$$\begin{aligned}\mathcal{E}_{max} &= N A B \omega \\ &= 8 (0.11 \text{ m}^2) (0.587 \text{ T}) \\ &\quad \times (417.204 \text{ rad/s}) \\ &= \boxed{215.511 \text{ V}}.\end{aligned}$$

010 (part 2 of 2) 10.0 points

What is the maximum induced current?

Correct answer: 25.414 A.

Explanation:

From Ohm's Law and the results to part (a), we find that the maximum induced current is

$$\begin{aligned}I_{max} &= \frac{\mathcal{E}_{max}}{R} \\ &= \frac{215.511 \text{ V}}{8.48 \Omega} \\ &= \boxed{25.414 \text{ A}}.\end{aligned}$$

keywords: