PHYSICS

NCERT - FULL MARKS PHYSICS(TAMIL)

ELECTROMAGNETIC WAVES

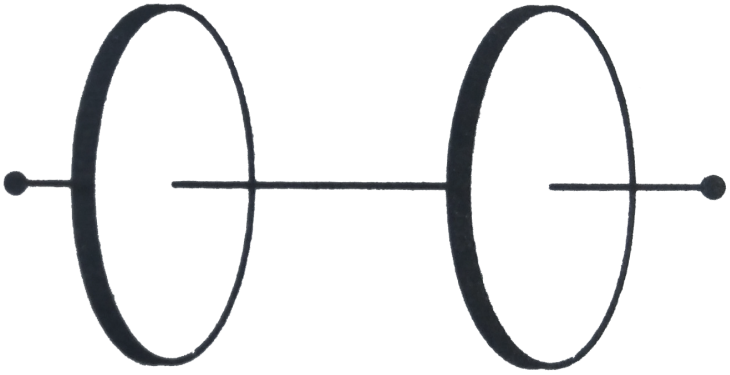
Exercises

1. Figure shows a capacitor made of two circular plates each of radius $12cm$, and separated by $5.0cm$. 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) Calcuate 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) vaild at each plate of the capacitor ? Explain.



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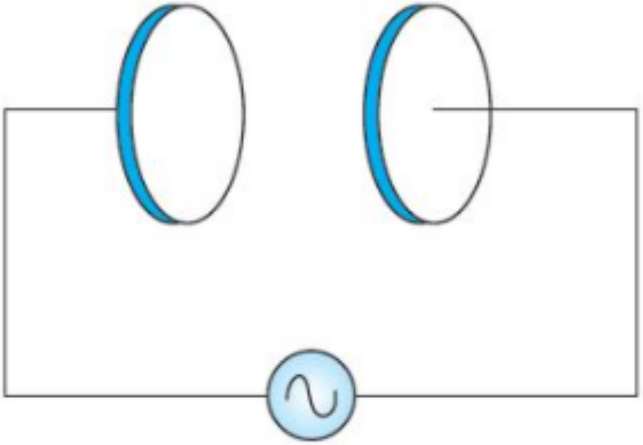
2. A parallel plate capacitor made of circular plates each of radius $R = 6.0$ cm has a capacitance $c = 100pF$. The

capacitor is connected to a $230VAC$ 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 $6800A$ 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 ots 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 frequency of electromagnetic waves produced by the oscillator is

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7. The amplitude of the magnetic field part of 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 us $E_0 = 120N/C$ and that its frequency is $50.0MHz$.

(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 ν (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 $2.0 \times 10^{10} H_z$ and amplitude $48 V_m^{-1}$

(a) What is the wavelength o f 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. $\left[c = 3 \times 10^8 ms^{-1}\right]$.

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Additional Exercises

1. Suppose that the electric field of an electromagnetic wave in vacuum is $E = \left\{(3.0N/C)\cos[1.8rad/m)y + \left(5.4 \times 10^6 rad/s\right)t\right]\}\hat{i}$

(a) What is the direction of propagation of wave?

(b) What is the wavelength lambda ?

(c) What is the frequency f ?

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

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

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2. 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 esmitted isotropically and neglect reflection.

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3. Use the formula $\lambda_m T = 0.29 cmK$ 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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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) $5890\widehat{A} - 5896\widehat{A}$ (double lines of sodium]

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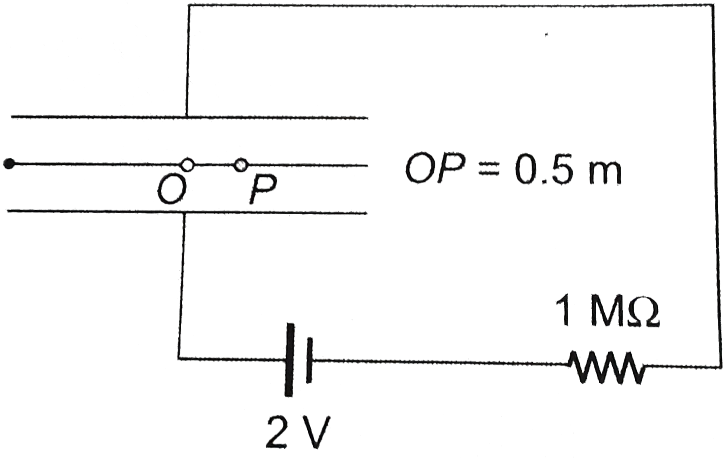
Example

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 cnetre and the periphery of the

plates, after $t = 10^{-3}$ sec.



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2. A plane electromagnetic wave of frequency $25Mhz$ 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

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

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

(b) Write an expression for the eletric field.

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

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

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-reflacting 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 $3m$. Assume that the efficiency of the bulb is $25\ \%$ and it is a point source.

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7. Consider a parallel plate capacitor which is maintained at potential of 200 V. If the separation distance between the plates of the capacitor and area of the plates are 1 mm and $20cm^2$. Calculate the displacement current for the time in μs.

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8. The relative magnetic permeability of the medium is 2.5 and the relative electrical permittivity of the medium is 2.25. Compute the refractive index of the medium.

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9. Computer the speed of the electromagnetic wave in a medium if the amplitude of electric and magnetic fields are $3 \times 10^4 NC^{-1}$ and $2 \times 10^{-4} T$, respectively.

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10. A magnetron in a microwave oven emits electromagnetic waves (em waves) with frequency f = 2450 MHz. What magnetic field strength is required for electrons to move in circular paths with this frequency?.

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Evaluation Multiple Choice Questions

1. The dimension of $\frac{1}{\mu_\circ \varepsilon_\circ}$ is

A. $\left[LT^{-1}\right]$

B. $\left[L^2T^{-2}\right]$

C. $\left[L^{-1}T\right]$

D. $\left[L^{-2}T^2\right]$

Answer: B

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2. If the amplitude of the magnetic field is $3 \times 10^{-6}T$, then amplitude of the electric field for a electromagnetic waves is

A. $100Vm^{-1}$

B. $300Vm^{-1}$

C. $600Vm^{-1}$

D. $900Vm^{-1}$

Answer: D

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3. Which of the following electromagnetic radiation is used for viewing objects through fog

A. microwave

B. gamma rays

C. X- rays

D. infrared

Answer: D

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4. Which of the following are false for electromagnetic waves

A. transverse

B. mechanical waves

C. longitudinal

D. none of these

Answer: C

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5. Consider an oscillator which has a charged particle and oscillates about its mean position with a frequency of 300 MHz. Th e wavelength of electromagnetic waves produced by this oscillator is

A. 1 m

B. 10 m

C. 100 m

D. 1000 m

Answer: A

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6. Th e electric and the magnetic fi eld, associated with an electromagnetic wave, propagating along X axis can be represented by

A. $\overrightarrow{E} = E_{\circ}\widehat{J}\,\text{and}\overrightarrow{B} = B_{\circ}\hat{k}$

B. $\overline{E} = E_{\circ}\hat{k} \quad \text{and} \quad \overrightarrow{B} = B_{\circ}\hat{j}$

C. $\overrightarrow{E} = E_{\circ}\hat{j} \quad \text{and} \quad \overrightarrow{B} = B_{\circ}\hat{j}$

D. $\overrightarrow{e} = E_{\circ}\hat{j} \quad \text{and} \quad \overrightarrow{B} = B_{\circ}\hat{j}$

Answer: B

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7. In an electromagnetic wave in free space the rms value of the electric fi eld is 3 V m^{-1}. Th e peak value of the magnetic fi eld is

A. $1.414 \times 10^{-8} T$

B. $1.0 \times 10^{-8} T$

C. $2.828 \times 10^{-8} T$

D. 2.0×10^{-8} T

Answer: A

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8. During the propagation of electromagnetic waves in a medium:

A. electric energy density is double of the magnetic energy density

B. electric energy density is half of the magnetic energy density

C. electric energy density is equal to the magnetic energy density

D. both electric and magnetic energy densities are zero

Answer: C

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9. If the magnetic monopole exists, then which of the Maxwell's equation to be modifi ed?.

A. $\oint \vec{E} . d\vec{A} = \frac{Q_{enclosed}}{\in_{\circ}}$

B. $\oint \vec{E} . d\vec{A} = 0$

C. $\oint \vec{E} . d\vec{A} = \mu_{\circ} I_{enclosed} + \mu_{\circ} \in_{\circ} \frac{d}{dt} \int \vec{E} . d\vec{A}$

D. $\oint \vec{E} . \vec{d} l = -\frac{d}{dt} \Phi_B$

Answer: B

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10. radiation of energy E falls normally on a perfectly refl ecting surface. The momentum transferred to the surface

A. $\frac{E}{c}$

B. $2\frac{E}{c}$

C. Ec

D. $\frac{E}{C^2}$

Answer: B

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11. Which of the following is an electromagnetic wave?

A. $\alpha - rays$

B. $\beta - rays$

C. $\gamma - rays$

D. all of them

Answer: C

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12. Which one of them is used to produce a propagating electromagnetic wave?.

A. an accelerating charge

B. a charge moving at constant velocity

C. a stationary charge

D. an uncharged particle

Answer: A

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13. Let $E = E_{\circ} \sin\left[10^{6} \times -\varepsilon t\right]$ be the electric field of plane electromagnetic wave, the value of ε is

A. $0.3 \times 10^{-14} rad's^{-1}$

B. $3 \times 10^{-14} \text{rad} s^{-1}$

C. $0.3 \times 10^{14} \text{rad} s^{-1}$

D. $3 \times 10^{14} \text{rad} s^{-1}$

Answer: D

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14. Which of the following is NOT true for electromagnetic waves?.

A. it transport energy

B. it transport momentum

C. it transport angular momentum

D. in vacuum, it travels with different speeds which depend on their frequency

Answer: D

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15. The electric and magnetic fields of an electromagnetic wave are

A. in phase and perpendicular to each other

B. out of phase and not perpendicular to each other

C. in phase and not perpendicular to each other

D. out of phase and perpendicular to each other

Answer: A

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Evaluation Numerical Problems

1. Consider a parallel plate capacitor whose plates are closely spaced. Let R be the radius of the plates and the current in the wire connected to the plates is 5 A, calculate the displacement current through the surface passing between the plates by directly calculating the rate of change of flux of electric field through the surface.

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2. A transmitter consists of LC circuit with an inductance of 1 μH and a capacitance of $1 \mu F$. What is the

wavelength of the electromagnetic waves it emits?

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3. A pulse of light of duration 10^{-6} s ia absorbed completely by a small object initially at rest. If the power of the pulse is $60 \times 10^{-3} W$, calculate the final momentum of the object.

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4. Let an electromagnetic wave propagate along the x direction, the magnetic field oscillates at a frequency of 10^{10} Hz and has an amplitude of 10^{-5} T, acting along the

y - direction. Then, compute the wavelength of the wave. Also write down the expression for electric field in this case.

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5. If the relative permeability and relative permittivity of the medium is 1.0 and 2.25, respectively. Find the speed of the electromagnetic wave in this medium.

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