Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: Solution   **Student ID:**   ,   **Signature:**

A sinusoidal electromagnetic wave of frequency 40 MHz travels in free space in the x direction. (a) Determine the wavelength and period of the wave. (b) At some point and at some instant, the electric field has its maximum value of *750* N/C and is directed along the y axis. Calculate the magnitude and direction of the magnetic field at this position and time.

Poynting vector : $\vec{S} = \dfrac{1}{\mu_0} \vec{E} \times \vec{B}$

$\downarrow \qquad\qquad \downarrow \quad \downarrow$

$\hat{x} \qquad\qquad \hat{y} \quad \hat{z}$

(a) $f = 40\, MHz$

$\lambda = \dfrac{c}{f} = \dfrac{3 \times 10^8}{4 \times 10^7} = 7.5\, m$

$T = \dfrac{1}{f} = \dfrac{1}{40 \times 10^6} = 25\, ns$

(b) $\vec{E} = E_{max} \cos(kx - \omega t)\, \hat{y}$

$\vec{B} = B_{max} \cos(kx - \omega t)\, \boxed{\hat{z}} \longrightarrow$ its direction

$B_{max} = \dfrac{E_{max}}{c} = \dfrac{750}{3 \times 10^8} = 25 \times 10^{-7}\, T \longrightarrow$ its magnitude

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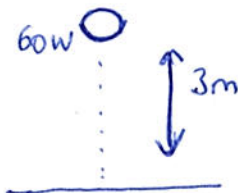**Quiz duration: 10 minutes**

Name: Solution   **Student ID:**   **Signature:**

Assume the classroom you are taking this quiz is illuminated by a very efficient point light source located at the ceiling about 3m high above you. If the source emits 60 W visible light, what would be the maximum magnitude of the magnetic field on your quiz page? Compare it with the Earth's magnetic field, which is about 0.5 Gauss. (μ_0 = $4\pi \times 10^{-7}$ Tm/A; c = 3×10^8 m/s)

60w ◯

$\uparrow$ 3m

B_{max} = ?

$$I = \frac{P}{A} = \frac{60}{\pi r^2} = \frac{60}{9\pi} \simeq 2.12 \ \text{w/m}^2$$

$$I = \frac{E_{max}^2}{2\mu_0 c} \simeq 2.12$$

$$E_{max} = \sqrt{(2.12)(2)(4\pi \times 10^{-9}).(3 \times 10^8)} \simeq 800 \ \text{N/c}$$

$$B_{max} = \frac{E_{max}}{c} \simeq 2.67 \times 10^{-6} \ T$$

$$1T = 10000 \ \text{Gauss}$$

$$10^{-6} \ T = 0.01 \ G$$

$$\therefore \ B_{max} \simeq 0.03 \ G$$

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: Solution   **Student ID:**   .   **Signature:**

If you direct your green laser pointer, that emits 3 mW light with a spot size of 2 mm in diameter, to your eye, (i) what would be the intensity of radiation that hits your eye? Compare it with the intensity of sunlight at the Earth's surface, which is about 1.4 kW/m^2. (ii) What is the radiation pressure on your eye? Compare it with the atmospheric pressure, which is about 10^5 N/m^2. (iii) Why lasers are dangerous to look into? (Take $\pi = 3$; assume perfect absorption)

$$P = 3mW$$

$$D = 2 \times 10^{-3} \, m \quad , r = 10^{-3} \, m \quad , A = \pi (10^{-3})^2 \simeq 10^{-6} \times 3 \, m^2$$

(i) $I = \dfrac{P}{A} = \dfrac{3 \times 10^{-3}}{3 \times 10^{-6}} = 10^3 \, w/m^2 \simeq 1 \, kW/m^2$

you are looking @ sun!

(ii) $P = \dfrac{I}{c} = \dfrac{10^3}{3 \times 10^8} = 0.33 \times 10^{-5} \, Pa$ → it is very small

(iii) In the most of the practical applications laser sources produce hundreds of mW, translated into brightness about **100** times larger than the sun! [we calculated @ (i)]

In addition, Lasers are coherent light sources which contain intense peak powers in general!

E.g. 3mW average power can correspond 100^s of watts peak powers for many practical systems,

(ultrashort systems; etc.)

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: Solution   **Student ID:**   **Signature:**

A source of electromagnetic waves with power 10 MW radiates uniformly and isotropically in all directions. Calculate the amplitude of the electric field vector for these waves at a distance of (i) 100 m and (ii) 1 km from the source. ($\mu_0 = 4\pi \times 10^{-7}$ Tm/A; $c = 3 \times 10^8$ m/s)

$$P = 10\ MW = 10^7\ W$$

$$(i)\quad r = 100\ m \quad,\quad E_{max} = ?$$

$$(ii)\quad r = 1000\ m \quad,\quad E_{max} = ?$$

Sol/

$$(i)\quad I = \frac{P}{A} = \frac{E^2}{2\mu_0 c} = \frac{10^7}{\pi (10^2)^2} = \frac{E^2}{2(4\pi \times 10^{-7})(3 \times 10^8)}$$

$$E^2 = \frac{24\pi \times 10^8}{\pi \times 10^4} \qquad,\qquad E_{max} \simeq 490\ N/C$$

$$(ii)\quad E_{max} \simeq 4.9\ N/C \qquad since \quad r' \rightarrow 10\,r$$

$$thus \quad I' \rightarrow \frac{I}{100}$$
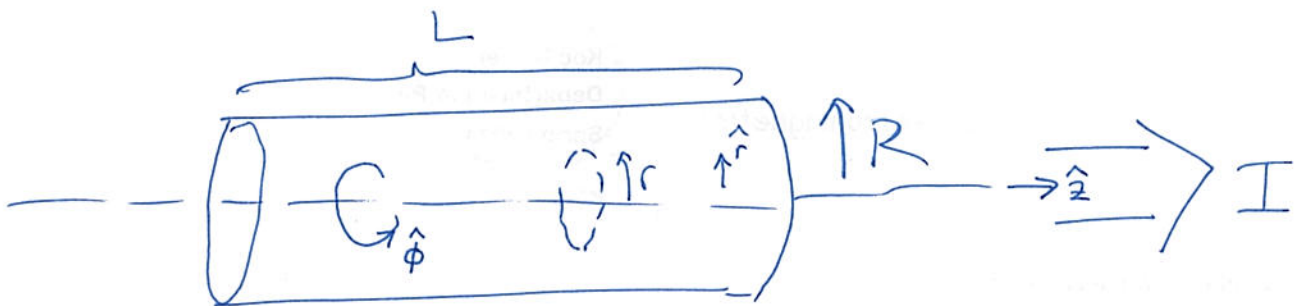
Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

Name: Solution   **Student ID:**   **Signature:**

A circular wire of radius R and resistivity ρ carries a current I. (a) Find the magnetic field at the surface of the wire using the Ampère's Law. (b) Find the electric field using the Ohm's law. (c) Calculate the Poynting vector magnitude and direction.

a) $B 2\pi r = \mu_0 I_{enc}$

   $r = R \Rightarrow \vec{B} = \dfrac{\mu_0 I}{2\pi R} \hat{\phi}$

b) $V = EL = I\left(\rho \dfrac{L}{\pi R^2}\right) \Rightarrow \vec{E} = \rho \dfrac{I}{\pi R^2} \hat{z}$

c) $\vec{S} = \dfrac{\vec{E} \times \vec{B}}{\mu_0} = -\rho \dfrac{I^2}{2\pi^2 R^3} \hat{r}$

   radially inward

X-section of wire