PHYSICS

BOOKS - MODERN PUBLISHERS PHYSICS (HINGLISH)

ELECTROMAGNETIC WAVES

Examples

1. Each of the circular plates of a parallel plate capacitor has radius of 4 cm . The capacitor is charged such that the electric field in the gap between the plates rises at a constant rate of $2 \times 10^{12} VM^{-1}s^{-1}$. What is the displacement current ? $\left[\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}\right]$

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2. The voltage between the plates of a parallel plate capacitance is changing at the rate of 10 V/s . Find the displacement current in the capacitor if the capacitance of the capacitor is 2.0 μF.

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3. A parallel plate capacitor is having plate area equal to A and constant current I is flowing to charge the capacitor . Consider a circle of radius r, Parallel to the plates of capacitor . Find the displacement current through the surface enclosed by this circle .Assume size of the circle is smaller than that of the size of plate of capacitor .

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4. A parallel plate capacitor has two circular plates each of radius 5 cm separated by a distance of 3 m m . The capacitor current of 6 A is delived to it , find

(a) The capacitance

(b) The rate of change of potential difference across the plates

(c) the displacement current .

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5. A point charge is moving along a straight line with a constant velocity v. Consider a small area A perpendicular to the direction of motion of the charge . Calculate the displacement current through the area when its distance from the charge is x. The value of x is not large so that the electric

field at any instant is essentially given by Coulomb's law.

(##HCV_VOL2_C40_E01_023_Q01##)

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6. A capacitor of capacitance C is connected to a battery of emf V through a resistance R with a switch connected in series .Switch is turned on at t=0 . Find the displacement current flowing between the plates of capacitor as a function of time .

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7. 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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8. Maximum electric field associated with the sunlight reaching Earth is 900 V/m what should be the maximum magnetic field associated with it ?

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9. The expression of magnetic field in a plane electromagnetic wave is given by

$\vec{B} = 2.5 \times 10^{-7} \sin\left(600x + 2 \times 10^{11} t\right) \hat{j} T$

(a) Calculate the wavelength and frequency of the wave .

Calculate ampletude for the electric field .

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10. intensity of sunlight near the surface ofEarth is 1200 W/m^2 . Find the amplitude of electric field assuming it to be a plane electromagnetic wave .

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11. Light is falling on a surface of area $3m^2$ normal to it . Energy flux of light is 10^6 W/m^2 . .find the avaerage force exerted on the surface in a time interval of 100 seconds assume that surface is completely reflecting .

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12. There is one small bulb of 500 watt .Assume its effiency to be 20 % caculate amplitude of electric field produced by it a

distance of 1 m from the bulb .

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13. electric field in an electromagnetic wave is given by

$$E = 60 \sin \frac{2\pi}{\lambda}(ct - x) N/c$$

what is the energy contained in a cyinder of length 40 cm (along the Y - axis) and area of cross section 20 cm^2 ?

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14. For a plane electromagnetic wave propagation in the X-direction , the field is in the Y-direction and has maximum magneitic of 44 V//m . The wavelength of wave is 5 mm. Express the electric and magnetic field as a function of displacement x and time t.

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15. The expression of electric field for a light beam travelling in the X- direction is

$E = 250 \sin \omega \left(t - \frac{x}{c} \right) V / m$

A proton is travelling along the y-direction with a speed of $2.2 \times 10^7 m / s$ calculate the maximum electric force and maximum magnetic force on the electron .

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Practice Problems

1. Calculate the rate of change in the potential difference between the parallel plates of a $1 \mu F$ capacitor to develop an

instantaneous displacement current of 0.5 A .

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2. Calculate the displacement current in a capacitor of 50 Ω reactance connected across of a power supply of 220 V.

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3. A parallel plate capacitor has a plate area of $300cm^2$ electric field between the plates continuously changes at a rate of $9 \times 10^{10} Vs^{-1}$. Calculate the displacement current developed between both the plates .

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4. A parallel plate capacitor has capacitance $1\mu F$. Deteremine the displcement current in the capacitor if rate of change of voltage between of 1A flows through it ?

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5. What should be the rate of change of potential difference across a parallel plate capacitor of $2\mu F$, so that displacement current of 1A flows through it ?

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6. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2 \times 10^{10} Hz$ and amplitude $48 V / m$. The wavelength of the wave will be-

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7. In the previous problem , Calculate the amplitude of oscillating magnetic field if amplitude of electric field is $30Vm^{-1}$

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8. An electromagnetic wave travels at a speed of 0.8 c in medium .Determine the value of relative permittivity of the medium if value is

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9. 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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10. Light with an energy flux of $18 W cm^{-2}$ falls on a non-reflecting surface at normal incidence. If the surface at normal incidence. If the surface has an area of $20 cm^2$, find the average force exerted on the surface during a span of 30 min.

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11. Calculate the peak values of electric and magnetic fields produces by the radiation coming form a 100watt bulb at a distance of 3m. Assume that the efficiency of the bulb is 2.5% and it is a point source?

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12. The frequency of plane electromagnetic wave moving in positive Z- direction is $6.2 \times 10^{14} Hz$. Determine the average energy density of electric field if electric field at any point varies sinusoidal with amplitude of 1.4 Vm^{-1}

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13. In the previous problem, calculate the average energy density of magnetic field .

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14. A beam of light has intensity $2.8 \times 10^{14} Wm^{-2}$ .Calculate the value of amplitude of electric field magnetic field of the beam .

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Conceptual Questions

1. Radio station telecast live news . Explain also estimate the time taken by such a singal to travel from one extreme end to

another of Earth .

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2. A capacitor has been fully charged by a DC source. What are the magnitude of conduction and displacement current when it is fully charged ?

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3. How will displacement current between the plates of a parallel connected to a variable frequency AC source change with increase in the frequency of the source .

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4. How are x- rays produced ? Explain the origin of the line spectra and the continuous spectra . What limits the minimum size of X - ray wavelengths ?

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5. Can we generate electrognetic waves of frequency $6.2 \times 10^{14} Hz$ in the visable region of light by oscillating charges ?

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6. Electromagnetic waves are not associated with a single wire carrying direct current. Comment.

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7. Assertion: Light can travel in vacuum but sound cannot do so.

Reason: Light is an em wave and sound is a mechanical wave.

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8. We can polarise electromagnetic waves but not sound waves. Comment.

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9. Welders wear special glass goggles ro facemask with glass window to protect their eyes from

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10. Why are infrared waves often called heat waves? Explain.

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11. An em wave exers pressure on the surface on which it is incident. Justify?

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12. Explain that microwaves are better carriers of signals than radio waves?

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Tough Tricky Problems

1. A parallel plate capacitor is connected to an ideal battery of emf E through a resistance R and a switch. Area of the plates of capacitor is A, and d is the separation between them. Resistance to the displacement current can be defined as $R_d = V/i_d$, where V and i_d are instantaneous potential difference between the plates and displacement current, respectively. Find displacement resistance as a function of time.

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2. If the electric amplitude of the electromagnetic wave is $5Vm^{-1}$, its magnetic amplitude will be

A. $5 \times 10^{-8}T$

B. $1.67 \times 10^{-8} T$

C. $1.67 \times 10^{-10} T$

D. $5 \times 10^{-10} T$

Answer:

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3. Show that average energy density of electromagnetic radiation can be written as $\varepsilon_0 E_{rms}^2$.

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4. A parallel plate capacitor is having plate area equal to A and constant current I is flowing to charge the capacitor . Consider

a circle of radius r , parallel to the plates of capacitor . Find the displacement current through the surface enclosed by this circle .Assume size of the circle is smaller than of the size of plate of capacitor .

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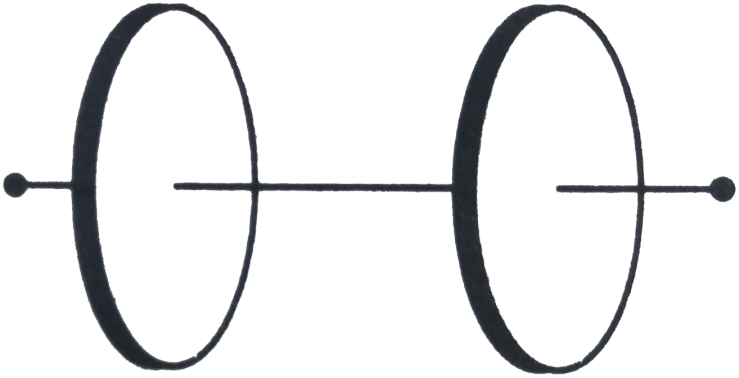
Ncert File Ncert Textbook Exercises

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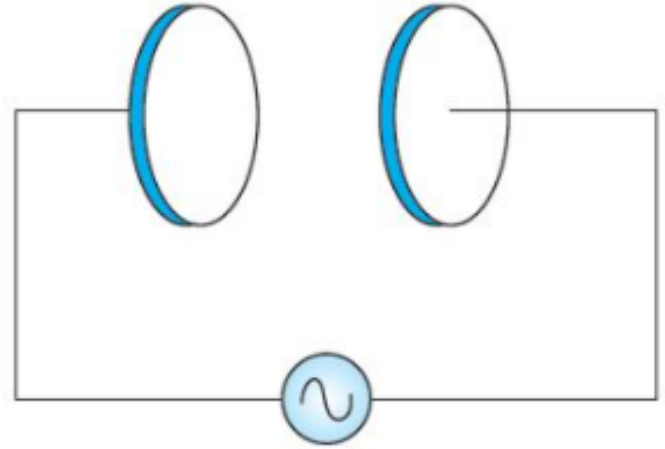
2. A parallel plate capacitor made of circular plates each of radius $R = 6.0$ cm has a capacitance $c = 100pF$. The capacitor is connected to a $230VAC$ supply with a (angular) frequency of $300rad/s$

(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. Which physical quantity is the same for X-rays of wavelength 10^{-10} m, red light of wavelength 6800 Å and radio waves of wavelength 500 m?

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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 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 a harmonic electromagnetic wave in vacuum is $B_0 = 540X10(-3)T$. What is the amplitude of the electronic 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 osciallates sinusoidally at a frequency of 2.0×10^{10} and amplitude $48m^{-1}$

(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 $\vec{E}$ field equals

to the average energy density of the $\vec{B}$ field .

$[c = 3.0 \times 10^8 ms^{-1}]$

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

$\vec{E} = \left(\left(3.1 N/C \cos \left[(1.8 rad/m) y + \left(5.4 \times 10^6 rads^{-1} t \right) \right] \right\} \hat{i}$

(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 maganetic field part of the wave .

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Ncert File Ncert Additional Exercises

1. 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 radiaton is emitted isotropically and neglect reflection

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2. 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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3. 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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4. 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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1. One requires $11eV$ of energy to dissociate a carbon monoxide molecule into carbon and oxygen atoms. The minimum frequency of the appropriate electromagnetic radiation to achieve the dissociation lies in.

A. Visible region

B. infrared region

C. Ultaviolet region

D. microwaves region .

Answer: A

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2. A linearly polarised electromagnetic wave given as $E = E_0\hat{i}\cos(kz - \omega t)$ is incident normally on a perfectly reflecting wall $z = a$. Assuming that the material of the optically inactive, the reflected wave will be give as

A. $\vec{E}_r = -E_0\hat{i}\cos(kz - \omega t).$

B. $\vec{E}_r = E_0\hat{i}\cos(kz + \omega t).$

C. $\vec{E} = -E_0\hat{i}\cos(kz + \omega t).$

D. $\vec{E}_r = E_0\hat{i}\sin(kz - \omega t).$

Answer: B

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3. Light with an energy flux$20W/cm^2$ falls on a non-reflecting surface at normal incidence. If the surface has an area of $30cm^2$. the total momentum delivered (for complete absorption)during 30 minutes is

A. $36 \times 10^{-5} kgm/s$

B. $36 \times 10^{-4} kgm/s$

C. $108 \times 10^{4} kgm/s$

D. $1.08 \times 10^{7} Kgm/s$

Answer: B

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4. The electric field intensity produced by the radiations coming from 100W bulbs at a 3m distance is E. The electric field intensity produced by the radiations coming from 50W bulb at the same distance is

A. $\frac{E}{2}$

B. $2E,$

C. $\frac{E}{\sqrt{2}}$

D. $\sqrt{2}E$

Answer: A

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5. If E and B represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of eletromagnetic wave is along.

A. $\overrightarrow{E}$

B. $\overrightarrow{B}$

C. $\overrightarrow{B} \times \overrightarrow{E}$

D. $\overrightarrow{E} \times \overrightarrow{B}$

Answer: D

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6. The ratio of contributions made by the eletric field and magnetic field components to the intensity of an EM wave is.

A. $c:1$

B. $c^2:1$

C. $1:1$

D. $\sqrt{c}:1$

Answer: C

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7. An EM wave radiates out wards from a dipole antenna with E_0 as the amplitude of its electric filed vector. The electric field E_0 which transports significant energy from the source falls off as

A. $\frac{1}{r^3}$

B. $\frac{1}{r^2}$

C. $\frac{1}{r}$

D. remains constant.

Answer: C

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8. An e.m. wave travels in vacuum along z direction: $\vec{E} = \left(E_1\hat{i} + E_2\hat{j}\right)\cos(kz - \omega)$. Choose the correct option from the following :

A. The associated magnetic field is given as $\vec{B} = \frac{1}{c}\left(E_1\hat{i} + E_2\hat{j}\right)\cos(kz - \omega t)$

B. the associated magnetic field is given as $\vec{B} = \frac{1}{c}\left(E_1\hat{i} - E_2\hat{j}\right)\cos(kz - \omega t)$.

C. The given electromagnetic field is circularly polarised .

D. the given electromagnetic wave is plane polarised

Answer: A::D

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9. An electromagnetic wave travelling along z-axis is given as $E = E_0 \cos (kz - \omega t)$. Choose the correct options from the following

A. The associated magnetic field is given as $\vec{B} = \frac{1}{c}\hat{k} \times \vec{E} = \frac{1}{\omega}\left(\hat{k} \times vevE\right)$.

B. The electromagentic field can be written in terms of the associated magnetic field as $\vec{E} = c\left(\vec{B} \times \hat{k}\right)$.

C. $\hat{k}.\overrightarrow{E}=0, \hat{k}\overrightarrow{B}=0$

D. $\hat{k}\times\overrightarrow{E}=0, \hat{k}\times\overrightarrow{B}=0$

Answer: A::B::C

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10. A plane electromagnectic wave propagating along x-direction can have the following pairs of E and B.

A. E_x, B_y

B. E_y, B_z

C. B_x, E_y

D. E_z, B_y

Answer: B::D

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11. A charged particle oscillates about its mean equilibrium position with a frerquency of $10^9 H_z$. The electromagnetic waves produced.

A. will have frequency of $10^9 Hz$.

B. will have frequency of $2 \times 10^9 Hz$

C. Will have a wavelength of 0.3 m.

D. Fall in the region waves .

Answer: A::C::D

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12. The source of electromagnetic waves can be a charge.

A. Moving with a constant velocity

B. moving in a circular orbit.

C. At rest

D. Failing in an electric field

Answer: B::D

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13. An electromagnetic wave of intensity I falls on a surface kept in vacuum and exerts radiation pressure p on it.Which of the following are true ?

A. Radiation pressure is I/c if the wave is totally absorbed .

B. Radiation pressure is I/c if the wave is totally reflected .

C. Radiation pressure is 2I/c if the wave is totally reflected

D. Radiation pressurre is in the range I/c lt P lt 2I/c for real surfaces.

Answer: A::C::D

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Ncert File Ncert Exemplar Problems Subjective Questions Very Short Answer Type Questions

1. Why is the orientation of the portable radio with respect tp broadcasting station important?

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2. Why does microwave oven heats up a food item containing water molecules most efficiently?

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3. The charge on a parallel plate capacitor varies as $= q_0 \cos 2\pi ft$. The plates are very large and close together (area=a,separation=d). Neglecting the edge effects, find the displacement current through the capacitor.

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4. A variable frequency AC source is connected to a capacitor. How will the displacement current change with decrease in frequency?

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5. The magnetic field of a bram emerging from a filter facing a floodlight is given by

$B = 12 \times 10^{-8} \sin\left(1.20 \times 10^{7} z - 3.60 \times 10^{15} t\right) t.$

what is the average intensity of the beam ?

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6. Polynting vectors $\vec{S}$ is defined as a vector whose magnitude is equal to the wave intensity and whose direction is along the direction of wave propogation. Mathematically, it is given by $\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$. Show the nature of S vs t graph

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7. Professor C.V Raman surprised his students by suspending freely a tiny light ball in a transparent vacuum chamber by shining a laser beam on it. Which property of EM waves was he exhibiting? Give one more example of this property.

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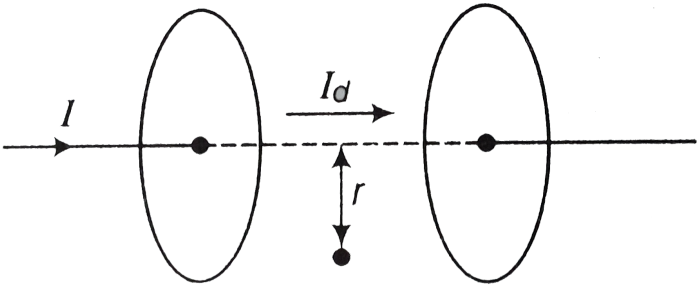
Ncert File Ncert Exemplar Problems Subjective Questions Short Answer Type Questions

1. Show that the magnetic field B at a point in between the plates of a parallel plate capacitor during charging is

$\frac{\mu_0 \varepsilon_0 r}{2} \frac{dE}{dt}$ (symbols having usual meaing). ,



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2. Electromagnetic waves with wavelength

(i) λ_1 is used in satellite communication.

(ii) λ_2 used to kill germs in water purifier.

λ used to detect leakage of oil in underground pipelines.

λ_4 used to improve visibility in runways during fog and mist conditions.

(a) Identify and name the part of e.m. spectrum to which these radiations belong.

(b) Arrange these wavelengths in ascending order of their magnitude.

(c) Write one more application of each.

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3. Show that average value of radiant flux density S over a single period 'T' is given by $S = \frac{1}{2c\mu_0} E_0^2$.

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4. You are given a $2\mu F$ parallel plate capacitor. How would you establish an instantaneous displacement current fo 1mA in the space between its plates?

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5. Show that the radiation pressure exerted by an EM wave of intensity I on a surface kept in vacuum is I/c.

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6. What happens to the intensity of light from a bulb if the distance from the bulb is doubled ? As a laser beam travels across the legth of room, its intesity essentially ramain constant.

What geonetrical characteristric of LASER beam is responsible for the constnat intensity which is missing in the case of light from the bulb?

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7. Even though an electric field $\vec{E}$ exerts a force $a\vec{E}$ on a charged particle yet the electric field of an EM wave does not contribute to the radiation pressure (but transfer energy). Explain.

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Higher Order Thinking Skils Advanced Level

1. electric field intensity of electromagnetic wave is represented as follows :

$E = (100N/C)\sin(kx - \omega t)$

Calculate intensity of electroamgnetic wave .

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2. Electromagnetic wave is travelling along X - axis and its electric field is found to oscillate along Y -axis amplitude 210 V/m what will be the amplitude of magnetic field ? One electron is constrained to move along Z- axis with a speed of 3×10^{-7}m/s . find maximum electric and magnetic force on electron .

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3. Light with intensity 20 W / cm^2 is falling along the normal on a surface , which completely abssorbs the light area of the surface is 25 cm^2

find the average force exerted y light on this surface in one hour .

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4. If intensity of light at a point in space is $30W/m^2$ then what would be the amplitude of magnetic field at that point .

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5. Elecromagnetic waves travel in a medium with a speed of $2 \times 10^8 m/s$.The relative permeability of the medium is 1. What is the relative permittivity of the medium-

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Revision Exercises Very Short Answer Questions

1. What is the missing term in Ampere's circuital law?

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2. Define displacement current.

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3. Mention the need for displacement current.

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4. What is displacement current and write the modified Ampere's circuital law.

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5. Why did Maxwell introduce the concept of displacement current in his theory?

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6. Write the magnitude of displacement current.

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7. Can a displacement current produce a magnetic field as the conduction current does?

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8. A variable frequency AC source is connected to a capacitor. How will the displacement current change with decrease in frequency?

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9. What are the magnitudes of conduction and displacement currents if a capacitor (charged by a d.c. source) is fully charged?

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10. If the charging current for a capacitor is 0.3 A then what is the displacement current?

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11. What is the source of an electromagnetic wave?

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12. A plane electromagnetic wave travels in vacuum along z-direction. What can you say about the direction of electric and magnetic field vectors?

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13. Can an electromagnetic wave be deflected by an electric field? By a magnetic field ?

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14. The magnetic field in a plane electromagnetic wave is: $B_y = 2 \times 10^{-7} \sin\left(0.5 \times 10^8 x + 1.5 \times 10^{11} t\right)$ T. What is the wavelength and frequency of the wave?

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15. What is the ratio of speed of infrared and radio waves in vacuum?

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16. INTENSITY OF ELECTROMAGNETIC WAVE

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17. What is the intensity of an electromagnetic wave in terms of electric and magnetic field?

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18. RADIATION PRESSURE

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19. Which of the following has lowest frequency? Gamma rays, Radio waves, Infrared rays

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20. The dereasing order of wavelength of infrared, microwave, ultraviloet and gammsa rays is

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21. write the following radiations in ascending order in respect of their frequencies: X-rays, microwaves, UV rays and radio waves.

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22. Name the electromagnetic radiations used for (a) water purification, and (b) eye surgery.

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23. Name the electromagnetic radiations which are produced when high energy electrons are bombarded on a metal target.

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24. Name the electromagnetic waves used for studying crystal structure of solids. What is its frequency range?

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25. How is the speed of em-waves in vacuum determined by the electric and magnetic fields ?

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26. What is the frequency range of radio waves?

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27. Which part of electromagnetic spectrum is detected by a human eye?

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28. Welders wear special glass goggles ro facemask with glass window to protect their eyes from

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29. What is the cause of the depletion of the ozone layer?

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30. Why microwaves are used in radar not radiowaves?

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31. What is the name given to the part of electromagnetic spectrum which is used for taking photographs of earth under foggy conditions from great heights ?

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32. Which part of electromagnetic spectrum is absorbed by ozone layer?

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33. How are radio waves produced?

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34. Write the expression for velocity of electromagnetic waves.

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35. Name any two properties of electromagnetic waves which are common to all parts of electromagnetic waves.

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36. Name the electromagnetic wave that is used to take radiograph of fractured bones.

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37. Write the expression for speed of light in terms of $'\mu_0'$ and $'\varepsilon_0$ explain the terms used.

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38. If the intensity of incident radio wave is 3 Watt/m^2,what is the pressure exerted by the absorbed wave?

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39. What does the cross product of electric and magnetic field vectors $\left(\overrightarrow{E} \times \overrightarrow{B}\right)$ indicate?

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40. Which part of electromagnetic spectrum is produced in nuclear reactions?

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41. Name any two electromagnetic waves. State any one similarity and one dissimilarity between them.

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42. Why a metal container should not be used in a microwave oven?

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43. To which part of the electromagnetic spectrum does a wave of frequency 5×10^{14} Hz belong?

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44. The ozone layer on the top of the stratosphere is crucial for human survival.Explain why?

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45. Mention the relative position of X-rays and γ-rays in the EM wave spectrum and give examples of their usage.

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46. The frequency of an electromagnetic wave is 1.5×10^{18} Hz. Calculate wavelength in angetrom.

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Revision Exercises Additional Questions

1. Electrimagnetic waves are transverse is nature is evident by

A. polarization

B. interference

C. reflection

D. diffraction.

Answer: A

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2. The electromagnetic waves used in the telecommunication are

A. ultraviolet

B. infrared

C. visible

D. microwaves

Answer: D

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3. According to Maxwell's hypothesis, a changing electrio field gives rise to

A. an emf

B. electric current

C. magnetic field

D. pressure gradient

Answer: C

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4. Which of the following electromagnetic radiation has the smallest wavelength?

A. X-rays

B. Radio waves

C. Microwaves

D. UV rays

Answer: A

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5. 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?

A. 30 m

B. 3 m

C. 100 m

D. 10 m

Answer: D

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6. Which of the following electromagnetic radiation has largest wavelength?

A. X-rays

B. UV rays

C. Microwaves

D. Radio waves

Answer: D

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7. The speed of electromagnetic waves in free space is

A. $\mu_0\varepsilon_0$

B. $\frac{1}{\mu_0\varepsilon_0}$

C. $\sqrt{\mu_0\varepsilon_0}$

D. $\frac{1}{\sqrt{(\mu_0\varepsilon_0)}}$

Answer: D

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8. Choose the correct alternative. Electromagnetic wave does not carry

A. energy

B. charge

C. information

D. momentum

Answer: B

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Revision Exercises Fill In The Blanks

1. The ..... part of the electromagnetic spectrum can be seen through our eyes.

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2. Assertion : Electromagnetic waves do not require medium for their propagation.

Reason : They can't travel in a medium.

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3. The force exerted by electromagnetic wave on unit area of the surface is called.....

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4. The orderly distrubution of electromagnetic radiations according to their wavelength or frequency is called the .....

Watch Video Solution

5. Name the electromagnetic waves used for studying crystal structure of solids. What is its frequency range?

Watch Video Solution

6. The electromagnetic waves which are used in the working of solar water heaters and cookers are called.....

Watch Video Solution

7. The waves used in telecommunication are

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Revision Exercises Short Answer Questions

1. What is displacement current? Explain its cause.

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2. You know that Ampere's circuital law is mathematically expressed as given below.

$$\oint \vec{B}\,\vec{dt} - \mu_0 I$$

Also you know that this law was corrected by Maxwell and

which is known as Ampere-Maxwell law. Write the general form of the law and name the additional term.

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3. Considering the case of a parallel plate capacitor being charged, show how one is required to generalize Ampere's circuital law of include the term due to displacement current.

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4. Define displacement current. What role does it play while charging a capacitor by de source? Is the value of displacement current same as that of the conduction current? Explain.

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5. How does a charge q oscillating at certain frequency produce electromagnetic waves? Sketch schematic diagram depicting electric and magnetic field for an electromagnetic wave propagating along the x-direction.

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6. What are electromagnetic waves?

Watch Video Solution

7. PROPAGATION OF ELECTROMAGNETIC WAVES

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8. (a) An e.m. wave is travelling in a medium with a velocity $\overrightarrow{v} = v\hat{i}$.Draw a sketch showing the propagation of the e.m. wave, indicating the direction of the oscillating electric and magentic fields.

(b) How are the magnitudes of the electric and magnetic fields related to the velocity of the e.m. wave?

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9. (a) When the oscillating electric and magnetic fields are along the X and Y-direction, respectively

(i) point out the direction of propagation of electromagnetic wave,

(ii) express the velocity of propagation in terms of the amplitudes of the oscillating electric and magnetic fields.

(b) How do you show that an em wave carries energy and momentum ?

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10. Illustrate by giving suitable example, how you can show that electromagnetic waves carry both energy and momentum.

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11. State any four properties of electromagnetic waves.

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12. What are electromagnetic waves? Write two uses of radio waves?

Watch Video Solution

13. Write two uses each of the following radiations: (i) Microwave (ii) Ultraviolet rays

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14. Give two properties and two uses of X-rays.

Watch Video Solution

15. What are X-Rays? Give their one use.

Watch Video Solution

16. State two properties and two uses of gamma rays.

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17. Write down the expression for the velocity of electromagnetic wave in a medium and hence find out an expression for the refractive index of the medium.

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18. RADIATION PRESSURE

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19. What is intesity of electromagnetic wave? Give its relation in terms of electric field E and magnetic field B

Watch Video Solution

20. What is electromagnetic spectrum? Name the important part of the electromagnetic spectrum.

Watch Video Solution

21. Name the parts of the electromagnetic spectrum which is

(a) suitable for radar system used in aircraft navigation

(b) used to treat muscular strain.

(c) Use as a diagnostic tool in medicine.

Write in brief, how these waves can be produced.

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22. Name the electromagnetic radiation which is used-

(a) to kill cancerous cells in human,

(b) to produce dehydrated fruits.

Watch Video Solution

23. Which electromagnetic waves are used for the following purposes?

(i) Diagnostic tool in medicine.

(ii) Kill germs in water purifiers.

(iii) Cellular phones.

(iv) In remote switches of household electronic systems.

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24. Which of the following electromagnetic wave play an important role in maintaining the earth's warmth or average temperature through the greenhouse effect?

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25. Name the following electromagnetic waves and arrange them in decreasing order of their wavelength: (a) Electromagnetic waves which are used for sterilizing surgical equipments

(b) Electromagnetic waves which are emitted from the nuclei of radioactive atoms

(c) Electromagnetic waves which are used by FM radio station for broadcasting

(d) Electromagnetic waves which are produced when fast moving electrons are stopped by a heavy metal target.

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26. Light waves are transverse in nature .

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27. What is electromagnetic spectrum? Which part of the electromagnetic spectrum is used in operating a radar?

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28. An electromagnetic wave of 25 MHz is travelling in X-direction, at C point E = 6.3 v/m. What will be B at that point?

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29. What are electromagnetic waves? Write the equations for associated electric and magnetic fields clearly mentioning their directions.

Watch Video Solution

30. Show that for an electromagnetic wave in vacuum, at any point, at any time, the unit of E/H ratio is ohm.

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31. What is an electromagnetic spectrum? Arrange the given electromagnetic radiations in the decreasing order of their frequencies. Infrared rays, X-rays, UV rays, gamma rays.

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32. (i) Why welder wears a special glass goggles during welding with arc?

(ii) Which part of the electromagnetic spectrum is used in operating radar and why?

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33. (a) Why are infrared waves often called heat waves? Explain.

(b) What do you understand by the statement, "Electromagnetic waves transport momentum"?

Watch Video Solution

34. Microwave Oven

Watch Video Solution

35. Why infrared waves are called heat waves?

Watch Video Solution

36. Give reasons for the following:

(i) Long distance radio broadcasts use short-wave bands.

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

(iii) Satellites are used for long distance TV transmission.

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37. (a) How does oscillating charge produce electromagnetic waves?

(b) Sketch a schematic diagram depicting oscillating electric and magnetic fields of an em wave propagating along + Z-direction.

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38. Name the types of e.m. radiations which (i) are used in destroying cancer cells, (ii) cause tanning of the skin and (iii) maintain the Earth's warmth.

Write briefly a method of producing any one of these waves.

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39. (a) How are electromagnetic waves produced?

(b) How do you convince yourself thal electromagnetic waves carry energy and momentum?

Watch Video Solution

40. Arrange the following electromagnetic waves in the descending order of their wavelengths:

(i) Microwaves

(ii) Infrared rays

(iii) Ultraviolet radiation

(iv) Gamma rays Write one use each of any two of them.

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41. Write any four characteristics of electromagnetic waves. Give two uses of:

(i) radio waves

(ii) microwaves.

Watch Video Solution

42. (a) Identiy the part of the electromagnatic spectrum used in (i) radar and (ii) eye surgery. Write their frequency range.

(b) Prove that the average energy density of the oscillating electric field is equal to that of the oscilating magnetic field.

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43. a) Cancer is one of the most dreaded diseases of humans. Explain 'Contact inhibitions' and Metastasis' with respect to the disease.

b) Name the group of genes which have been identified in normal cells that could lead to cancer and how they do so?

c) Name any two technique which are used to detect cancers of interorgans?

d) Why are cancer pateints often given a-interferon as part of the treatment.

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44. Answer the following:

(a) Name the em waves which are used for the treatment of certain forms of cancer. Write their frequency range.

(b) Thin ozone layer on top of stratosphere is crucial for human

survival. Why?

(c) An em wave exerts pressure on the surface on which it is incident. Justify.

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45. Identify the electromagnetic waves whose wavelength very as: (a) $10^{-12}m < \lambda < 10^{-8}m$ (b) $10^{-3}m < \lambda < 10^{-1}m$. Write one use each.

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46. What are the quantities that oscillate in an electromagnetic wave? Show by means of a diagram, the relative orientation of the directions of the electric vector, magnetic vector and propagation of the electromagnetic wave.

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Revision Exercises Long Answer Questions

1. Maxwell's equations of electromagnetism and hertz experiments on generation and detection of electromagnetic waves established the

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Revision Exercises Numerical Problems

1. How can we establish an instantaneous current of 2 Ain the space between the plates of a 2 μF capacitor?

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2. Find the value of displacement current for 10^{-10}s between the plates of a capacitor having 3 mm separation connected to an electric circuit having 500 V. The plate area is 70 cm^2?

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3. A parallel plate capacitor having rectangular metal plates of sides $15cm \times 15$cm is charged in such a way that the conduction current is 200 mA. The plates are separated by a distance of 3 mm. Find the rate of change of potential of the charging source.

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4. In an electromagnetic wave, the electric field Oscillates sinusoidally with a frequency of 3×10^9 Hz and having amplitude 60 V/m. Find the wavelength of the wave and the amplitude of the magnetic field.

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5. The oscillating magnetic field in a plane electromagnetic wave is given by $B_y = \left(8 \times 10^{-6}\right) \sin\left[2 \times 10^{11} t + 300\pi x\right] T$

(i) Calculate the wave length of the electromagnetic wave..

(ii) Write down the expression for the oscillating electric field.

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6. An electromagnetic wave is travelling along Z-axis is described by an electric field

$B_x = 4 \times 10^{-10} T \sin(\omega t - kz)$

Find the maximum electric and magnetic force on an alpha particle moving along Y-axis with a speed of 5×10^6 m/s. Charge on the electron is$1.6 \times 10^{-19} C$.

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7. A parallel plate capacitor having capacitance of 300pF. The capacitor is connected to a 300 V supply with an angular frequency of 300 rad/s.

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

(b) Find the peak value of displacement current.

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8. Find the values of electric and magnetic field produced by a radiation coming from 200 W bulb. The bulb is placed at a distance of 5 m from the point of observation.

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Competition File Objective Type Questions Multiple Choice Questions A

1. During charging of capacitor, I_C. is the conduction current flowing in the wires connecting capacitor to the battery and I_d is the Displacement current flowing between the plates of the capacitor.

A. $I_c > I_d$

B. $I_c < I_d$

C. $I_c = I_d$

D. No relation exists between i_c and I_d

Answer: C

View Text Solution

2. Magnetic field cannot be produced by

A. changing electric field

B. moving charge

C. charge at rest

D. current-carrying wire

Answer: C

Watch Video Solution

3. Which one of the following can produce electromagnetic waves?

A. Charge at rest

B. charge moving with constant velocity

C. Acceleration charge

D. Electrically neutral particle

Answer: C

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4. If E and B represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of eletromagnetic wave is along.

A. $\vec{E} \times \vec{B}$

B. $\vec{E}$

C. $\vec{B}$

D. $\vec{B} \times \vec{E}$

Answer: A

Watch Video Solution

5. Hertz experiment is used for

A. Producing electromagnetic waves

B. detecting electromagnetic waves

C. Both (a) and (b)

D. None of these

Answer: C

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6. A compass needle is placed in the gap of a parallel plate capacitor. The capacitor is connected to a battery through a resistance. The compass needle

A. Remains un - deflecteed .

B. Gets deflected and remains in deflected position as long as battery is connected .

C. Gets deflected for a very short time and then it quickly comes back to original position .

D. Gets deflected and slowly comes back to original position as charging gets over.

Answer: D

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7. Which of the following is not transported by electromagnetic waves?

A. Momentum

B. Energy

C. Information

D. Charge

Answer: D

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8. There is one parallel plate capacitor with circular plates of radius R. Capacitor is being charged by connecting to a battery . If I is the instantaneous conduction current flowing in the connecting wires then what will be displacement current flowing in the region between the plates enclosed between radii, $R/2$ to R

A. $3I/4$

B. I

C. $I/4$

D. $3I/5$

Answer: A

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9. Red and blue light appear different to a human due to different

A. speed

B. Intensity

C. amplitude

D. frequency

Answer: D

Watch Video Solution

10. Out of the following, choose the ray which does not travel with the velicty of light

A. X- ray

B. $\gamma - ray$

C. Microwaves

D. $\beta - ray$

Answer: D

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11. An electromagnetic wave going through vacuum is described by

$E = E_0 \sin(kx - \omega t), B = B_0 \sin(kx - \omega t).$

Then

A. $E_0\omega = B_0 k$

B. $E_0 k = B_0\omega$

C. $E_0 B_0 = \omega k$

D. $E_0 B_0 = \omega / k$

Answer: B

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12. A plane electromagnetic wave is incident on a material surface. The wave delivers momentum p and energy E.

A. $E = 0, p = 0$

B. $E \neq 0, p \neq 0$

C. $E = 0, p \neq 0$

D. $E \neq 0, p = 0$

Answer: B

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13. Electromagnetic wave is deflected by

A. electric field only

B. magnetic field only

C. electric and magnetic field both

D. Netither by electric field nor by magnetic field

Answer: D

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14. Consider the following two statements regarding a linearly polarized, plane electromagnetic wave:

The electric field and the magnetic field have equal average values.

The electric energy and the magnetic energy have equal average values.

A. Both A and B are correct

B. Both A and B are incorrect

C. A is correct but B is incorrect

D. A is incorrect but B is correct

Answer: A

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15. Which of the following factors affects speed of electromagnetic waves ?

A. Wavelength

B. Intensity

C. Power of source

D. Medium , in which wave travels

Answer: D

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16. Displacement current is produced between the plates of a capacitor when potential difference between the plates

A. is maximum

B. is minimum

C. is zero

D. is changing with time

Answer: D

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17. An electric field $\left(\overrightarrow{E}\right)$ and a magnetic field $\left(\overrightarrow{B}\right)$ exist in a region . The fields are not perpendicular to each other.

A. Electromagnetic wave must be passing through the given region

B. Electromagnetic wave may be passing through the given region

C. Electromagnetic wave may be passing through the given region

D. Given situation is not possible

Answer: C

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18. Which of the following represents correct dimensional formula of $\frac{1}{2}\varepsilon_0 E^2$ where symols have usual meanings ?

A. $[ML^{-1}T^{-2}]$

B. $[MLT^{-1}]$

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

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

Answer: A

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19. which one of the following represents correct dimensional formula of $1/\mu_0\varepsilon_0$?

A. $\left[M^{0}LT^{-1}\right]$

B. $\left[M^{1}Lt^{-1}\right]$

C. $\left[m^{0}L^{2}T^{-2}\right]$

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

Answer: C

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20. Which has the longest wavelength

A. Ultraviolet ray

B. X-ray

C. Infrared ray

D. Radio wave

Answer: D

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Competition File Objective Type Questions Multiple Choice Questions B

1. The frequencies of X-rays, γ-rays and ultraviolet rays are respectively $a, b \text{ and } c$.Then

A. $a < b, b > c$

B. $a > b, b > c$

C. $a > b, b < c$

D. $a < b, b < c$

Answer: A

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2. An EM wave is propagating in a medium whith a velocity $\overrightarrow{v} = v\hat{i}$. The instantaneous oscillating electric field of this of em wave is along $+y$ axis. Then the direction of oscillating magnetic field of the EM wave will be along

A. $-Y$ direction

B. $+Z$ direction

C. $-Z$ direction

D. $-x$ direction

Answer: B

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3. When light travels from air to water, which parameter does not change?

A. Wave length

B. Frequency

C. Velocity

D. All of these.

Answer: B

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4. The difference between soft and hard X-rays is of:

A. velocity

B. intensity

C. frequency

D. polarisation.

Answer: C

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5. What is the cause of "Green house effect"?

A. Infrared rays

B. Ultraviolet rays

C. X-rays

D. Radio waves.

Answer: A

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6. The velocity of electromagnetic wave is parallel to

A. $\overrightarrow{B} \times \overrightarrow{E}$

B. $\overrightarrow{E} \times \overrightarrow{B}$

C. $\overrightarrow{E}$

D. $\overrightarrow{B}$

Answer: B

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7. Which of the following has minimum wavelenght?

A. X-rays

B. UV rays

C. $\gamma -$ rays

D. Cosmic rays

Answer: C

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8. Sodium lamps are used in foggy conditions because

A. Yellow light is scattered less by fog particles

B. Yellow light is scattered more by fog particles

C. yellow light is unaffected by fog

D. Wavelength of yellow light is mean of visible part of spectrum .

Answer: A

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9. Due to the earth's magnetic field, charged cosmic ray particles

A. can never reach poles

B. can never reach equator

C. require greater energy to reach equator than to poles

D. require less energy to reach to poles than to equator.

Answer: B

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10. If there were no atmosphere, Earth would have been

A. slightly hotter

B. slightly cooler

C. very cool

D. very hot

Answer: C

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11. A parallel plate capacitor of capacitance 20 μF is being charged by a voltage source whose potential is changing at the rate of 3 V/s. The conduction current through the connecting wires, and the displacement current through the plates of the capacitor, would be, respectively:

A. zero, zero

B. zero , 60 μA

C. $60\mu A, 60\mu A$

D. $60\mu A,$ zero

Answer: C

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12. According to Maxwell's hypothesis, a changing electrio field gives rise to

A. an emf

B. electric current

C. magnetic field

D. pressure radiant

Answer: C

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13. Radio frequency choke uses core of

A. air

B. iron

C. air & iron

D. none of these.

Answer: B

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14. $\lambda_v, \lambda_x, \lambda_m$represent wave lengths of visible light, X-ray and microwaves then:

A. $\lambda_m > \lambda_x > \lambda_v$

B. $\lambda_v > \lambda_m > \lambda_x$

C. $\lambda_m > \lambda_x > \lambda_m$

D. $\lambda_m > \lambda_v > \lambda_x$

Answer: D

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15. The pressure exerted by electromagnetic wave of intensity I on a non - reflecting surface is (where c= velocity of light):

A. IC

B. Ic^2

C. $\frac{I}{c}$

D. $\frac{I}{c^2}$

Answer: C

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16. The electric and magnetic field of an electromagnetic wave are:

A. in opposite phase and perpendicular to each other

B. in opposite phase and parallel to each other

C. in phase and perpendicular to each other

D. in phase and parallel to each other.

Answer: C

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17. The electric field associated with an electromagnetic wave in vacuum is given by $\vec{E} = 40\cos\left(kz - 6 \times 10^8 t\right)\hat{i},$

where E, z and t are in volt per meter, meter and second respectively. The value of wave vector k is

A. $3m^{-1}$

B. $2m^{-1}$

C. $0.5m^{-1}$

D. $6m^{-1}$

Answer: B

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18. The condition under which a microwave oven heats up a food item containing water molecules most efficiently is:

A. Frequency of the microwaves has no relation with natural frequency of water molecules.

B. Microwaves are heat waves, so always produce heating

C. Infrared waves produce heating in a microwave oven.

D. The frequency of the microwaves must match the resonant frequency of the water molecules.

Answer: D

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19. Light with an enargy flux of $25 \times 10^4 Wm^{-2}$ falls on a perfectly reflecting surface at normal incidence. If the surface area is $15cm^2$, the average force exerted on the surface is

A. $1.25 \times 10^{-6} N$

B. $2.50 \times 10^{-6} N$

C. $1.20 \times 10^{-6} N$

D. $3.0 \times 10^{-6} N$

Answer: C

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20. A radiation of energy 'E'falls normally on a perfectly reflecting surface. The momentum transferred to the surface is (C = Velocity of light)

A. $\frac{2E}{C}$

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

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

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

Answer: A

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21. Which of the following electromagnetic waves has highest wavelength?

A. X-rays

B. UV rays

C. Infrared rays

D. Microwaves.

Answer: D

Watch Video Solution

22. Out of the following options which one can be used to produce a propagating electromagnetic wave?

A. A charge moving at constant velocity

B. A stationary charge

C. A chargeless particle

D. An accelerating charge

Answer: D

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23. In an electromagnetic wave in free space the root mean square value of the electric field is $E_{rms} = 6\text{V/m}$. The peak value of the magnetic field is:

A. $1.41 \times 10^{-8} T$

B. $2.83 \times 10^{-8} T$

C. $0.70 \times 10^{-8} T$

D. $4.23 \times 10^{-8} T$

Answer: B

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24. The magnetic field of an electromagnetic wave is given by:

$$\overset{B}{=} 1.6 \times 10^{-6} \cos\left(2 \times 10^{7} z + 6 \times 10^{15} t\right)\left(2\hat{i} + \hat{j}\right) \frac{Wb}{m^2}$$

The associated electric field will be:

A.

$$\vec{E} = 4.8 \times 10^2 \cos\left(2 \times 10^7 z + 6 \times 10^{15} t\right)\left(-1\hat{i} + 2\hat{j}\right)\frac{V}{m}$$

B.

$$\vec{E} = 4.8 \times 10^2 \cos\left(2 \times 10^7 z + 6 \times 10^{15} t\right)\left(-2\hat{j} + 2\hat{i}\right)\frac{V}{m}$$

C. $\vec{E} = 4.8 \times 10^2 \cos\left(2 \times 10^7 z + 6 \times 10^{15} t\right)\left(\hat{i} + 2\hat{j}\right)\frac{V}{M}$

D. $\vec{E} = 4.8 \times 10^2 \cos\left(2 \times 10^7 z + 6 \times 10^{15} t\right)\left(2\hat{i} + \hat{j}\right)\frac{V}{m}$

Answer: A

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25. The magnetic field of a plane electromagnetic wave is given by: $\vec{B} = B_0\hat{i} - [\cos(kz - \omega t)] + B_1\hat{j}\cos(kz + \omega t)$ where $B_0 = 3 \times 10^{-5} T$ and $B_1 = 2 \times 10^{-6} T$. The rms value of the

force experienced by a stationary charge $Q = 10^{-4}C$ at $z = 0$ is close to:

A. $0.9N$

B. $0.6N$

C. $0.1N$

D. $3 \times 10^{-2}N$

Answer: B

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26. A monochromatic beam of light has a frequency $v = \frac{3}{2\pi} \times 10^{12}Hz$ and is propagating along the direction $\frac{\hat{i} + \hat{j}}{\sqrt{2}}$. It is polarizied along the $\hat{k}$ direction. The accpetable fromfor the magnetic field is :

A. $\frac{E_0}{C}\left(\frac{\hat{i}-\hat{j}}{\sqrt{2}}\right)\cos\left[\frac{\left(\hat{i}-\hat{j}\right)}{\sqrt{2}}\overrightarrow{r}-\left(3\times10^{12}\right)t\right]$

B. $\frac{E_0}{C}\hat{k}\cos\left[10^4\frac{\left(\hat{i}-\hat{j}\right)}{\sqrt{2}},\overrightarrow{r}+\left(3\times10^{12}\right)t\right]$

C. $\frac{E_0}{C}\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)\cos\left[10^4\frac{\left(\hat{i}+\hat{j}\right)}{\sqrt{2}}..Vecr+\left(3\times10^{12}t\right)\right]$

D.

$$\frac{E_0}{C}\left(\frac{\hat{i}+\hat{j}+\hat{k}}{\sqrt{3}}\right)\cos\left[10^4\frac{\left(\hat{i}+\hat{j}\right)}{\sqrt{2}}.Vecr+\left(3\times10^{12}\right)t\right]$$

Answer: C

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27. An electromagnetic wave of v=3 MHz passes from vacuum into dielectric medium with$\varepsilon=4\varepsilon_0$.

then

A. Wavelength is doubled and frequency becomes half .

B. Wavelength is doubled and frequency is same .

C. Wavelength and frequency both remain unchanged .

D. Wavelength is halved but frequency remains same .

Answer: D

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28. A plane electromagnetic wave of wavelength λ has an intensity I. It is propagating along the positive Y-direction. The allowed expression for the electric and magnetic fields ar given by :

A. $\vec{E} = \sqrt{\frac{2I}{\varepsilon_0 C}} \cos\left[\frac{2\pi}{\lambda}(y - ct)\right]\hat{k}, \vec{B} = +\frac{1}{C}E\hat{i}$

B. $\vec{E} = \sqrt{\frac{I}{\varepsilon_0 C}} \cos\left[\frac{2\pi}{\lambda}(y - ct)\right]\hat{k}, \vec{B} = +\frac{1}{C}E\hat{i}$

C. $\vec{E} = \sqrt{\frac{I}{\varepsilon_0 C}} \cos\left[\frac{2\pi}{\lambda}(y - ct)\right]\hat{k}, \vec{B} = \frac{1}{C}E\hat{i}$

D. $\vec{E} = \sqrt{\frac{I}{\varepsilon_0 C}} \cos\left[\frac{2\pi}{\lambda(y - ct)}\right]\hat{k}, \vec{B} = \frac{1}{C}e\hat{k}$

Answer: A

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29. The rms value of the electric field of the light from the sun is $720N/C$ The total energy density of the electromagnetic wave is

A. $3.3 \times 10^{-3} J/m^3$

B. $4.58 \times 10^{-6} J/m^3$

C. $6.37 \times 10^{-9} j/m^3$

D. $81.35 \times 10^{-12} j/m^3$

Answer: B

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30. An electromagnetic wave in vacuum has the electric and magnetic field $\vec{E}$ and $\vec{B}$, which are always perpendicular to each other. The direction of polarization is given by $\vec{X}$ and that of wave propagation by $\vec{K}$. Then

A. $\vec{X} \| \vec{E}$ and $\vec{K} \| \vec{B} \times \vec{E}$

B. $\vec{X} \| \vec{B}$ and $\vec{K} \| \vec{B} \times \vec{E}$

C. $\vec{X} \| \vec{E}$ and $\vec{k} \| \vec{E} \times \vec{B}$

D. $\vec{X} \| \vec{B}$ and $\vec{k} \| \vec{E} \times \vec{B}$

Answer: C

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31. The magnetic field in a travelling electromagnetic wave has a peak value of 20 nT . The peak value of electric field strength is :

A. 6 V/m

B. 9V/m

C. 12 V/m

D. 3 V/m

Answer: A

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

A. Both electric and magnetic energy densitites are zero

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

C. Electric energy density is half of the magnetic energy density .

D. Electric energy density is equal to the magnetic energy density

Answer: D

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33. Match List-I (Electromagnetic wave type) with List-II (Its association/application) and select the correct option from the choice given below the lists :

List – I		List – II	
(a)	Infrared waves	(i)	To treat muscular strain
(b)	Radio waves	(ii)	For broadcasting
(c)	X-rays	(iii)	To detect fracture of bones
(d)	Ultraviolet rays	(iv)	Absorbed by the ozone layer of the atmosphere

A. $\begin{matrix} A & B & C & D \\ I & II & III & IV \end{matrix}$

B. $\begin{matrix} A & B & C & D \\ IV & III & II & I \end{matrix}$

C. $\begin{matrix} A & B & C & D \\ I & II & IV & III \end{matrix}$

D. $\begin{matrix} A & B & C & D \\ III & III & I & IV \end{matrix}$

Answer: A

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34. For plane electromagnetic waves propagating in the z-direction , which one of the following combinations gives the correct possible direction for $\vec{E}$ and $\vec{B}$ field respectively ?

A. $\hat{i}+2\hat{j}$ and $2\hat{i}-\hat{j}$

B. $-2\hat{i}-3\hat{j}$ and $3\hat{i}-2\hat{j}$

C. $2\hat{i}+3\hat{j}$ and $\hat{i}+2\hat{j}$

D. $3\hat{i}+4\hat{j}$ and $4\hat{i}-3\hat{j}$

Answer: B

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35. Consider an electromagnetic wave propagating in vacuum. Choose the correct statement : For an electromagnetic wave

propagating in $+y$directionn the

A. for an electroamgnetic wave propagation in +X direction the electric field is $\overrightarrow{E} = \frac{1}{\sqrt{2}} E_{yz}(x,t)\left(\overrightarrow{y} - \overrightarrow{z}\right)$ and the magnetic field is $\overrightarrow{B} = \frac{1}{\sqrt{2}} B_{yz}(x,t)\left(\overrightarrow{y} + \overrightarrow{z}\right)$

B. For an electromagnetic wave propagation in +X direction the electric field is $\overrightarrow{E} = \frac{1}{\sqrt{2}} E_{yz}(y,z,t)(\hat{y} + \hat{z})$

C. For an electromagnetic wave propagation in + y directiono the electric field is $\overrightarrow{E} = \frac{1}{\sqrt{2}} E_{yz0\,(x,t)\,\hat{y}}$ and the magnetic field is $\overrightarrow{B} = \frac{1}{\sqrt{2}} B_{yz}(x,t)\hat{z}$

D. For an electromagnetic wave proparating in +y direction the electric field is $\overrightarrow{E} = \frac{1}{\sqrt{2}} E_{yz}(x,t)\hat{z}$ and the magnetic field is $\overrightarrow{B} = \frac{1}{\sqrt{2}} B_{z}(x,t)\hat{y}$

Answer: A

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36. An electromagnetic wave travelling in the X- direction has freqency of 2×10^{14} Hz and electric field for this wave ?

A.

$$\vec{B}(x,t) = \left(3 \times 10^{-8} T\right) \sin\left[2\pi\left(1.5 \times 10^{-6} x - 2 \times 10^{4} t\right)\right]$$

B.

$$\vec{B}(x,t) = \left(9 \times 10^{-8} T \hat{k} \sin\left[2\pi\left(1.5 \times 10^{-6} x - 2 \times 10^{4} t\right)\right]\right.$$

C.

$$\vec{B}(x,t) = \left(9 \times 10^{-8} T\right) \hat{i} \sin\left[2\pi\left(1.5 \times 10^{-6} x - 2 \times 10^{4} t\right)\right]$$

D.

$$\vec{E}(X,t) = \left(9 \times 10^{-8} T\right) \hat{j} \sin\left[\left(1.5 \times 10^{-6} x - 2 \times 10^{4} t\right)\right]$$

Answer: B

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37. Microwave oven acts on the principle of :

A. transferring electrons from lower to higher energy levels in water molecule

B. giving rotaional energy to water moleculs

C. Giving vibrational energy to water molecule

D. giving translation energy to water molecules

Answer: B

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38. Magnetic field in a plane electromagnetic wave is given by

$\vec{B} = B_0 \sin(kx + \omega t)\hat{j}T$

expression for corresponding electric field will be where c is speed of light .

A. $\vec{E} = B_0 c \sin(kx + \omega t)\hat{k}V/m$

B. $\vec{E} = \frac{B_0}{c}\sin(kx + \omega t)V/m$

C. $\vec{E} = -B_0 C \sin(kx + \omega t)\hat{k}V/m$

D. $\vec{E} = B_0 C \sin(kx + \omega t)\hat{k}V/m$

Answer: A

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39. The electric field of a plane electromagnetic wave propagating along the x direction in vacuum is $\vec{E} = E_0\hat{j}\cos(\omega t - kx)$. The magnetic field $\vec{B}$, at the moment t=0 is :

A. $\frac{2E_0}{c}\hat{j}\sin kz\cos\omega t$

B. $-\frac{2E_0}{c}\hat{j}\sin kz\sin\omega t$

C. $\frac{2E_0}{c}\hat{j}\sin kz\sin\omega t$

D. $\frac{2E_0}{c}\hat{j}\cos kz\cos\omega t$

Answer: A

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40. An EM wave from air enters a medium .The electric fields are $\vec{E}_1 = \vec{E}_{01}\hat{x}\cos\left[2\pi v\left(\frac{z}{c} - t\right)\right]$ in air and $\vec{E}_2 = E_{02}\hat{x}\cos[k(2z - ct)]$ in medium , where the wave number k and frequency v refer to their values in air . the medium is non - magnetic . if ε_{r_1} and ε_{r_2} refer to relative permittivities of air and medium respectively , which of the following options is correct ?

A. $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{1}{4}$

B. $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = \frac{1}{2}$

C. $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = 4$

D. $\frac{\varepsilon_{r_1}}{\varepsilon_{r_2}} = 2$

Answer: A

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Competition File Objective Type Questions Multiple Choice Questions C

1. Electromagnetic waves can transfer

A. energy

B. momentum

C. charge

D. information

Answer: A::B::D

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2. Displacement current exists between the plates of capacitor , when charge of the capacitor

A. remains constant

B. increase

C. decreases

D. zero

Answer: B::C

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3. Speed of electromagnetic waves is not affected by

A. wavelength

B. intensity

C. Power of source

D. medium , in which travels

Answer: A::B::C

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4. In electromagnetic waves there is zero average value for

A. electric field intensity

B. magnetic field intensity

C. electric field energy

D. magnetic field energy

Answer: A::B

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5. Which of the following is / are not electromagnetic wave?

A. Gamma rays

B. Alpha rays

C. Beta rays

D. X- rays

Answer: B::C

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Competition File Objective Type Questions Multiple Choice Questions D

1. When charge is at rest then it creates only electric field not the magnetic field. A moving charge generates electric as well

as magnetic field around it. If charge is moving with constant velocity then electric and magnetic field do not change with time, hence, it cannot produce electromagnetic wave. When charge is accelerated then time-varying electric and magnetic fields are created and thus electromagnetic wave is produced by accelerated charge. We know that the current-carrying wire creates magnetic field around it. If alternating current is flowing through the wire then it creates variable magnetic field around it and thus starts radiating electromagnetic waves. When a charged capacitor is connected across an inductor then charge starts oscillating between the plates of the capacitor. Normally one plate of the capacitor is connected to Earth and the other plate is connected to an antenna. Antenna radiates electromagnetic wave. Hertz successfully produced electromagnetic waves using such LC oscillator. Speed of electromagnetic wave in vacuum is constant and equal to 3×10^8 m/s. But inside a medium the speed changes according

to electrical and magnetic properties of the medium.

Which of the following cannot create electromagnetic wave ?

A. Wire carrying alternating current

B. Oscillating charge

C. Wire connected to a DC power source

D. charge moving in a circular path

Answer: C

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2. When charge is at rest then it creates only electric field not the magnetic field. A moving charge generates electric as well as magnetic field around it. If charge is moving with constant velocity then electric and magnetic field do not change with

time, hence, it cannot produce electromagnetic wave. When charge is accelerated then time-varying electric and magnetic fields are created and thus electromagnetic wave is produced by accelerated charge. We know that the current-carrying wire creates magnetic field around it. If alternating current is flowing through the wire then it creates variable magnetic field around it and thus starts radiating electromagnetic waves. When a charged capacitor is connected across an inductor then charge starts oscillating between the plates of the capacitor. Normally one plate of the capacitor is connected to Earth and the other plate is connected to an antenna. Antenna radiates electromagnetic wave. Hertz successfully produced electromagnetic waves using such LC oscillator. Speed of electromagnetic wave in vacuum is constant and equal to 3×10^8 m/s. But inside a medium the speed changes according to electrical and magnetic properties of the medium.

IF μ_r and ε_r are the relative permeability and relative

premittivity of the medium then speed of light in that medium can be written as

A. $\frac{1}{\sqrt{\mu_0 \mu_r \varepsilon_0 e \pi s_r}}$

B. $\frac{1}{\sqrt{(\mu_0 e \pi s_0)}}$

C. $\frac{1}{\sqrt{\mu_r \varepsilon_r}}$

D. $\frac{\sqrt{\mu_r \varepsilon_r}}{\sqrt{\mu_0 \varepsilon_0}}$

Answer: A

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3. We know that the Sun is fundamental source of all energy that we use. Huge amount of energy is being produced in the Sun and this energy is radiated all around in the form of electromagnetic waves of several possible wavelengths. We can

treat the Sun as a point source because it radiates energy uniformly in all directions. Intensity of wave at a point is defined as amount of energy passing that point per unit time and per unit area. We know that Earth is at a distance approximately 1.5×10^{11} m from the Sun and assume that intensity of radiation of the Sun reaching Earth's surface is 10^3 W/m^2.

How much energy is being radiated by the sun in one second ?

A. $2.8 \times 10^{26} J$

B. $5.6 \times 10^{26} J$

C. $2.8 \times 10^{22} J$

D. $5.6 \times 10^{22} J$

Answer: A

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4. We know that the Sun is fundamental source of all energy that we use. Huge amount of energy is being produced in the Sun and this energy is radiated all around in the form of electromagnetic waves of several possible wavelengths. We can treat the Sun as a point source because it radiates energy uniformly in all directions. Intensity of wave at a point is defined as amount of energy passing that point per unit time and per unit area. We know that Earth is at a distance approximately 1.5×10^{11} m from the Sun and assume that intensity of radiation of the Sun reaching Earth's surface is 10^3 W/m^2.

How much force is applied by the radiation on a roof is size $9m \times 10m$. Assume that materical of roof is perfectly absorbing .

A. $2 \times 10^{-4} N$

B. $3 \times 10^{-4} N$

C. $4 \times 10^{-4} N$

D. $5 \times 10^{-4} N$

Answer: B

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Competition File Objective Type Questions Assertion Reason Type Questions

1. A : The radiation pressure due to light waves is maximum when the surface is a perfect reflector.

R : The momentum transfer by the photons to a perfectly reflecting surface is maximum.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion

B. IF both assertion and reason are correct but reson is not the correct explantion of assertion

C. If assertion is correct but reason is incorrect

D. IF assertion is incorrect but reason is correct .

Answer: A

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2. Statement-I : Light waves can be polarised.

Statement-II: It is because light waves are transverse in nature.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion

B. IF both assertion and reason are correct but reson is not the correct explantion of assertion

C. If assertion is correct but reason is incorrect

D. IF assertion is incorrect but reason is correct .

Answer: A

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3. Statement-1 : A changing electric field produces a magnetic field

Statement-2: A changing magnetic field produces an electric field.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion

B. IF both assertion and reason are correct but reson is not the correct explantion of assertion

C. If assertion is correct but reason is incorrect

D. IF assertion is incorrect but reason is correct .

Answer: B

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4. Assertion : All electromagnetic waves travel with same speed in vacuum .

Reason : speed of electromagnetic wave in a medium is given

by speed of light in vacuum divided by refractive index of the material .

A. If both assertion and reason are correct and reason is a correct explanation of the assertion

B. IF both assertion and reason are correct but reson is not the correct explantion of assertion

C. If assertion is correct but reason is incorrect

D. IF assertion is incorrect but reason is correct .

Answer: B

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5. A : In a material medium the speed of a particle can be more than the speed of light in that medium.

R : In the phenomenon of green house effect, low wavelength radiation is allowed to pass but high wavelength radiation is not allowed to pass.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion

B. IF both assertion and reason are correct but reson is not the correct explantion of assertion

C. If assertion is correct but reason is incorrect

D. IF assertion is incorrect but reason is correct .

Answer: B

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6. Assertion: Light can travel in vacuum but sound cannot do so.

Reason: Light is an em wave and sound is a mechanical wave.

A. If both assertion and reason are correct and reason is a correct explanation of the assertion

B. IF both assertion and reason are correct but reson is not the correct explantion of assertion

C. If assertion is correct but reason is incorrect

D. IF assertion is incorrect but reason is correct .

Answer: A

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7. Assertion : Thermal radiations can propagate in vacuum .

Reason : Similar to light wave , thermal radiation is also electroamgnetic wave .

A. If both assertion and reason are correct and reason is a correct explanation of the assertion

B. IF both assertion and reason are correct but reson is not the correct explantion of assertion

C. If assertion is correct but reason is incorrect

D. IF assertion is incorrect but reason is correct .

Answer: A

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Competition File Objective Type Questions Integer Type Questions

1. Peak value of magnetic field is 20 nT for an electromagnetic wave . What will be the peak value of electric intensity in SI units ?

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2. Power of a Source producing electromagnetic wave is 1500 W. Maximum value of electric field at a point 3m from the source is found to be E_0 measureed in V/m, $E_0/20 = V/m$

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3. Electric field of an electromagnetic wave travelling in vacuum is given by

$E = 20\sin\left(kx - 6 \times 10^8 t\right)$

what should the value of k in SI units ?

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4. Electromagnetic wave is travelling in a medium of relative permittivity 2.25 and relative permeability 4. speed of the wave is found to be $a \times 10^8 m/s$ what is the value of a ?

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5. There is a source of leaser beam whose power is 3 m W. Energy stored in 90 cm length of this laser beam is found to be

$n \times 10^{-12} J$. what is the value of n ?

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6. Electric field intensity of an electromagnetic wave is represented as E= (100 N/C) sin $(\omega t - kx)$. Amount of energy stored in a cylindrical volume of cross section 10 cm^2 and length 100 cm , along X -axis is given by 0.443×10^{-2x} Joules . what is the value of x ?

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7. Electromagnetic wave is passing through a small volume .Frequency of the wave is v. Energy contained within volume is found to osciallate with frequency nv. What is n?

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Chapter Practice Test

1. Can a displacement current produce a magnetic field as the conduction current does ?

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2. A plane electromagnetic wave travels in vacuum along z-direction. What can you say about the direction of electric and magnetic field vectors?

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3. Name the electromagnetic waves used for studying crystal structure of solids. What is its frequency range?

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4. Microwaves are used in Radars, why ?

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5. Calculate the wavelength of electromagnetic wave having frequency 5×10^{16} Hz in free space.

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6. Why did Maxwell introduce the concept of displacement current? Explain.

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7. Show that the avearge energy density of the electric field $\vec{E}$ equals the average energy density of the magnetic field $\vec{B}$, in electromagnetic waves.

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8. Light can travel in vacuum but sound cannot travel. Explain.

Watch Video Solution

9. What are microwaves? Give their uses.

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10. (a) When the oscillating electric and magnetic fields are along the X- and Y-direction respectively

(i) point out the direction of propagation of electromagnetic wave,

(ii) express the velocity of propagation in terms of the amplitudes of the oscillating electric and magnetic fields.

(b) How do you show that an electromagnetic wave carries energy and momentum?

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11. Name the parts of the electromagnetic spectrum which is

(a) suitable for radar system used in aircraft navigation

(b) used to treat muscular strain.

(c) Use as a diagnostic tool in medicine.

Write in brief, how these waves can be produced.

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12. Give reasons for the following:

(i) Long distance radio broadcasts use short-wave bands.

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

(iii) Satellites are used for long distance TV transmission.

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13. A capacitor, made of two parallel plates each of plate area A and separation d, is being charged by an external ac socurce. Show that the displacement current inside the same as the current charging the capacitor.

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14. (a) Derive a relation for the velocity of electromagnetic wave.

(b) An electromagnetic wave is travelling along Z-axis is described by magnetic field

$B_x = 4 \times 10^{-10} \sin(\omega t - kx - kz)T$

Find the maximum electric and magnetic field on an alpha particle moving along Y-axis with a speed of 5×10^6 m/s. Charge on the electron is1.6×10^{-19} C.

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