DPP – 1 (EM Waves)

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Q 1. If $\vec{E}$ and $\vec{B}$ are the electric and magnetic field vectors of E.M. waves then the direction of propagation of E.M. wave is along the direction of
(a) $\vec{E}$ (b) $\vec{B}$
(c) $\vec{E} \times \vec{B}$ (d) none of these

Q 2. In an electromagnetic wave, the electric field oscillated sinusoidally with amplitude 48 V/m. The RMS value of oscillating magnetic field will be
(a) 1.6×10^{-8} T (b) 16×10^{-8} T
(c) 144×10^{8} T (d) 11.3×10^{-8} T

Q 3. In a plane EM wave, the electric field oscillates sinusoidally at a frequency of 2.5×10^{10} Hz and amplitude 480 V/m. The amplitude of oscillating magnetic field will be,
(a) $1.6 \times 10^{-8}\ Wb/m^2$ (b) $16 \times 10^{-8}\ Wb/m^2$
(c) $1.6 \times 10^{-6}\ Wb/m^2$ (d) $16 \times 10^{-6}\ Wb/m^2$

Q 4. In a plane EM wave of frequency 1.5×10^{12} Hz, the amplitude of the magnetic field is 6.0×10^{-6} T. The amplitude of the electric field will be?
(a) 1.8 V/m (b) 180 V/m
(c) 1800 V/m (d) 120 V/m

Q 5. Displacement current is
(a) Continuous when electric field is changing in the circuit
(b) Continuous when magnetic field is changing in the circuit
(c) Continuous in both type of field
(d) Continuous throughout wires and resistance only

Q 6. A capacitor has been charged by a DC source. What are the magnitude of conduction (I_c) and displacement (I_d) current when it is fully charged?
(a) $I_d = I_c = 1$ (b) $I_d = I_c = 0$
(c) $I_d = 1, I_c = 0$ (d) $I_d = 0,\ I_c = 1$

Q 7. A parallel plate capacitor made of two circular plates each of radius 10 cm and separated by 4.0mm. The capacitor is being charged by an external source. The charging current is constant and equal to 0.10A. Calculate the rate of change of potential difference between the plates and the displacement current
(a) 1.44×10^{9} V/sec, 0.10 A
(b) 1.44×10^{9} V/sec, 0.05 A
(c) 2.11×10^{10} V/sec, 0.10 A

(d) 2.11×10^{10} V/sec, 0.05 A

Q 8. In electromagnetic wave the phase difference between electric and magnetic field vectors $\vec{E}$ and $\vec{B}$ is -

(a) 0 (b) $\frac{\pi}{2}$

(c) π (d) $\frac{\pi}{4}$

Q 9. In a plane EM wave of frequency 1.5×10^{12} Hz, the amplitude of the magnetic field is 6.0×10^{-6} T. What is the total average energy density of the e.m. wave?

(a) $1.4 \times 10^{-5}\ J/m^3$ (b) $1.6 \times 10^{-3}\ J/m^3$

(c) $2.4 \times 10^{-5}\ J/m^3$ (d) $4.2 \times 10^{-5}\ J/m^3$

Q 10. In an electromagnetic wave, the amplitude of electric field is 10V/m. The wave is propagating along Z-axis, find the average energy density of magnetic field

(a) 1.2×10^{-9} J/m³ (b) 2.2×10^{-10} J/m³

(c) 4.1×10^{-9} J/m³ (d) 3.2×10^{-10} J/m³

Q 11. The rms value of electric field of a plane electromagnetic wave is 314 V/m. The average energy density of electric field and the total average energy density are

(a) $4.3 \times 10^{-7}\ J/m^3$, $2.15 \times 10^{-7}\ J/m^3$

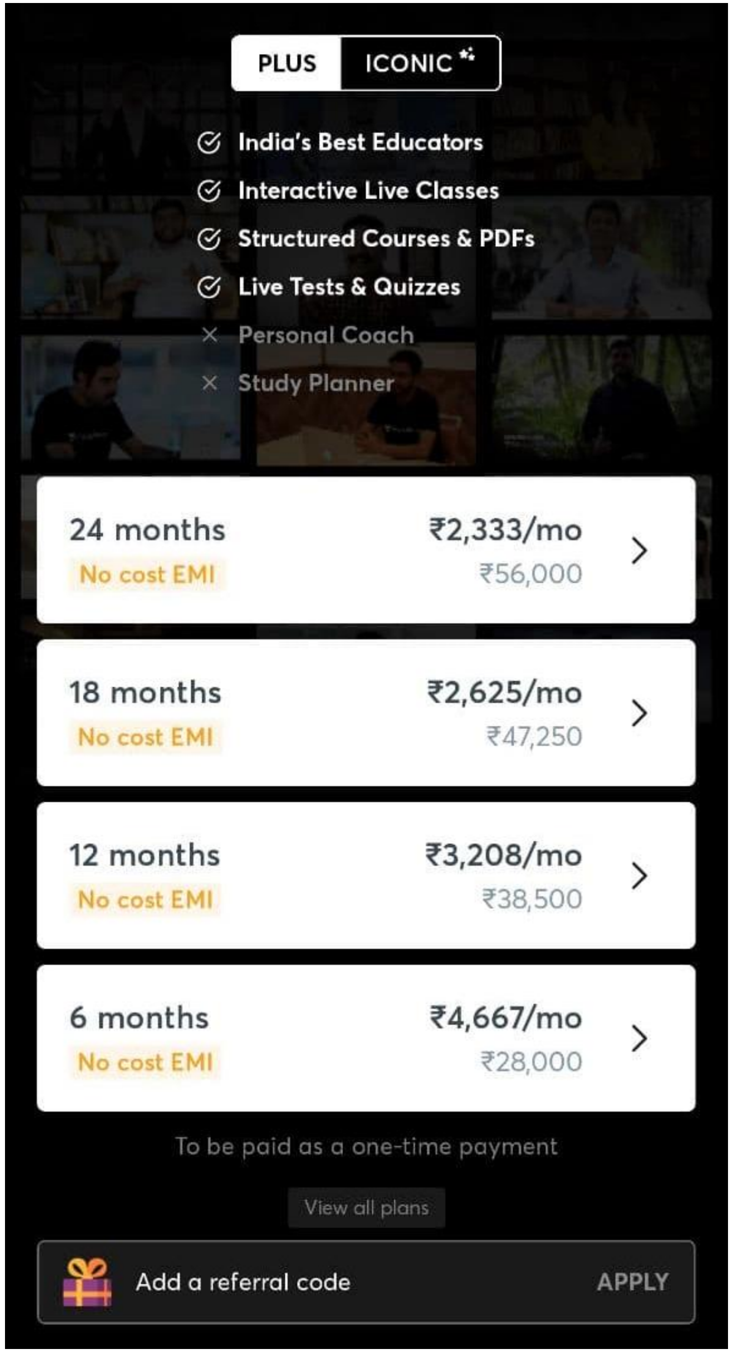
(b) $4.3 \times 10^{-7}\ J/m^3$, $8.6 \times 10^{-7}\ J/m^3$

(c) $2.15 \times 10^{-7}\ J/m^3$, $4.3 \times 10^{-7}\ J/m^3$

(d) $8.6 \times 10^{-7}\ J/m^3$, $4.3 \times 10^{-7}\ J/m^3$

Answer Key

Q.1 c	**Q.2 d**	**Q.3 c**	**Q.4 c**	**Q.5 a**
Q.6 b	**Q.7 a**	**Q.8 a**	**Q.9 a**	**Q.10 b**
Q.11 b				



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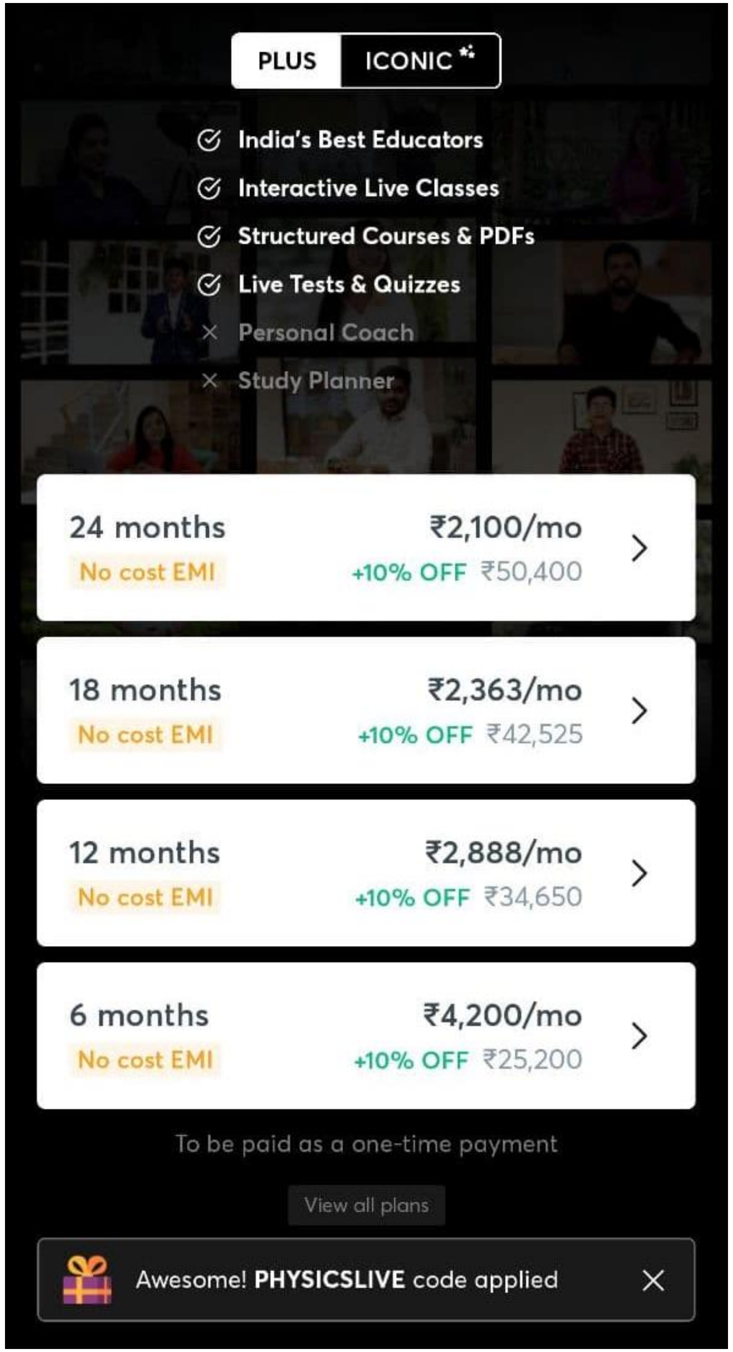

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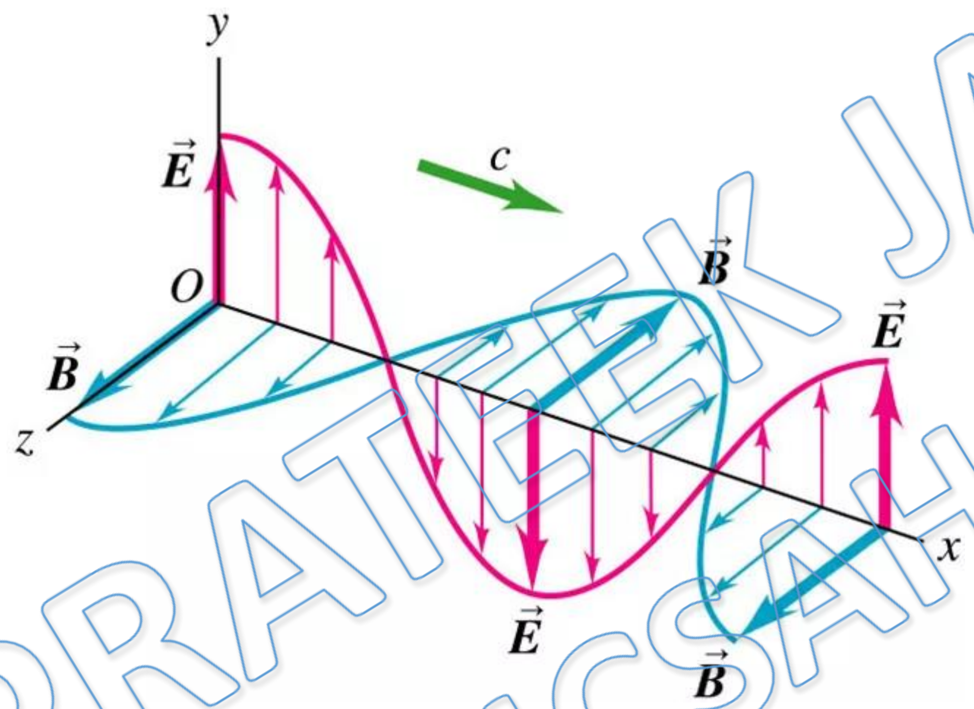
Written Solution

DPP-1 EM Wave: EM Wave, Displacement Current & Energy Density

By Physicsaholics Team

Solution: 1



Ans. c

Solution: 2

$$E_0 = c B_0$$

$$B_0 = \frac{E_0}{c} = \frac{48}{3\times10^8} = 16 \times 10^{-8} \; T$$

$$B_{rms} = \frac{B_0}{\sqrt{2}} = \frac{16\times10^{-8}}{\sqrt{2}}$$

$$\boxed{B_{rms} = 11.3 \times 10^{-8} \; T} \text{ Ans}$$

Ans. d

Solution: 3

$E_0 = 480$ V/m

$E_0 = cB_0$

$B_0 = \frac{E_0}{c} = \frac{480}{3\times10^8}$

$B_0 = \frac{480}{3}\times10^{-8} = 160\times10^{-8}$

$B_0 = 16\times10^{-7}$ T

or

$B_0 = 1.6\times10^{-6}$ T Ans

Ans. c

Solution: 4

$B_0 = 6 \times 10^{-6}\ T$

$E_0 = cB_0$

$= 3 \times 10^{8} \times 6 \times 10^{-6}$

$= 18 \times 10^{2}$

$E_0 = 1800\ V/m$ Ans

Ans. c

Solution: 5

Displacement current is set up in a space where the electrical field is varying with the time.

$$i_d = \varepsilon_0 \frac{d\phi_E}{dt}$$

when ; $\phi_E = \vec{E} \cdot \vec{A}$

when E is changing

then $i_d \neq 0$

i_d = continuous

Ans. a

Solution: 6

$\because I_d = I_c$

and when capacitor is fully charged

$I_c = 0$

So, $\boxed{I_c = I_d = 0}$ Ans.

Ans. b

Solution: 7

$\because I_d = I_c = \frac{dQ}{dt}$

& $Q = CV$

$\therefore I_d = I_c = \frac{d(CV)}{dt} = C\frac{dV}{dt}$

$I_d = I_c = 0.10\ A$ Ans.

$\because C = \frac{\epsilon_0 A}{d} = \frac{8.85\times10^{-12}\times\pi(10\times10^{-2})^2}{4\times10^{-3}}$

$C = 6.94\times10^{-11}\ F$

and $0.10 = C\frac{dV}{dt}$

$0.10 = 6.94\times10^{-11}\frac{dV}{dt}$

$\Rightarrow \frac{dV}{dt} = 1.44\times10^{9}\ V/s$ Ans.

Ans. a

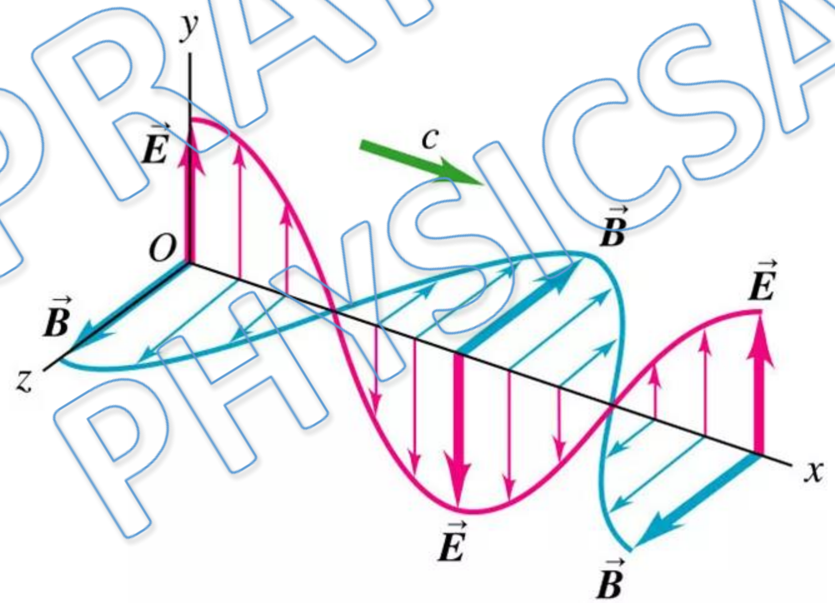
Solution: 8

$E = E_0 \sin \omega \left(t - \frac{x}{c}\right)$

$B = B_0 \sin \omega \left(t - x/c\right)$

B & E are in same phase

so; $\boxed{\Delta\phi = 0}$ Ans.



Ans. a

Solution: 9

$$u_{av} = \frac{B_0^2}{2\mu_0} = \frac{(6\times10^{-6})^2}{2(4\pi\times10^{-7})} = \frac{36\times10^{-12}}{8\pi\times10^{-7}}$$

$$u_{av} = \frac{36}{8\pi}\times10^{-5} = \frac{9}{2\pi}\times10^{-5}$$

$$\boxed{u_{av} = 1.4\times10^{-5}\ J/m^3}\ \text{Ans}$$

Ans. a

Solution: 10

$E_0 = 10\ V/m$

$\because (U_{av})_B = (U_{av})_E = \frac{1}{4}\varepsilon_0 E_0^2 = \frac{1}{4}\frac{B_0^2}{\mu_0}$

$\therefore (u_{av})_B = \frac{1}{4}\varepsilon_0 E_0^2$

$= \frac{1}{4} \times (8.85 \times 10^{-12}) \times (10)^2$

$= 2.2 \times 10^{-10}$

$(u_{av})_B = 2.2 \times 10^{-10}\ J/m^3$ Ans

Ans. b

Solution: 11

$E_{rms} = 314 = \frac{E_0}{\sqrt{2}} \Rightarrow \boxed{E_0 = 314\sqrt{2}\ V/m}$

Average E.f. Energy density

$$(U_E)_{avg} = \frac{1}{4}\epsilon_0 E_0^2$$

$$= \frac{1}{4} \times 8.85 \times 10^{-12} \times (314\sqrt{2})^2$$

$$= 4.3 \times 10^5 \times 10^{-12}$$

$$\boxed{(U_E)_{avg} = 4.3 \times 10^{-7}\ J/m^3}$$ As

Total Average energy density

$$U_{avg} = \frac{1}{2}\epsilon_0 E_0^2 = 2\,(U_E)_{avg}$$

$$\boxed{U_{avg} = 8.6 \times 10^{-7}\ J/m^3}$$ As

Ans. b

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Chalo Niklo