



PHYSICS

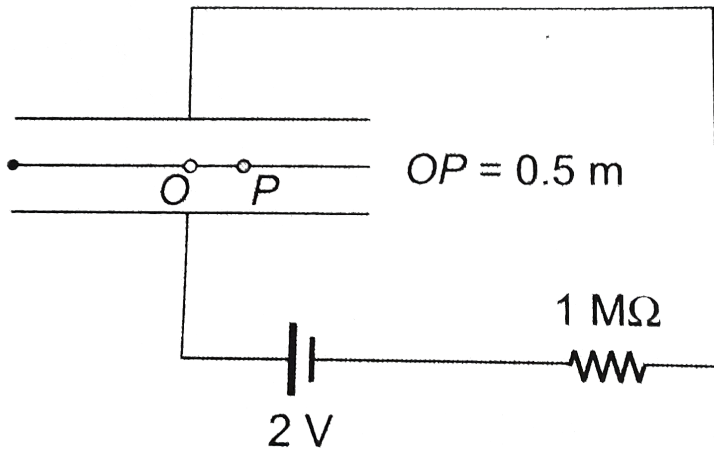
NCERT - NCERT PHYSICS(ENGLISH)

ELECTROMAGNETIC WAVES

Solved Examples

1. A parallel plate capacitor with circular plates of radius $1m$ has a capacitor of $1nF$. At $t = 0$, it is connected for charging in series with a resistor $R = 1M\Omega$ across a $2V$ battery. Calculate the

magnetic field at a point P , halfway between the centre and the periphery of the plates, after $t = 10^{-3}$ sec.



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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, $E = (6.3j)V/m$.

What is B at this point?



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

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

(a) What is the wavelength and frequency of the wave?

(b) Write an expression for the electric field.



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4. Light with an energy flux of $18W/cm^2$ falls on a non-reflecting 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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5. Calculate the electric and magnetic fields produced by the radiation coming from a 100 W bulb at a distance of $3m$. Assume that the efficiency of the bulb is 25 % and it is a point source.



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Exercise

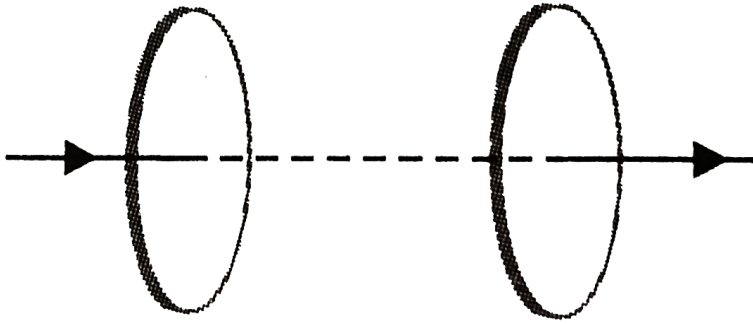
1. Fig. shows a capacitor made of two circular plates each of radius 12 cm and separated by 5.0mm. The capacitor is being charged by an external source (not shown in the figure). The charging current is constant and equal to 0.15A.

(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 valid at each plate of the

capacitor ? Explain.



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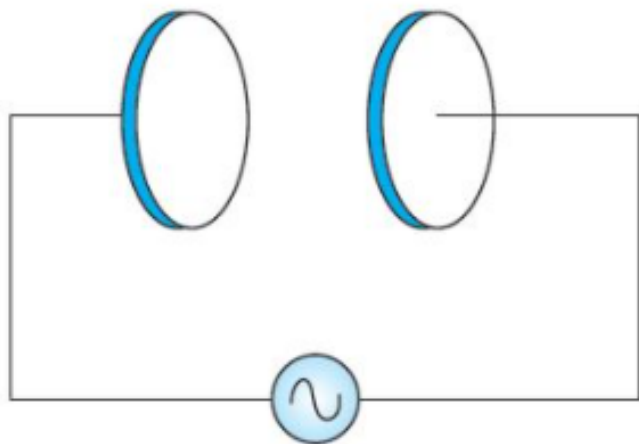
2. A parallel plate capacitor made of circular plates each of radius $R = 6.0$ cm has a capacitance $c = 100\text{pF}$. The capacitor is connected to a 230V AC supply with a (angular) frequency of 300rad/s

(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 3.0cm 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 6800\AA and radio waves 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 30MHz , what is its wavelength?



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

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6. A charged particle oscillates about its mean equilibrium position with a frequency of 10^9 Hz . The electromagnetic waves produced.

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7. The amplitude of the magnetic field part of a harmonic electromagnetic wave in vacuum is $B_0 = 510 \text{ nT}$. 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 $E_0 = 120 \text{ N/C}$ and that its frequency is 50.0 MHz .

(a) Determine B_0 , ω , k and λ ,

(b) find expressions for E and B .



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9. The terminology of different parts of the electromagnetic spectrum is given in the text. Use the formula $E = h \nu$ (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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10. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2.0 \times 10^{10} \text{ Hz}$ 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 field

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



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11. Suppose that the electric field part of an electromagnetic wave in vacuume is

$$E = 3.1 \text{ N/C} \cos [(1.8 \text{ rad/m})y + (5.4 \times 10^8 \text{ rad/s})t] \hat{i}$$

(a) What is the direction of motion?

(b) What is the wavelength λ ?

(c) What is the frequency ν ?

(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.



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12. About 5 % of the power of a $100W$ 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 $10m$?

Assume that the radiation is emitted isotropically and neglect reflection.



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13. Use the formula $\lambda_m T = 0.29 \text{ cmK}$ to obtain the characteristic temperature ranges for different parts of the e.m. spectrum. What do the number that you obtain tell you?



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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) $5890\text{\AA} - 5896\text{\AA}$ (double lines of sodium)

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



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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 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? Answer the following questions: (a) Long distance radio broadcasts use short-wave bands.

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