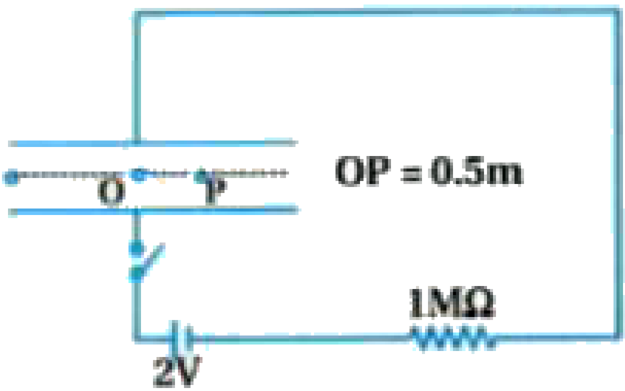
PHYSICS

NCERT - NCERT PHYSICS(GUJRATI)

ELECTROMAGNETIC WAVES

Example

1. A parallel plate capacitor with circular plates of radius 1 m has a capacitance of 1 nF. At t = 0, it is connected for charging in series with a resistor $R = 1MO\neg a$ across a 2V battery. 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 t is q (t) = CV [1 - exp $(-t/\tau)$], where the time constant τ is equal to CR.)



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2. A plane electromagnetic 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 this point?

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

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

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

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

Write an expression for the electric field.

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5. Light with an energy flux of $18W/cm^2$ falls on a nonreflecting surface at normal incidence. If the surface has an area of $20cm^2$, 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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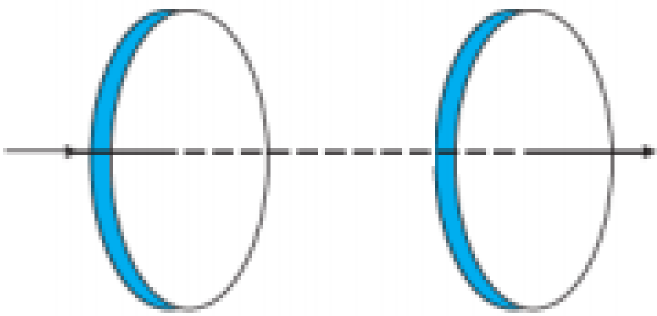
Exercises

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 0.15A.

(a) Calculate the capacitance and the rate of change 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.



આકૃતિ 8.6

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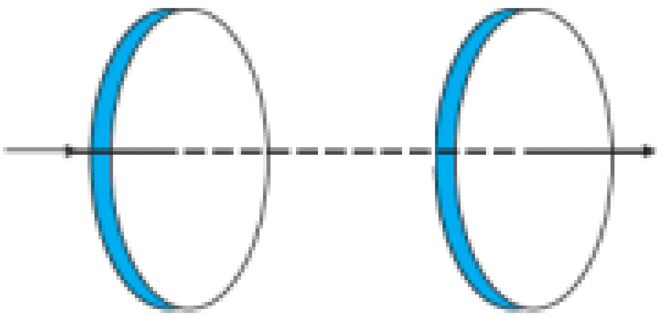
2. A parallel plate capacitor (Fig. 8.7) made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad s^{-1}.

(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.



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

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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?

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

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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?

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

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8. Suppose that the electric field amplitude of an electromagnetic wave is $E_0 = 120N/C$ and that its frequency is ν = 50.0 MHz. (a) Determine,$B_0 \omega, k, \text{ and } \lambda$.

(b) Find expressions for E and B.

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

(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. $\left[c = 3 \times 10^{8} m s^{-1}.\right]$

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Additional Exercises

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

What is the direction of propagation ?

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2. 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 1m from the bulb?

(b) at a distance of 10 m?

Assume that the radiation is emitted isotropically and neglect reflection.

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3. 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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4. 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) $5890Å - 5896Å$ [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)].

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5. 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 radiotelescopes 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?

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