PHYSICS

BOOKS - DHANPAT RAI & CO PHYSICS (HINGLISH)

ELECTROMAGNETIC WAVES

Example

1. The charging current for a capacitor is $0.25A$. What is the displacement current across its plates?

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2. A parallel plate capacitor has circular plates, each of radius $5.0cm$. It is being charged so that electric field in the gap between its plates rises steadily at the rate of $10^{12}\mathrm{Vm}^{-1}\mathrm{s}^{-1}$. What is the displacement current?

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3. The voltage between the plates of a parallel-plate capacitor of capacitance $1.0\mu F$ is changing at the rate of $5\mathrm{Vs}^{-1}$. What is the displacement current in the capacitor?

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4. A parallel plate capacitor with plate area A and plate separation d, is charged by a constant current I. Consider a

plane surface of area $A/2$ parallel to the plates and situated symmetrically between the plates. Determine the displacement current through this area.

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5. A parallel capacitor is being charged by an external source. Show that the sum of conductor current and displacement current has the same value everywhere in the circuit.

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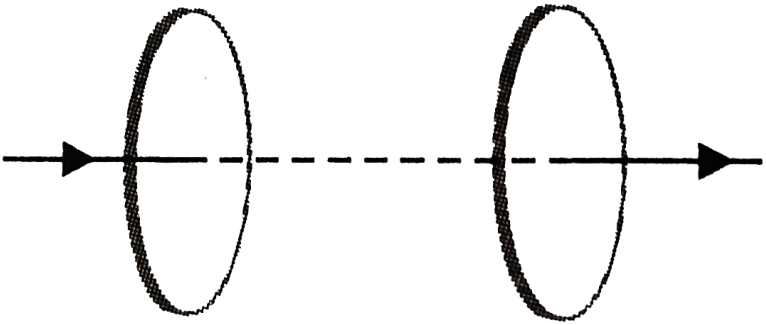
6. Fig. shows a capacitor made of two circular plates each of radius 12 cm and separated by 5.0mm. The capacitor is

being charged by an external source (not shown in the figure). The charging current is constant and equal to 0.15A.

(a) Calculate the capacitance and the rate of change of potential difference between the plates.

(b) Obtain the displacement current across the plates.

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



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7. A parallel plate capacitor of area $50cm^2$ and plate separation $3.0mm$ is charged initially to $80\mu C$. Due to radio-active source nearby , the medium between the plates gets slightly conducting and the plate loses charge the rate of $1.5 \times 10^{-8}\mathrm{Cs}^{-1}$. what is the magnitude and direction of displacement current ? What is the magnetic field between the plates

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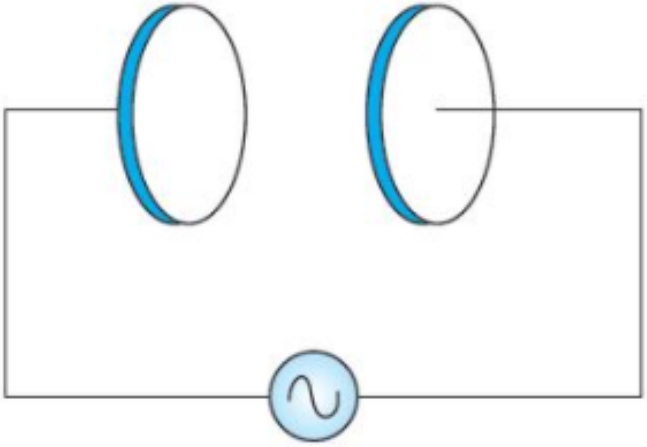
8. A parallel plate capacitor made of circular plates each of radius $R = 6.0$ cm has a capacitance $c = 100pF$. The capacitor is connected to a $230VAC$ supply with a (angular) frequency of $300rad/s$

(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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9. In a plane electromagnetic wave, the electric field oscillates sinusoidally at a frequency of $2.0 \times 10^{16} Hz$ and

amplitude $48Vm^{-1}$

What is the amplitude of the oscillating magnetic field?

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10. Find the photon energy for electromagnetic waves of wavelength $20m$. Given $h = 6.63 \times 10^{-34}\text{Js}$.

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11. Find the energy fo photon in watt-hour for electromagentic waves of wavelength 3000Å. Given $h = 6.6 \times 10^{-34}\text{Js}$.

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12. 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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13. 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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14. The maximum electric field in a plane electromagnetic wave is $600NC^{-1}$. The wave is going in the x-direction and

the electric field is in the y- direction. Find the maximum magnetic field in the wave and its direction.

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15. A plane electromagnetic wave in the visible region is moving along z-direction. The frequency of the wave is $6 \times 10^{14} Hz$, and the electric field at any point is varying sinusoidally with time with an amplitude of $2Vm^{-1}$. Calculate

(i) average energy density of the electric field and

(ii) average energy density of the magnetic field.

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16. Electro magnetic waves travel in a medium with speed of $2 \times 10^8 m/\sec$. The relative permeability of the medium is 1 find relative permittivity.

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17. The electric field in an electromagnetic wave is given by $E = \left(50N\left(C^{-1}\right)\right)\sin\omega\left(t - \frac{x}{c}\right)$. Find the energy contained in a cylinder of cross section $10cm^2$ and length 50 cm along the x- axis.

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18. A plane electromagnetic wave propagating in the x-direction has a wavelength of 5.0 mm. The electric field is in the y-direction and its maximum magnitude is $30V\left(m^{-1}\right)$. Write suitable equations for the electric and magnetic fields as a function of x and t.

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19. What should be the height of transmitting antenna if the T.V. telecast is to cover of a radius of $128km$?

Radius of earth $= 6.4 \times 10^6 m.$

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20. A TV tower has a height of $80m$. find the radius of the circle within which the transmission can be observed. If the radius of the earth is $6.4 \times 10^6 m$. How much population is covered by the TV broadcast if the average population density around the tower is $80km^{-2}$?

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21. A T.V. transmission tower at a particular station has a height of $160m$.

(a) What is its coverage range ?

(b) How much population is covered by transmission , if the average population density around the tower is $1200km^{-2}$?

(c) By how much the height of tower be increased to double its coverage range ?

Given radius of earth $= 6400km.$

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Problem

1. A radio transmitter operates at a frequency of $880kHz$ and a power of $10kW$. The number of photons emitted per second are

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2. A laser beam has intensity $2.5 \times \left(10^{14}\right) W\left(m^{-2}\right)$. Find the amplitudes of electric and magnetic fields in the beam.

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3. A light beam travelling in the x-direction is described by the electric field : $E_y = 270 \sin\omega\left(t - \frac{x}{c}\right)$. An electron is constrained to move along the y-direction with a speed of $2.0 \times 10^7 \mathrm{ms}^{-1}$. find the maximum electric force and maximum magnetic force on the electron.

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4. Find the energy stored in a 60cm length of a laser beam operating at 6mW.

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5. In a radio receiver, the short wave and medium wave station are tuned by using the same capacitoer butcoils of different inductance L_s and L_m respectively then

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6. If a capacitor of $2.0\mu F$ is charged to 20V and then suddenly short-circuited by a coil of negligible resistance and of inductance $8.0\mu H$ Calculate the maximum

amplitude and the frequency of the resulting current oscillations.

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7. A parallel plate capacitor with circular plates of radius 1m has a c apacitance of 1n F. At $t = 0$, it is connected for charging in series with a resistance $R = 1M\Omega$ across2V battery . Calculate the magnetic field at a point P, in between the plates and half way between the centre and the periphery of the plates after $10^{-3}s$.

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8. 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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Problem For Self Practice

1. How would you establish an instantaneou displacement current of 2.0A in the space between the parallel plates of $1\mu F$ capacitor?

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2. A capacitor consists of two circular plates each of radius 8.0 cm and separated by 3.0 mm. The capacitor is being charged by an external battery. The charging current is constant and is equal to 0.3 A. Calculate (i) capacitance of capacitor, (ii) the rate of change of potential difference across the plates of capacitor and (iii) the displacement current.

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3. A parallel plate capacitor is made out of two rectangular metal pates of sides $30cm \times 15cm$ and separated by a distance of 2.0 mm. The capcitor is charged in such a way that the charging current has a constant value of 100mA. What must be the rate of change of potential of the

charging source to ensure this and what will be the displacement current in the region between the capacitor plates?

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4. A paprallel plate capacitor of capacitance $C = 0.1\mu F$ is connected across on a.c. source of (angular) frequency $500 \text{rad} s^{-1}$. the value fo conduction current is $1mA$. What is the rms value of the voltage from the source ? What is the displacement current across the capacitor plates?

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5. A parallel capacitor made of circular plates radius 10.0 cm has a capacitance of 200 pF. The capacitor is connected to a 200 a.c. supply with an angular frequency of $200\text{rad} \quad s^{-1}$.

(i) What is the r.m.s. value of conduction current

(ii) Is the conduction current equal to displacement current?

(iii) Find peak value of displacement current ?

(iv) Determine the amplitude of magnetic field at a point 2.0cm from the axis between the plates.

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6. A parallel plate capacitor made of circular plates each of redius $R = 12.0cm$ has a capacitance of $100pF$. It is connected to an a.c. source of 220 V, 50 Hz. (a) Find the rms value of the conduction current (b) Is the conduction current equal to the displacement current (c) Determine the amplitude of $\vec{B}$ at a point 6.0 cm from the axis between the plates.

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7. The sunlight reaching the earth has maximum electric field of 810V $\left(m^{-1}\right)$. What is the maximum magnetic field in this light?

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8. In a plane electromagnetic wave the ainusoidal electrical oscillations have a lre-quency of 5×10^{10}Hz and amplitude $48Vm^{-1}$. Calculate (a) its wavelength (b) the amplitude of the oscillating magnetic field.

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9. The electric field vector of a plane electromagnetic wave oscillates sinusoidally at a frequency of 4.5×10^{10} Hz. What is the wavelength?

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10. The frequencies of radio waves in the AM broadcast band range from 0.55×10^6 Hz to 1.6×10^6 Hz. What are the longest and the shorted wavelengths in this band

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11. A plane electromagnetic wave is moving along x-direction . The frequency of the wave is 10^{15}Hz and the electric field at any point is varying sinusoidally with time with an amplitude of $2Vm^{-1}$. Calculate the average density of the electric and magnetic fields.

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12. In a plane electromagnetic wave of frequency 1.0×10^{12}Hz, the amplitude of the magnetic field is $5.0 \times 10^{-6}T$. (a) Calculate the amplitude of the electric field. (b) what is the total average energy density of the e.m. wave?

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13. The permittivity and permeability of free space are $\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2} \text{and} \mu_0 = 4\pi \times 10^{-7} \text{TmA}^{-1}$, respectively. Find the velocity of the electromagnetic wave.

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14. Find the photon energy in (i) calories (ii) watt hour (iii) electron volt, for e.m. wave of wavelength $300\mu m$. Give, $h = 6.6 \times 10^{-34} Js$.

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15. The magnetic field in a plane electromagnetic wave is given by $B = (200(\mu)T)\sin\left[\left(4.0 \times \left(10^{15}\right)\left(s^{-1}\right)\left(t - \left(\frac{x}{c}\right)\right)\right)\right]$. Find the maximum electric field and the average energy density corresponding to the electric field .

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16. A millimetre wave has a wavelength of $2.00mm$ and the oscillating electric field associated with it has an amplitude of $20Vm^{-1}$. Determine the frequency of oscillations of the electric and magnetic fileds of this electromagnetic wave. What is the amplitude of the magnetic field oscillations of this wave?

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17. In a plane e.m. wave, the electric field varies with time having an amplitude $1Vm^{-1}$. The frequency of wave is $0.5 \times 10^{15}Hz$. The wave is propagating along Z-axis. What is the average energy density of (i) electric field (ii)

magnetic field (iii) total average energy density (iv) what is the amplitude of magnetic field?

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18. The TV transmission tower at Pitampura,Delhi has a height F235 m. what is coverage range if the radius of the earth is 6400 km.

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19. A TV tower has a height of 200m. How much population is covered by TV brood-cast ? Given radius of the earth $= 6.4 \times 10^6$ m and avarege density of population $= 10^3 km^{-2}$.

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20. A TV transmitter is at a height of 100m. What is its coverage range ? By how much should its height be increased to double the coverage range. Radius of earth $= 6400\text{km}$.

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21. A TV tower has a height of $100m$. How much population is covered by TV broadcast? Given radius of the earth $= 6.4 \times 10^6 m$ and average density of population $= 10^3 km^{-2}$.

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