E.M.WAVES

1.“Taller the antenna longer is the coverage of television broadcast”. Justify this statement with the help of a figure.

2.If v_g, v_x & v_m represents the speed of gamma rays, X-rays & microwaves respectively then how will you how arrange these radiations according to there speeds in vacuum?

3.An amplitude modulating wave is produced by super imposing a signal of 300Hz on a carrier frequency of 3MHz. the amplitude of the resultant wave will vary with time with frequency equal to_____.

4. Give the value of impedance of a perfect conductor to EM waves.

5. At a particular instant electric field intensity in e.m.waves in vacuum is $2x10^{-3}$ N/C. Find the magnitude of magnetic induction of the wave.

6. A plane e.m.wave of frequency 20 MHz travels in free space along the x direction. At a particular point in space & time B= $2.3x10^{-6}$ $\hat{k}$ telsa. Find the value of electric field at this point.

7. The electric field in a plane electromagnetic wave is given by $E_z = 60 \sin (0.5X\ 10^3x+1.5X10^{11}t)$ V/m.

a) Determine the wavelength & frequency of the wave.

b) Write an expression for the magnetic field.

8. How can you establish an instantaneous displacement current of 1.5A in the space between the two parallel plates of 3 μF capacitor?

9. A capacitor is made of two circular plates each of radius 10cm & is separated by 6mm. The capacitor is being charged by an external source. The charging current is constant & is equal to 0.1 A. using ampere’s law, calculate magnetic field between the plates at a point.

a) on the axis

b) 8.5cm from the axis

c) 16cm from the axis.

10. Which of the following if any can act as a source of e.m.waves. Give reason.

a) A charge at rest.

b) A charge moving in circular orbit.

c) A charge moving with constant velocity.

11. An electromagnetic radiation has energy 11KeV. To which region of e .m. spectrum does it belong to? Give any two uses of this radiation.

12. What is the condition of the electrons in the transmitting antenna when maximum magnetic field is being transmitted?

A maximum current is flowing, so the electrons have maximum speed up and down the antenna. The electric current produces the magnetic field.

13. How can the electric portion of the electro-magnetic wave be detected?

It can be detected by an antenna similar to the transmitting antenna except that a detector of electric current replaces the voltage source.

14.The small ozone layer on the top of the atmosphere is crucial for human survival. Why?

The ozone in the atmosphere is confined to the ozone layer, some 50-80 km above the ground. The ozone layer blocks the passage of the ultra-violet radiations; x-rays and y-rays from the solar and other extra-terrestrial sources and effectively protects us from the dangerous and harmful portions of solar radiations as they cause genetic damages to living cells. Practically all radiations of wave length less than 3 x 10^{-}7m are absorbed by the ozone layer. This explains why ozone layer on the top of the atmosphere is crucial for human survival.

15.How does "Green House Effect" affect the temperature of the earth's surface ?

Green house effect serves to keep the earth's surface warm at night.

16.How do we make television broadcasts for larger coverage and for long distance?

By using (i) tall antennas which is familiar landmark in many cities and (ii) using artificial satellites —called geostationary satellites. Since television signals are of high frequency and are not reflected by ionosphere so we use satellites to get them reflected & transmission of TV signals can be used for larger coverage as well as for long distance.

17. Scientists put x-ray astronomical telescope on the artificial satellite orbiting above the earth's atmosphere whereas they build optical and radio-telescopes on the surface of the earth. Why ?

X-rays have very high frequency and much smaller wavelength. These rays get absorbed by the earth's atmosphere. On the other hand, optical (visible) radiations and radio-waves can pass through the atmosphere. That is why optical and radio telescopes can be installed on the earth's surface.

18. For an electromagnetic wave, write the relationship between amplitude of electric and magnetic fields in free space.

[Hints If E_o is the amplitude of an electric field and B_o is the amplitude of the associated magnetic field in free space then $c = \frac{E_0}{B_0}$ where c is the *speed of light* in free space *i.e.* 3x10^8 m/s.

19. The charging current for a capacitor is 0.25 A. What is the displacement current across its plates?

Hints: Displacement current = Charging current = 0.25 A]

20. Why short wave communication over long distances is not possible via ground waves?

|Hints: Because the wave gets attenuated.]

21. Are conduction and displacement currents the same?

[Hint: No; they are different but they are equal .

22. It is necessary to use satellites for long distance TV transmission. Why?

It is so because television signals are not properly reflected by the ionosphere. Therefore, for reflection of signals satellites are needed as reflection is effected by satellites.

23. Optical and radio telescopes are built on ground but X-ray astronomy is possible only from satellites orbiting the earth. Why?

Atmosphere absorbs X-rays, while visible and radiowaves can penetrate it. That is why optical and radio telescopes can work on earth's surface but X-ray astronomical telescopes must be used on satellites orbiting the earth.

24. If the earth did not have an atmosphere, would its average surface temperature be higher or lower than what it is now?

Ans. The temperature of the earth would be lower because the green house effect of the atmosphere would be absent.

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25. What is the equation for the speed of electromagnetic waves in free space?

C= $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

26. The wavelength of electro magnetic radiation is doubled. What will happen to the energy of the photon?

The energy will be halved because frequency will be halved.

27. Name the part of electromagnetic spectrum to which waves of wavelength (i) 1A° and (ii) 10^{-2} m belong. Using the relation λT = (0.29 cm) K, obtain the characteristic kelvin temperature corresponding to these two wavelengths.

(i) X-rays, (ii) Microwaves

Again, (i) $T = \frac{0.29\,cm}{1\times10^{-10}\,cm} = 29\times10^{-8}\ K$ **(ii)** $T = \frac{0.29\,cm}{1\,cm} = 0.29\ K$

28. Show that the average energy density of the E field equals the average energy density of the B field.

Ans. Energy density in E field, $u_E = \frac{1}{2}\varepsilon_0 E^2$

Energy density in B field,---------- $u_B = \frac{1}{2\mu_0} B^2$

Using E = cB and c = $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$**, uE = uB.**

29. On what factors does its velocity in vacuum depend?

Ans. Electromagnetic waves consist of sinusoidal variation of electric and magnetic field vectors. The field vectors vibrate with the same frequency and are in the same phase. The field vectors and the direction of propagation are all mutually perpendicular. The velocity

of electromagnetic waves in vacuum depends upon absolute permeability μ_o and absolute permittivity ε_0.Note that c = $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

30. What is the name associated with the following equations?

$(i) \quad \oint \vec{E}.d\vec{S} = \frac{q}{\varepsilon_0}$ $\qquad (ii) \oint \vec{B}.d\vec{S} = 0$

$(iii) \quad \oint \vec{E}.d\vec{l} = -\frac{d}{dt}\int \vec{B}.d\vec{S}$ $\qquad (ii) \oint \vec{B}.d\vec{S} = \mu_0 \varepsilon_0 \frac{d}{dt}\int \vec{E}.d\vec{S} + \mu_0 I$

(i) Gauss's law (ii) No particular name
(iii) Faraday's law (iv) Ampere's law.

31. Electromagnetic waves with wavelength
(i) λ_1 are used to treat muscular strain
(ii) λ_2 are used by a FM radio station for broadcasting
(iii) λ_3 are used to detect fracture in bones
(iv) λ_4 are absorbed by the ozone layer of the atmosphere.
Identify and name the part of the electromagnetic spectrum to which these radiations belong. Arrange these wavelengths in decreasing order of magnitude.

Ans. (i) λ_1 -»infrared (ii) λ_2 -» radiowaves
(iii) λ_3 —> X-rays (in) λ_4 —> ultra-violet rays $\lambda_2 > \lambda_1 > \lambda_4 > \lambda_3$.

32. If you find closed loops of B in a region in space, does it necessarily mean that actual charges are flowing across the area bounded by the loops?

Ans. Not necessarily. A displacement current such as that between the plates of a capacitor that is being charged can also produce loops of B •

33. A closed loop of B is produced by a changing electric field. Does it necessarily mean that E and $\frac{dE}{dt}$ are non-zero at all points on the loop and in the area enclosed by the loop?

Ans. Not necessarily. All that is needed is that the total electric flux through the area enclosed by the loop should vary in time. The flux change may arise from any portion of the area. Elsewhere E or $\frac{dE}{dt}$ may be zero. In particular, there need be no electric field at the points which make the loop.

34. Why is it that induced electric fields due to changing magnetic flux are more readily observable than the induced magnetic fields due to changing electric fields?

Ans. The magnitude of the magnetic field due to displacement current is too small to be easily observable. This effect can of course be increased by increasing the displacement current. [In an AC circuit, this can be done by increasing ω.]

On the other hand, the effect of induced electric field due to changing magnetic flux can be increased simply by taking more and more number of turns in the coil. The induced emfs in different turns of the same coil add up in series.

35. A variable-frequency AC source is connected to a capacitor. Will the displacement current increase or decrease with increase in frequency?

Ans. Increase in frequency causes decrease in impedance of the capacitor and consequent increase in the current which equals displacement current between the plates.

36. Some scientists have predicted that a global nuclear war on the earth would be followed by a severe 'nuclear winter' with a devastating effect on life on earth. What might be the basis of this prediction?

Ans. The clouds produced by a global nuclear war would perhaps cover substantial parts of the sky preventing solar light from reaching many parts of the globe. This would cause a 'winter'.

37. What is the contribution of the Greenhouse effect towards the surface temperature of the earth?

Ans. The infrared radiation emitted by the earth's surface keeps the earth warm. In the absence of this effect, the surface temperature of earth would be lower.

38. Why the small ozone layer on top of the stratosphere is crucial for human survival?

Ans. The small ozone layer on the top of the stratosphere absorbs ultraviolet radiations, y-rays etc. from the sun. It also absorbs cosmic radiations. So, these radiations, which can cause genetic damage to the living cells, are prevented from reaching the earth. Thus, the small ozone layer on top of the stratosphere is crucial for human survival.

39. Given below are some famous numbers associated with electromagnetic radiation in different contexts in physics. State the part of the e m spectrum to which each belongs.

(i) 21 cm (wavelength emitted by atomic hydrogen in interstellar space).

(ii) 1057 MHz [frequency of radiation arising from two close energy levels in hydrogen; known as Lamb shift].

(Hi) 2.7 K temperature associated with the isotropic radiation filling all space-thought to be a relic of the 'big-bang' origin of the universe.

(iv) 5890 A - 5896 A [double lines of sodium].

(v) 14.4 keV [energy of a particular transition in 57Fe nucleus associated with a famous high resolution spectroscopic method (Mossbauer spectroscopy).

Ans. (i) Radio (short wavelength end) (ii) Radio (short wavelength end) (Hi) Microwave (iv) Visible (Yellow) (v) X-rays (or soft y-ray) region.

40. Electromagnetic waves in a cavity with conducting walls can exist only in certain modes i.e., they cannot exist, for example, with any arbitrary wavelength. Suggest a simple reason why this should be so.

Ans. The waves must satisfy a boundary condition. The electric field should be zero on the walls of the conductor. This restricts the possible modes. [It is something like the restricted modes of a string fixed at two ends.]