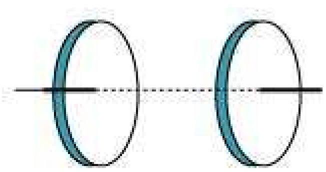
Question 8.1:

Figure 8.6 shows a capacitor made of two circular plates each of radius 12 cm, and separated by 5.0 cm. The capacitor is being charged by an external source (not shown in the figure). The charging current is constant and equal to 0.15 A.

(a) Calculate the capacitance and the rate of charge of potential difference between the plates.

(b) Obtain the displacement current across the plates.

(c) Is Kirchhoff's first rule (junction rule) valid at each plate of the capacitor? Explain.



Answer

Radius of each circular plate, r = 12 cm = 0.12 m

Distance between the plates, d = 5 cm = 0.05 m

Charging current, I = 0.15 A

Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

(a) Capacitance between the two plates is given by the relation,

$$C = \frac{\varepsilon_0 A}{d}$$

Where,

A = Area of each plate $= \pi r^2$

$$C = \frac{\varepsilon_0 \pi r^2}{d}$$

$$= \frac{8.85\times10^{-12}\times\pi\times(0.12)^2}{0.05}$$

$$= 8.0032\times10^{-12}\ \text{F} = 80.032\ \text{pF}$$

Charge on each plate, $q = CV$

Where,

V = Potential difference across the plates

Differentiation on both sides with respect to time (t) gives:

$$\frac{dq}{dt} = C\frac{dV}{dt}$$

But, $\frac{dq}{dt} = \text{current } (I)$

$$\therefore \frac{dV}{dt} = \frac{I}{C}$$

$$\Rightarrow \frac{0.15}{80.032\times10^{-12}} = 1.87\times10^{9} \text{ V/s}$$

Therefore, the change in potential difference between the plates is 1.87×10^9 V/s.

(b) The displacement current across the plates is the same as the conduction current. Hence, the displacement current, i_d is 0.15 A.

(c) Yes

Kirchhoff's first rule is valid at each plate of the capacitor provided that we take the sum of conduction and displacement for current.

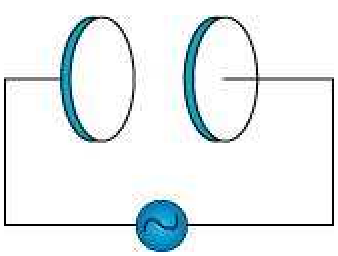
Question 8.2:

A parallel plate capacitor (Fig. 8.7) made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad s^{-1}.

(a) What is the rms value of the conduction current?

(b) Is the conduction current equal to the displacement current?

(c) Determine the amplitude of **B** at a point 3.0 cm from the axis between the plates.



Answer

Radius of each circular plate, R = 6.0 cm = 0.06 m

Capacitance of a parallel plate capacitor, C = 100 pF = 100×10^{-12} F

Supply voltage, V = 230 V

Angular frequency, ω = 300 rad s^{-1}

(a) Rms value of conduction current, $I = \frac{V}{X_C}$

Where,

X_C = Capacitive reactance

$= \frac{1}{\omega C}$

$\therefore I = V \times \omega C$

$= 230 \times 300 \times 100 \times 10^{-12}$

$= 6.9 \times 10^{-6}$ A

= 6.9 μA

Hence, the rms value of conduction current is 6.9 μA.

(b) Yes, conduction current is equal to displacement current.

(c) Magnetic field is given as:

$B = \frac{\mu_0 r}{2\pi R^2} I_0$

Where,

μ_0 = Free space permeability $= 4\pi \times 10^{-7}$ N A^{-2}

I_0 = Maximum value of current = $\sqrt{2}\, I$

r = Distance between the plates from the axis = 3.0 cm = 0.03 m

$$\therefore B = \frac{4\pi \times 10^{-7} \times 0.03 \times \sqrt{2} \times 6.9 \times 10^{-6}}{2\pi \times (0.06)^2}$$

= 1.63 × 10^{-11} T

Hence, the magnetic field at that point is 1.63 × 10^{-11} T.

Question 8.3:

What physical quantity is the same for X-rays of wavelength 10^{-10} m, red light of wavelength 6800 Å and radiowaves of wavelength 500 m?

Answer

The speed of light (3 × 10^8 m/s) in a vacuum is the same for all wavelengths. It is independent of the wavelength in the vacuum.

Question 8.4:

A plane electromagnetic wave travels in vacuum along z-direction. What can you say about the directions of its electric and magnetic field vectors? If the frequency of the wave is 30 MHz, what is its wavelength?

Answer

The electromagnetic wave travels in a vacuum along the z-direction. The electric field (*E*) and the magnetic field (*H*) are in the *x*-*y* plane. They are mutually perpendicular.

Frequency of the wave, ν = 30 MHz = 30 × 10^6 s^{-1}

Speed of light in a vacuum, *c* = 3 × 10^8 m/s

Wavelength of a wave is given as:

$$\lambda = \frac{c}{\nu}$$

$$= \frac{3 \times 10^8}{30 \times 10^6} = 10 \text{ m}$$

Question 8.5:

A radio can tune in to any station in the 7.5 MHz to 12 MHz band. What is the corresponding wavelength band?

Answer

A radio can tune to minimum frequency, v_1 = 7.5 MHz= 7.5 × 10^6 Hz

Maximum frequency, v_2 = 12 MHz = 12 × 10^6 Hz

Speed of light, c = 3 × 10^8 m/s

Corresponding wavelength for v_1 can be calculated as:

$$\lambda_1 = \frac{c}{v_1}$$
$$= \frac{3\times10^8}{7.5\times10^6} = 40 \text{ m}$$

Corresponding wavelength for v_2 can be calculated as:

$$\lambda_2 = \frac{c}{v_2}$$
$$= \frac{3\times10^8}{12\times10^6} = 25 \text{ m}$$

Thus, the wavelength band of the radio is 40 m to 25 m.

Question 8.6:

A charged particle oscillates about its mean equilibrium position with a frequency of 10^9 Hz. What is the frequency of the electromagnetic waves produced by the oscillator?

Answer

The frequency of an electromagnetic wave produced by the oscillator is the same as that of a charged particle oscillating about its mean position i.e., 10^9 Hz.

Question 8.7:

The amplitude of the magnetic field part of a harmonic electromagnetic wave in vacuum is B_0 = 510 nT. What is the amplitude of the electric field part of the wave?

Answer

Amplitude of magnetic field of an electromagnetic wave in a vacuum,

B_0 = 510 nT = 510 × 10^{-9} T

Speed of light in a vacuum, c = 3 × 10^8 m/s

Amplitude of electric field of the electromagnetic wave is given by the relation,

$E = cB_0$

= 3 × 10^8 × 510 × 10^{-9} = 153 N/C

Therefore, the electric field part of the wave is 153 N/C.

Question 8.8:

Suppose that the electric field amplitude of an electromagnetic wave is E_0 = 120 N/C and that its frequency is v = 50.0 MHz. (a) Determine, B_0, ω, k, and λ. (b) Find expressions for **E** and **B**.

Answer

Electric field amplitude, E_0 = 120 N/C

Frequency of source, v = 50.0 MHz = 50 × 10^6 Hz

Speed of light, c = 3 × 10^8 m/s

(a) Magnitude of magnetic field strength is given as:

$$B_0 = \frac{E_0}{c}$$

$$= \frac{120}{3 \times 10^8}$$

$$= 4 \times 10^{-7} \text{ T} = 400 \text{ nT}$$

Angular frequency of source is given as:

$\omega = 2\pi v$

= 2π × 50 × 10^6

= 3.14 × 10^8 rad/s

Propagation constant is given as:

$$k = \frac{\omega}{c}$$
$$= \frac{3.14\times10^{8}}{3\times10^{8}} = 1.05 \text{ rad/m}$$

Wavelength of wave is given as:

$$\lambda = \frac{c}{\nu}$$
$$= \frac{3\times10^{8}}{50\times10^{6}} = 6.0 \text{ m}$$

(b) Suppose the wave is propagating in the positive *x* direction. Then, the electric field vector will be in the positive *y* direction and the magnetic field vector will be in the positive *z* direction. This is because all three vectors are mutually perpendicular.

Equation of electric field vector is given as:

$$\vec{E} = E_0 \sin(kx - \omega t)\,\hat{j}$$
$$= 120 \sin\left[1.05x - 3.14\times10^{8}t\right]\hat{j}$$

And, magnetic field vector is given as:

$$\vec{B} = B_0 \sin(kx - \omega t)\,\hat{k}$$
$$\vec{B} = \left(4\times10^{-7}\right)\sin\left[1.05x - 3.14\times10^{8}t\right]\hat{k}$$

Question 8.9:

The terminology of different parts of the electromagnetic spectrum is given in the text. Use the formula *E* = *hv* (for energy of a quantum of radiation: photon) and obtain the photon energy in units of eV for different parts of the electromagnetic spectrum. In what way are the different scales of photon energies that you obtain related to the sources of electromagnetic radiation?

Answer

Energy of a photon is given as:

Website: www.vidhyarjan.com *Email: contact@vidhyarjan.com* *Mobile: 9999 249717*

Head Office: 1/3-H-A-2, Street # 6, East Azad Nagar, Delhi-110051
(One Km from 'Welcome' Metro Station)

$$E = h\nu = \frac{hc}{\lambda}$$

Where,

h = Planck's constant = 6.6×10^{-34} Js

c = Speed of light = 3×10^{8} m/s

λ = Wavelength of radiation

$$\therefore E = \frac{6.6\times10^{-34}\times3\times10^{8}}{\lambda} = \frac{19.8\times10^{-26}}{\lambda}\text{ J}$$

$$= \frac{19.8\times10^{-26}}{\lambda\times1.6\times10^{-19}} = \frac{12.375\times10^{-7}}{\lambda}\text{ eV}$$

The given table lists the photon energies for different parts of an electromagnetic spectrum for differentλ.

λ (m)	10^{3}	1	10^{-3}	10^{-6}	10^{-8}	10^{-10}	10^{-12}
E (eV)	12.375×10^{-10}	12.375×10^{-7}	12.375×10^{-4}	12.375×10^{-1}	12.375×10^{1}	12.375×10^{3}	12.375×10^{5}

The photon energies for the different parts of the spectrum of a source indicate the spacing of the relevant energy levels of the source.

Question 8.10:

In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of 2.0×10^{10} Hz and amplitude 48 V m^{-1}.

(a) What is the wavelength of the wave?

(b) What is the amplitude of the oscillating magnetic field?

(c) Show that the average energy density of the **E** field equals the average energy density of the **B** field. [$c = 3 \times 10^{8}$ m s^{-1}.]

Answer

Frequency of the electromagnetic wave, $v = 2.0 \times 10^{10}$ Hz

Electric field amplitude, $E_0 = 48$ V m^{-1}

Speed of light, $c = 3 \times 10^8$ m/s

(a) Wavelength of a wave is given as:

$$\lambda = \frac{c}{v}$$

$$= \frac{3\times10^8}{2\times10^{10}} = 0.015 \text{ m}$$

(b) Magnetic field strength is given as:

$$B_0 = \frac{E_0}{c}$$

$$= \frac{48}{3\times10^8} = 1.6\times10^{-7} \text{ T}$$

(c) Energy density of the electric field is given as:

$$U_E = \frac{1}{2}\epsilon_0 E^2$$

And, energy density of the magnetic field is given as:

$$U_B = \frac{1}{2\mu_0}B^2$$

Where,

ϵ_0 = Permittivity of free space

μ_0 = Permeability of free space

We have the relation connecting E and B as:

$E = cB$ … (1)

Where,

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} \quad \ldots (2)$$

Putting equation (2) in equation (1), we get

$$E = \frac{1}{\sqrt{\epsilon_0 \mu_0}} B$$

Squaring both sides, we get

$$E^2 = \frac{1}{\epsilon_0 \mu_0} B^2$$

$$\epsilon_0 E^2 = \frac{B^2}{\mu_0}$$

$$\frac{1}{2}\epsilon_0 E^2 = \frac{1}{2}\frac{B^2}{\mu_0}$$

$$\Rightarrow U_E = U_B$$

Question 8.11:

Suppose that the electric field part of an electromagnetic wave in vacuum is **E** = {(3.1 N/C) cos [(1.8 rad/m) *y* + (5.4 × 10^6 rad/s)*t*]} $\hat{i}$.

(a) What is the direction of propagation?

(b) What is the wavelength λ?

(c) What is the frequency *v*?

(d) What is the amplitude of the magnetic field part of the wave?

(e) Write an expression for the magnetic field part of the wave.

Answer

(a) From the given electric field vector, it can be inferred that the electric field is directed along the negative *x* direction. Hence, the direction of motion is along the negative *y* direction i.e., $-\hat{j}$.

(b) It is given that,

$$\vec{E} = 3.1\ \text{N/C}\cos\left[\left(1.8\ \text{rad/m}\right)y + \left(5.4\times10^{8}\ \text{rad/s}\right)t\right]\hat{i} \qquad \ldots(1)$$

The general equation for the electric field vector in the positive *x* direction can be written as:

$$\vec{E} = E_0 \sin\left(kx - \omega t\right)\hat{i} \qquad \ldots(2)$$

On comparing equations (1) and (2), we get

Electric field amplitude, E_0 = 3.1 N/C

Angular frequency, ω = 5.4 × 10^8 rad/s

Wave number, k = 1.8 rad/m

Wavelength, $\lambda = \frac{2\pi}{1.8}$ = 3.490 m

(c) Frequency of wave is given as:

$$\nu = \frac{\omega}{2\pi}$$

$$= \frac{5.4\times10^{8}}{2\pi} = 8.6\times10^{7}\ \text{Hz}$$

(d) Magnetic field strength is given as:

$$B_0 = \frac{E_0}{c}$$

Where,

c = Speed of light = 3 × 10^8 m/s

$$\therefore B_0 = \frac{3.1}{3\times10^{8}} = 1.03\times10^{-7}\ \text{T}$$

(e) On observing the given vector field, it can be observed that the magnetic field vector is directed along the negative z direction. Hence, the general equation for the magnetic field vector is written as:

$$\vec{B} = B_0 \cos\left(ky + \omega t\right)\hat{k}$$

$$= \left\{\left(1.03\times10^{-7}\ \text{T}\right)\cos\left[\left(1.8\ \text{rad/m}\right)y + \left(5.4\times10^{6}\ \text{rad/s}\right)t\right]\right\}\hat{k}$$

Question 8.12:

About 5% of the power of a 100 W light bulb is converted to visible radiation. What is the average intensity of visible radiation

(a) at a distance of 1 m from the bulb?

(b) at a distance of 10 m?

Assume that the radiation is emitted isotropically and neglect reflection.

Answer

Power rating of bulb, P = 100 W

It is given that about 5% of its power is converted into visible radiation.

∴ Power of visible radiation,

$$P' = \frac{5}{100} \times 100 = 5 \text{ W}$$

Hence, the power of visible radiation is 5W.

(a) Distance of a point from the bulb, d = 1 m

Hence, intensity of radiation at that point is given as:

$$I = \frac{P'}{4\pi d^2}$$

$$= \frac{5}{4\pi (1)^2} = 0.398 \text{ W/m}^2$$

(b) Distance of a point from the bulb, d_1 = 10 m

Hence, intensity of radiation at that point is given as:

$$I = \frac{P'}{4\pi (d_1)^2}$$

$$= \frac{5}{4\pi (10)^2} = 0.00398 \text{ W/m}^2$$

Question 8.13:

Use the formula $\lambda_m T$= 0.29 cm K to obtain the characteristic temperature ranges for different parts of the electromagnetic spectrum. What do the numbers that you obtain tell you?

Answer

A body at a particular temperature produces a continous spectrum of wavelengths. In case of a black body, the wavelength corresponding to maximum intensity of radiation is given according to Planck's law. It can be given by the relation,

$$\lambda_m = \frac{0.29}{T} \text{ cm K}$$

Where,

λ_m = maximum wavelength

T = temperature

Thus, the temperature for different wavelengths can be obtained as:

For $\lambda_m = 10^{-4}$ cm; $T = \frac{0.29}{10^{-4}} = 2900\ ^{o}K$

For $\lambda_m = 5 \times 10^{-5}$ cm; $T = \frac{0.29}{5\times10^{-5}} = 5800\ ^{o}K$

For $\lambda_m = 10^{-6}$ cm; $T = \frac{0.29}{10^{-6}} = 290000\ ^{o}K$ and so on.

The numbers obtained tell us that temperature ranges are required for obtaining radiations in different parts of an electromagnetic spectrum. As the wavelength decreases, the corresponding temperature increases.

Question 8.14:

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

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

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

(c) 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].

(d) 5890 Å - 5896 Å [double lines of sodium]

(e) 14.4 keV [energy of a particular transition in ^{57}Fe nucleus associated with a famous high resolution spectroscopic method
(Mössbauer spectroscopy)].

Answer

(a) Radio waves; it belongs to the short wavelength end of the electromagnetic spectrum.

(b) Radio waves; it belongs to the short wavelength end.

(c) Temperature, T = 2.7 °K

λ_m is given by Planck's law as:

$$\lambda_m = \frac{0.29}{2.7} = 0.11 \text{ cm}$$

This wavelength corresponds to microwaves.

(d) This is the yellow light of the visible spectrum.

(e) Transition energy is given by the relation,

$E = hv$

Where,

h = Planck's constant = 6.6×10^{-34} Js

v = Frequency of radiation

Energy, E = 14.4 K eV

$$\therefore v = \frac{E}{h}$$
$$= \frac{14.4 \times 10^3 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$
$$= 3.4 \times 10^{18} \text{ Hz}$$

This corresponds to X-rays.

Question 8.15:

Answer the following questions:

(a) Long distance radio broadcasts use short-wave bands. Why?

(b) It is necessary to use satellites for long distance TV transmission. Why?

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

(d) The small ozone layer on top of the stratosphere is crucial for human survival. Why?

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

(f) 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?

Answer

(a) Long distance radio broadcasts use shortwave bands because only these bands can be refracted by the ionosphere.

(b) It is necessary to use satellites for long distance TV transmissions because television signals are of high frequencies and high energies. Thus, these signals are not reflected by the ionosphere. Hence, satellites are helpful in reflecting TV signals. Also, they help in long distance TV transmissions.

(c) With reference to X-ray astronomy, X-rays are absorbed by the atmosphere. However, visible and radio waves can penetrate it. Hence, optical and radio telescopes are built on the ground, while X-ray astronomy is possible only with the help of satellites orbiting the Earth.

(d) The small ozone layer on the top of the atmosphere is crucial for human survival because it absorbs harmful ultraviolet radiations present in sunlight and prevents it from reaching the Earth's surface.

(e) In theabsenceof an atmosphere, there would be no greenhouse effect on the surface of the Earth. As a result, the temperature of the Earth would decrease rapidly, making it chilly and difficult for human survival.

(f) A global nuclear war on the surface of the Earth would have disastrous consequences. Post-nuclear war, the Earth will experience severe winter as the war will produce clouds of smoke that would cover maximum parts of the sky, thereby preventing solar light form reaching the atmosphere. Also, it will lead to the depletion of the ozone layer.

5. ELECTRO MAGNETIC WAVES

GIST

1. Conduction current and displacement current together have the property of continuity.
2. Conduction current & displacement current are precisely the same.
3. Conduction current arises due to flow of electrons in the conductor. Displacement current arises due to electric flux changing with time.
4. $I_D = \varepsilon_0 \int \frac{d\phi_E}{dt}$
5. Maxwell's equations

- **Gauss's Law in Electrostatics**
  $\oint \vec{E}.\overrightarrow{dS}=\frac{Q}{\varepsilon_0}$
- **Gauss's Law in Magnetism**
  $\oint \vec{B}.\overrightarrow{dS}=0$
- **Faraday's -Lenz law of electromagnetic induction.**
  $\oint \vec{E}\,.\overrightarrow{dl}=\int \frac{\vec{B}}{dt}.\overrightarrow{dS}$
- **Ampere's – Maxwell law**
  $\int \vec{B}\,.\overrightarrow{dl} = \mu_0 I + \mu_0 \varepsilon_0 \int \frac{\vec{E}}{dt}\,.\overrightarrow{dS}$

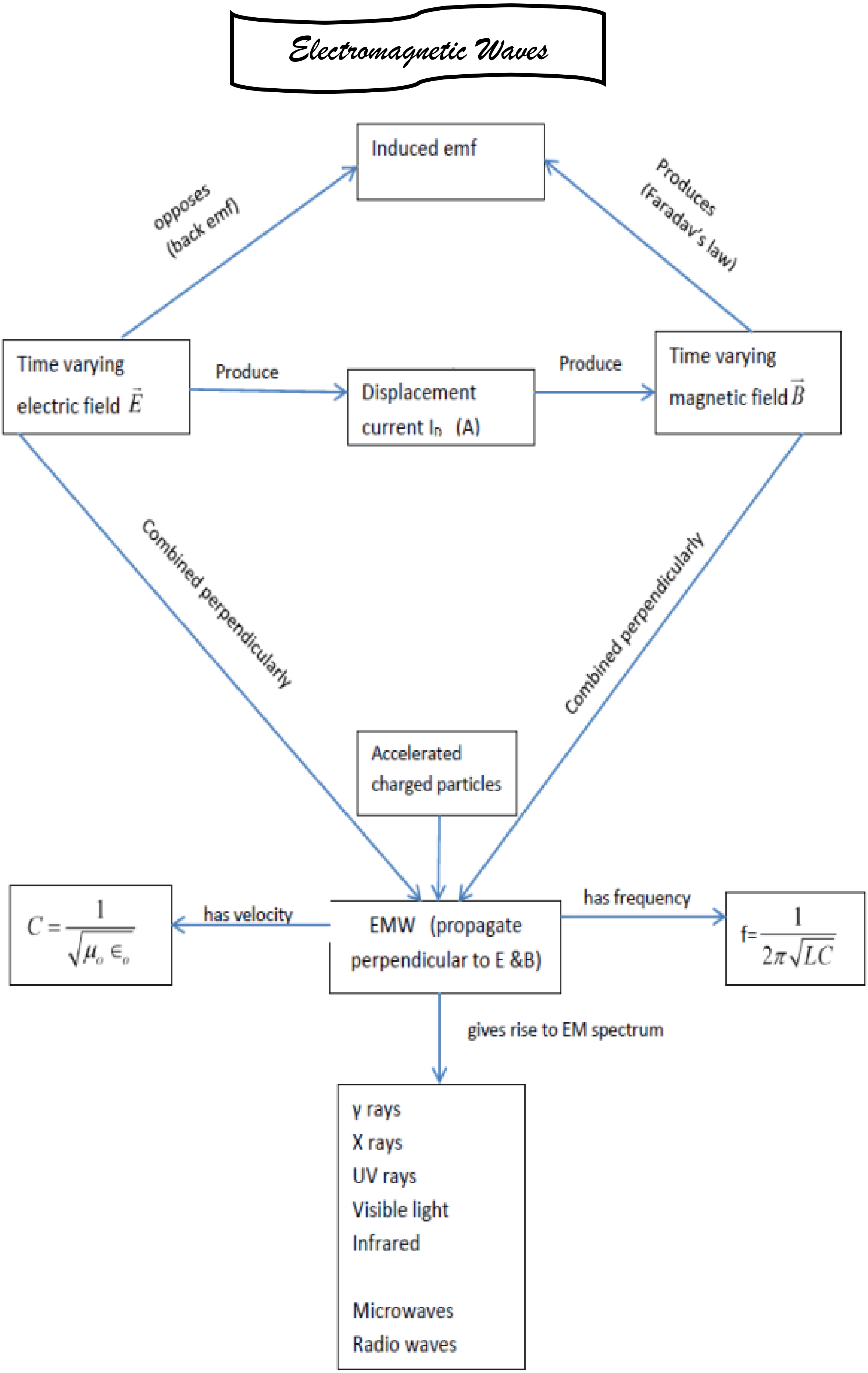
6. **Electromagnetic Wave :-** The wave in which there are sinusoidal variation of electric and magnetic field at right angles to each others as well as right angles to the direction of wave propagation.
7. Velocity of EM waves in free space:$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ 3x10^8 m/s
8. The Scientists associated with the study of EM waves are Hertz, Jagdish Chandra Bose & Marconi.
9. EM wave is a transverse wave because of which it undergoes polarization effect.
10. Electric vectors are only responsible for optical effects of EM waves.
11. The amplitude of electric & magnetic fields are related by $\frac{E}{B} = c$
12. Oscillating or accelerating charged particle produces EM waves.
13. Orderly arrangement of electro magnetic radiation according to its frequency or wavelength is electromagnetic spectrum.
14. **Hint to memorise the electromagnetic spectrum in decreasing order of its frequency.**
    Gandhiji's X-rays Used Vigorously InMedical Research
15. EM waves also carry energy, momentum and information.

ELECTRO MAGNETIC SPECTRUM, ITS PRODUCTION, DETECTION AND USES IN GENERAL

Type	Wave length Range Frequency Range	Production	Detection	Uses
Radio	>0.1m 10^9 to 10^5Hz	Rapid acceleration / deceleration of electrons in aerials	Receiver's aerials	Radio, TV Communication
Microwave	0.1mm 10^{11} to10^9 Hz	Klystron valve or magnetron valve	Point contact diodes	Radar, TV communication

Infrared	1mm to 700nm 10^{11} to10^{14} Hz	Vibration of atom or molecules	Thermopiles, Bolometer Infrared Photographic Film	Green House effect, looking through haze, fog and mist, Ariel mapping.
Light	700nm to 400nm $8x10^{14}$ Hz	Electron in an atom during transition	Eye, Photocell, Photographic Film	Photography, Illuminations, Emit & reflect by the objects.
Ultraviolet	400nm to 1nm $5x10^{14}$ to $8x10^{14}$	Inner Shell electron in atom moving from one energy level to a lower energy level	Photocell & photographic film	Preservation of food items, Detection of invisible writing, finger print in forensic laboratory. Determination of Structure of molecules & atoms.
X-rays	1nm to 10^{-3}nm 10^{16} to 10^{21} Hz	X-ray tube or inner shell Electrons	Photographic film, Geiger tube, ionization chamber.	Study of crystal structure & atom, fracture of bones.
Gamma ray	$<10^{-3}$nm 10^{18} to 10^{22} Hz	Radioactive decay of the nucleus	Photographic film, Geiger tube, ionization chamber	Nuclear reaction & structure of atoms & Nuclei. To destroy cancer cells.

CONCEPT MAP


Electromagnetic Waves
Induced emf
opposes (back emf)
Produces (Faraday's law)
Time varying electric field $\vec{E}$
Produce
Displacement current I_D (A)
Produce
Time varying magnetic field $\vec{B}$
Combined perpendicularly
Combined perpendicularly
Accelerated charged particles
$C = \frac{1}{\sqrt{\mu_o \in_o}}$
has velocity
EMW (propagate perpendicular to E &B)
has frequency
$f = \frac{1}{2\pi\sqrt{LC}}$
gives rise to EM spectrum
γ rays
X rays
UV rays
Visible light
Infrared
Microwaves
Radio waves

QUESTIONS

1. Write the SI unit of displacement current? 1

Ans : Ampere

2. If $\vec{E}, \vec{B}$ represent electric and magnetic field vectors of the electromagnetic waves, then what is the direction of propagation of the electromagnetic wave? 1

Ans: $\vec{E} \times \vec{B}$

3. Can the velocity of light in vacuum be changed? 1

Ans: Not possible

4 Calculate the wavelength of EMW emitted by the oscillator antenna system, if L= 0.253 μH & C = 25Pf ? 1

Ans

$$\frac{1}{2\pi\sqrt{LC}}$$

5. The magnetic component of polarized wave of light is
$B_X = (4 \times 10^{-6} T)\text{Sin}\,[(1.57 \times 10^7 m^{-1})y + (4.5 \times 10^{11} t)]$

(a) Find the direction of propagation of light
(b) Find the frequency
(c) Find intensity of light

3

Ans Y axis
f = $(4.5 \times 10^{11})/2\pi$ Hz
I ∝ A^2

6. What physical quantity is same for X-rays of wavelength 10^{-10} m, red light of wavelength 6800 Å and radio wave of wavelength 500 m? 1

Ans Velocity

7. The amplitude of $\vec{B}$ of harmonic electromagnetic wave in vacuum is B_o=510 n T. What is the amplitude of the electric field part of the wave? 1

Ans 153 N/C

8. Suppose E_o =120 N/C and its frequency ν = 50Hz. Find B_o, ω, k and λ and write expression for E and B ? 2

Ans $\vec{E}_y = 120\, Sin[1.05x - 3.14 \times 10^8 t]\hat{j}$ NC^{-1}
$\vec{B}_Z = 400\, Sin[1.05x - 3.14 \times 10^8 t]\hat{k}$ nT
B_o = 400 n T ; ω = 10^8 rad/s, k=1.05 rad/m , λ = 6m

9. The charging current for a capacitor is 0.25 A. what is the displacement current across its plates? 1

Ans 0.25 A

10. A variable frequency a.c source is connected to a capacitor. Will the displacement current increase or decrease with increasing frequency? 1

Ans Increases

11. EMW travel in a medium at a speed of $2x10^8$ m/s. the relative permeability of the medium is 1.0. Calculate the relative permittivity?

Ans $\varepsilon_r = 2.25$

$$V = \frac{C}{\sqrt{\mu_r \varepsilon_r}}$$

12. How does a charge q oscillating at certain frequency produce electromagnetic wave? 1

Ans Oscillating charge produces oscillating E which produces oscillating B and so on

13. How would you establish an instantaneous displacement current of 1A in the space between the parallel plates of 1µF capacitor? 1

Ans By changing the voltage $dv/dt = 10^6$ V/s

14. Name the Maxwell's equation among the four which shows that the magnetic monopole does not exist? 1

Ans Gauss's theorem of Magnetism

15. Write the unit of $\mu_o \varepsilon_o$? 1

Ans $(m/s)^{-2}$

16. Give reason for decrease or increase in velocity of light, when it moves from air to glass or glass to air respectively? 1

Ans The velocity of light depends on ε & µ of the medium.

17. A parallel plate capacitor made of circular plates each of radius 10 cm has a capacitance 200pF. The capacitor is connected to a 200V a.c. supply with an angular frequency of 200 rad/s.

a) What is the rms value of conduction current
b) Is the conduction current equal to displacement current 2
c) Peak value of displacement current
d) Determine the amplitude of magnetic field at a point 2cm from the axis between the plates

Ans a) $I_{rms} = 8\mu A$
b) $I_c = I_d$
c) $I_o = 2^{1/2}\ I_{rms}$
$B = 4.525 \times 10^{-12}$ T

18. 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 produced by bombarding metal target by high speed electrons. 3

(iv) λ_4, are observed by the ozone layer of the atmosphere.

Identify and name the part of electromagnetic spectrum to which these radiation belong. Arrange these wave lengths, in decreasing order of magnitude.

Ans $\lambda_1 \longrightarrow$ Infra red radiation.

$\lambda_2 \longrightarrow$ VHF / Radiowaves.

$\lambda_3 \longrightarrow$ X – rays

$\lambda_4 \longrightarrow$ UV $\qquad \lambda_2 > \lambda_1 > \lambda_4 > \lambda_3$

19. a) Which of the following if any, can act as a source of electromagnetic waves.
(i) A charge moving with constant velocity.
(ii) A charge moving in circular orbit.
(iii)A charge at rest. Give reason 3
(b) Identify the part of electromagnetic spectrum to which the waves of frequency
(i) 10^{20} Hz (ii) 10^{9} Hz belong.

Ans a) Can't produce em waves because no accelration.
(ii) It is accelrated motion - can produce em waves.
(iii)Can't produce em waves because no accelration.
b) (i) Gamma rays.
(ii) Micro waves