# PHYSICS

# BOOKS - VIKRAM PUBLICATION ( ANDHRA PUBLICATION)

# ELECTROMAGNETIC WAVE

## Textual Examples

**1.** A parallel plate capacitor with circular plates of radius 1m has a capacitance of 1 nF. At t=0 ,

It is connected for charging in series with are resistor R=1 M Q across a 2V battery (fig). Calculate the magnetic field at a point P halfway between the centre and the periphery of the plates. after t $= 10^{-3}s$. (The charge on the capacitor at time $\tau$ is q(t) CV [1 =exp $(-t/\tau)$ ], where the time constant $\tau$ is equal to CR).

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**2.** A plane electromagentic wave of frequency 25 MHz travels in free space along the x-direction. At a particular point in space and time , E=6.3 $\hat{j}$ V/m . What is B at the point ?

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**3.** The magnetic field in a plane electromagnetic wave is given by

$B_y = 2 \times 10^{-7} \sin\left(0.5 \times 10^3 x + 1.5 \times 10^{11} t\right) T$

.

What is the wavelength and frequency of the wave ?

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**4.** The magnetic field in a plane electromagnetic wave is given by

$B_y = 2 \times 10^{-7} \sin\left(0.5 \times 10^3 x + 1.5 \times 10^{11} t\right) T$

.

Write an expression for the electric field.

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**5.** Light with an energy flux of 18 $W / cm^2$ falls on a non reflecting surface at normal incidence. If the surface has an area of 20 $cm^2$ . Find the average force exerted on the surface during a 30 minute time span.

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**6.** Calculate the electric and magnetic fields produced by the radiation coming from a 100 W bulb at a distance of 3 m . Assume that the

efficiency of the bulb is 2.5 % and it is a point source.

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## Problems

**1.** A plane electromagnetic wave travels in vaccum 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 ?

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**2.** 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 ?

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## Very Short Answer Questions

**1.** What is the average wavelength of X-rays ?

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**2.** Give any one use of infrared rays.

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**3.** If the wavelength of electromagnetic radiation is doubled, what happens to the energy of photon ?

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**4.** What is the principle of production of electromagnetic waves ?

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**5.** What is the ratio of speed of infrared rays and ultraviolet rays in vacuum ?

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**6.** What is the relation between the amplitudes of the electric and magnetic fields in free space for an electromagnetic wave ?

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**7.** What are the applications of microwaves ?

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**8.** Microwaves are used in Radars, why ?

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**9.** Give two uses of infrared rays.

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**10.** The charging current for a capacitor is 0.6 A. What is the displacement current across its plates ?

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**11.** How are infrared rays produced ? How they can be detected ?

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**12.** How are radio waves produced ? How can they detected ?

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**13.** If the wave length of E.M radiation is doubled, what happens to the energy ot photon ?

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**14.** How are microwaves produced ? How can they detected ?

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**15.** Define displacement current.

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## Short Answer Questions

**1.** What does an electromagnetic wave consists of ? On what factors does its velocity in vacuum depend ?

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**2.** What is Greenhouse effect and its contribution towards the surface temperature of earth ?

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**3.** State six characteristics of electromagnetic waves. What is Greenhouse effect ?

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## Long Answer Questions

**1.** Give the brief history of discovery of knowledge of electromagnetic waves.

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**2.** State six characteristics of electromagnetic waves. What is Greenhouse effect ?

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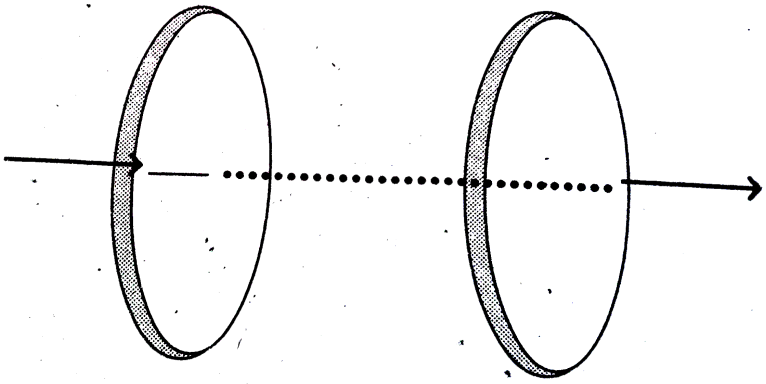
## Textual Exercises

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



Calculate the capacitance and the rate of

charge of potential difference between the plates.

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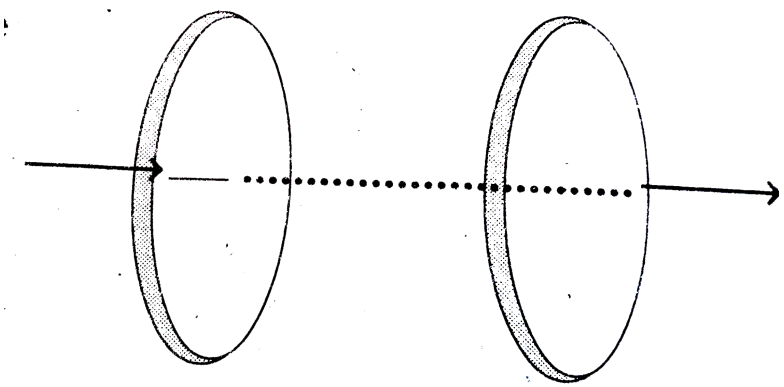
**2.** The figure shows a capacitor made of two circular plates each of radius 12 cm, and separated by 5.0 cm . The capacitor is beging charged by an external source (not shown in the figure. ) The charing is constant and equal to 0.15 A



Obtain the displacement current across the plates.

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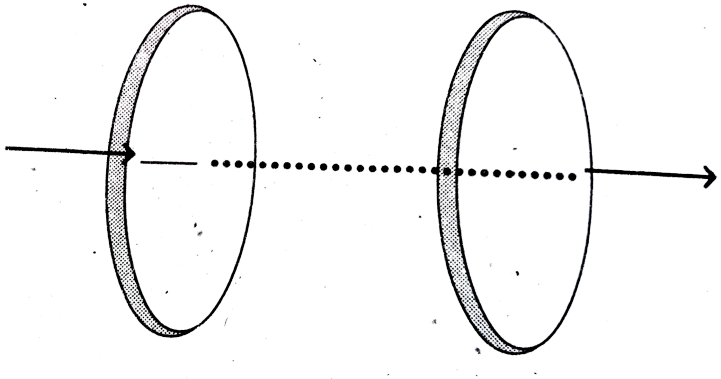
**3.** The figure shows a capacitor made of two circular plates each of radius 12 cm, and separated by 5.0 cm . The capacitor is beging charged by an external source (not shown in

the figure. ) The charing is constant and equal to 0.15 A



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

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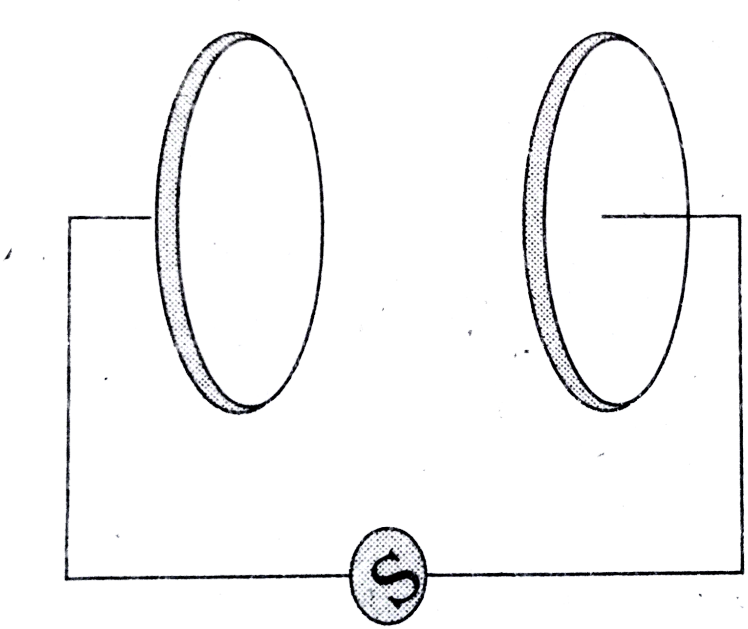
**4.** A parallel plate capacitor in the figure made of circular plates each of radius R=6.0 cm has a

capacitance C=100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad $s^{-1}$.



What is the rms value of the conduction current ?

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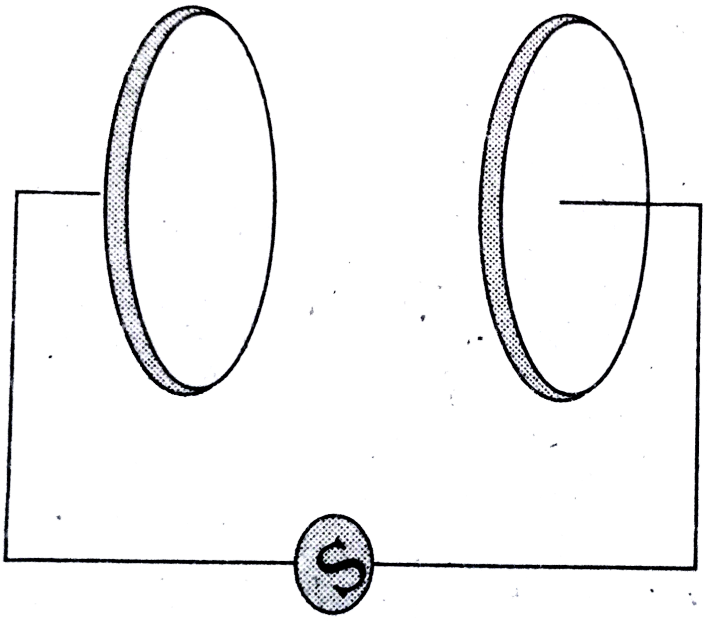
**5.** A parallel plate capacitor in the figure made of circular plates each of radius R=6.0 cm has a capacitance C=100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad $s^{-1}$.



Is the conduction current equal to the displacement current ?

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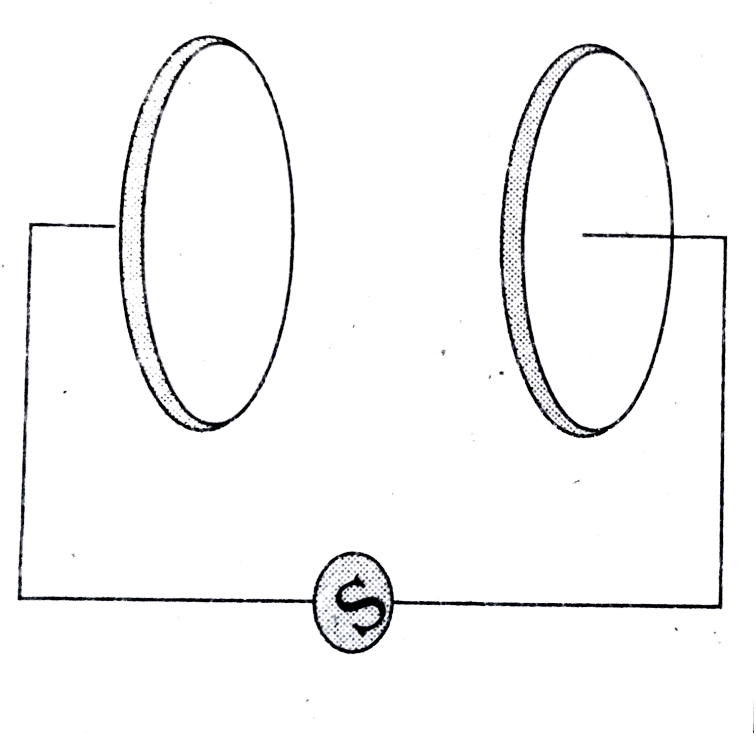
**6.** A parallel plate capacitor in the figure made of circular plates each of radius R=6.0 cm has a capacitance C=100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad $s^{-1}$ .



Determine the amplitude of B at a point 3.0 cm from the axis between the plates.

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

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**8.** A plane electromagnetic wave travels in vaccum 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 ?

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**9.** A radio can tune into any station in the 7.5 MHz to 12MHz band. Wha t is the corresponding wavelength band ?

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**10.** A charged particles 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 ?

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**11.** 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 ?

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**12.** 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. Determine. $B_0, \omega, k$ and $\lambda$

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**13.** 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.Find expressions for E and B.

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**14.** 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 ?

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**15.** In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2.0 \times 10^{10} Hz$ and amplitude 48

V $m^{-1}$.

What is the wavelength of the wave ?

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

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

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## Additional Exercises

**1.** 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 $\times$ $10^6$ rad/s} t]} i.

What is the direction of propagation ?

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**2.** 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 $\times$ $10^6$ rad/s} t]} i.

What is the wavelength $\lambda$ ?

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**3.** 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 $\times$ $10^6$ rad/s} t]} i.

What is the frequency v ?

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**4.** 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 $\times$ $10^6$ rad/s} t]} i.

What is the amplitude of the magnetic field part of the wave ?

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**5.** 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 $\times$ $10^6$ rad/s} t]} i.

Write an expression for the magnetic field part of the wave .

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**6.** About 5% of the power of a 100 W light bulb is converted to visible radiation . What is the average intensity of visible radiation at a distance of 1 m from the bulb ?

Assume that the radiation is emitted isotropically and neglect reflection .

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

distance of 10 m ?

Assume that the radiation is emitted isotropically and neglect reflection .

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**8.** 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 ?

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**9.** 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.

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

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**10.** 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.

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

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**11.** 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.

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].

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**12.** 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.

5890 Å -5896 Å [double lines of sodium].

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**13.** 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.

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

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**14.** Long distance radio broadcasts use short-wave bands . Why ?

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**15.** It is neccessary to use satellites for long distance TV transmission. Why ?

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

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

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

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**19.** Some scientists have predicited 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 ?

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