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Class: XII
Subject: Physics
Topic: Electromagnetic Waves
No. of Questions: 20
Duration: 60 Min
Maximum Marks: 60

1. An electromagnetic wave going through vacuum is described by $E = E_0 \sin(kx - \omega t)$; $B = B_0 \sin(kx - \omega t)$ Which of the following equations is true?

a. $E_0 k = B_0 \omega$
b. $E_0 \omega = B_0 k$
c. $E_0 B_0 = \omega k$
d. None of these

Ans. A

Solution:

We know $E_0 = c B_0$, where c is the velocity of light.

$\therefore \quad c = v\lambda = \frac{\omega}{2\pi}\lambda = \frac{\omega}{k}$

where $\quad k = \frac{2\pi}{\lambda}$

Thus, $\quad E_0 = \frac{\omega}{k} B_0$

or $\quad E_0 k = B_0 \omega$

2. An electric charge oscillating with a frequency of 1 kilo cycles/s can radiate electromagnetic waves of wavelength

a. 100km
b. 200km
c. 300km
d. 400km

Ans. C

Solution:

$$\lambda = \frac{c}{v} = \frac{3\times 10^8}{1000}$$

$$= 3\times 10^5\,\text{m} = 300\,\text{km}$$

3. The sun delivers 10^4 W/m^2 of electromagnetic flux to the earth's surface. The total power that is incident on a roof of dimensions (10 ×10) m^2 will be
a. 10^4w
b. 10^5w
c. 10^6w
d. 10^7w

Ans. C

Solution:
Total power = solar constant × area
10^4 x (10x10)=10^6w
4. The electromagnetic waves of much short wavelength (25 mm to 5 mm) were produced and observed by
a. Maxwell
b. Hertz
c. Marconi
d. J.C. Bose

Ans. D

5. If $\vec{E}$and $\vec{B}$ are the electric and magnetic field vectors of electromagnetic waves the direction of propagatio n if electromagnetic wave is along the direction of
a. $\vec{E}$
b. $\vec{B}$
c. $\vec{E} \times \vec{B}$
d. None of these

Ans. C

6. An electromagnetic wave, going through vacuum is described by $E = E_0 \sin(kx - \omega t)$. Which of the following is independent of wavelength?
a. K
b. ω
c. k/ω
d. k ω

Ans. C
Solution:

Here, $kx = \theta_0$ or $k = \theta_0 / x$

and $\omega t = \theta_0$ or $\omega = \theta_0 / t$

$\therefore \quad \frac{k}{\omega} = \frac{t}{x} = \frac{1}{(x/t)} = \frac{1}{v}$

where is the velocity of electromagnetic wave, which independent of wavelength of wave but depends upon the nature of medium of propagatio n of wave?

7. If $\vec{E}$ is an electric field and $\vec{B}$ is the magnetic induction, then the energy flow per unit area per unit time in an electromagnetic field is given by

a. $\vec{E} \times \vec{B}$
b. $\vec{E}.\vec{B}$
c. $E^2 + B^2$
d. E/B

Ans. A

Solution:

Energy flow per unit area per unit time is called pointing

Vectors $\vec{S} = \vec{E} \times \vec{B}$

8. A circular ring of radius r is placed in a homogeneous magnetic field perpendicular to the plane of the ring. The field B changes with time according to the equation B = Kt, where K is a constant and t is the time. The electric field in the ring is

a. $\frac{Kr}{4}$
b. $\frac{Kr}{3}$
c. $\frac{Kr}{2}$
d. $\frac{Kr}{2r}$

Ans. C

Solution

$$\oint \vec{E}.d\vec{l} = \frac{d\phi_B}{dt}$$

$$E\, 2\pi r = \frac{d}{dt}(K\, t \times \pi r^2)$$

$$E = \frac{Kr}{2}$$

9. The nature of electric field in the region between the two plates of a capacitor, while charging, is
a. always constant
b. varying
c. depends on value of C and R
d. depends on emf of battery

Ans. B

Solution:
During charging a capacitor there will be different amount of charge on the plates of capacitor at different instants. Due to which the electric field is varying

10. If a source is transmitting electromagnetic wave of frequency 8.2×10^6 Hz, then wavelength of the electromagnetic waves transmitted from the source will be
a. 36.6 m
b. 40.5 m
c. 42.3 m
d. 50.9 m

Ans. A
Solution:

$$\text{Here, } \lambda = \frac{c}{v} = \frac{3 \times 10^8}{8.2 \times 10^6} = 36.6\text{m}$$

11. A plane e.m. wave of wave intensity 10 W/m^2 strikes a small mirror of area 20 cm^2, held perpendicular to the approaching wave. The radiation force on the mirror will be
a. 6.6×10^{-11} N
b. 1.33×10^{-11} N
c. 1.33×10^{-10} N
d. 6.6×10^{-10} N

Ans. C
Solution:
Radiation force = momentum transferred per sec by electromagnetic wave to the mirror

$$= \frac{2S_{av}A}{c} = \frac{2 \times (10) \times (20 \times 10^{-4})}{(3 \times 10^8)}$$

$$= 1.33 \times 10^{-10} \text{ N}$$

12. An electromagnetic wave of frequency v= 3.0 MHZ passes from vacuum into a dielectric medium with permittivity E = 4.0. Then
a. wavelength is doubled and frequency unchanged
b. wavelength is doubled and frequency becomes half
c. wavelength is halved and frequency remains unchanged
d. wavelength and frequency both remain unchanged

Ans. C
Solution:

In vacuum, $\varepsilon_0 = 1$

In medium, $\varepsilon = 4$

So, refractive index

$$\mu = \sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{\frac{4}{1}} = 2$$

Wavelength $\lambda' = \frac{\lambda}{\mu} = \frac{\lambda}{2}$

and wave velocity $v = \frac{c}{\mu} = \frac{c}{2}$

Hence, it is clear that wavelengt h and velocity become half but frequency remains unchanged when the passing through any medium.

13. Electromagnetic waves are transverse in nature is evident by
a. Polarization
b. Interference
c. Reflection
d. Diffraction

Ans. A

14. A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is
a. E/c
b. 2 E/c
c. Ec
d. E/c^2

Ans. B
Solution:
Initial momentum of surface

$$p_i = \frac{E}{c}$$

where c is velocity of light.
Since, the surface is perfectly reflecting, so the same momentum will be reflected completely.
Final momentum

$$p_i = \frac{E}{c}$$

∴ Change in momentum

$$\Delta p = p_f - p_i = \frac{-E}{c} - \frac{E}{c} = \frac{-2E}{c}$$

Thus, momentum transferred to the surface is $\frac{2E}{c}$

15. Maxwell's modified form of Ampere's circuital law is

a. $\oint \vec{B}.d\vec{S} = 0$

b. $\oint \vec{B}.d\vec{l} = \mu_0 i$

c. $\oint \vec{B}.d\vec{l} = \mu_0 i + \frac{1}{\varepsilon_0}\frac{dq}{dt}$

d. $\oint \vec{B}.d\vec{l} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\phi E}{dt}$

Ans. D

16. A large parallel plate capacitor, whose plates has an area of $1m^2$ and are separated from each other by 1 mm, is being charged at a rate of 25 V/s. If the dielectric between plates has, the dielectric constant 10, then the displacement current at this instant is

a. 25 μ A
b. 11 μ A
c. 2.2 μ A
d. 1.1μ A

Ans. C
Solution:

$$C = \frac{\varepsilon_0 KA}{d} = \frac{(8.85\times10^{-12})\times10\times1}{10^{-3}}$$
$$= 8.85\times10^{-8}\ F$$
$$i = \frac{d}{dt}(CV) = \frac{dV}{dt} = 8.85\times10^{-8}\times25$$
$$= 2.2\times10^{-6} A$$
$$= 2.2\mu\ A$$
$$d = \sqrt{2hR}$$

17. Consider the following two statements regarding a linearly polarized plane electromagnetic wave
    (i) Electric field and the magnetic field have equal average values
    (ii) Electric energy and the magnetic energy have equal average values

a. (i) is true
b. (ii) is true
c. both are true
d. both are false

Ans. C

18. Find the values of magnetic field between plates of capacitor at distance 1 m from center, where electric field varies by 10^{10} V/m per second

a. 5.56×10^{-8} T
b. 5.56×10^{-3} T
c. 5.56 ×μT
d. 5.56 T

Ans. A
Solution:

$$B = \frac{\mu_0\varepsilon_0 r}{2}\frac{dE}{dt} = \frac{1}{9\times10^{16}\times2}\times10^{10}$$
$$= 5.56\times10^{-8}\,T$$

19. A radio wave has a maximum magnetic field induction of 10^{-4} T on arrival at a receiving antenna. The maximum electric field intensity of such a wave is
a. Zero
b. 3×10^{4} V/m
c. 5.8×10^{-9} V/m
d. 3.3×10^{-13} V/m

Ans. B
Solution:
$E_0 = c B_0 = 3 \times 10^{8} \times 10^{-4} = 310^{4}$ V/m

20. The magnetic field between the plates of radius 12 cm separated by distance of 4mm of a parallel plate capacitor of capacitance 100 pF along the axis of plates. having conduction current of 0.15 A is:
a. Zero
b. 1.5 T
c. 15 T
d. 0.15 T

Ans. A
Solution: