PHYSICS

BOOKS - MTG-WBJEE PHYSICS (HINGLISH)

ELECTROMAGNETIC WAVES

Wb Jee Workout Category 1 Single Option Correct Type

1. The maxwells four equations are written as

i. $\oint \overrightarrow{E} . \overrightarrow{dS} = \frac{q}{\varepsilon_0}$

ii. $\oint \overrightarrow{B} . \overrightarrow{dS} = 0$

iii. $\oint \overrightarrow{E} . \overrightarrow{dl} = \frac{d}{dt} \oint \overrightarrow{B} . \overrightarrow{dS}$

iv. $\oint \overrightarrow{B} . \overrightarrow{dl} = \mu_0 \varepsilon \frac{d}{dt} \oint \overrightarrow{E} . \overrightarrow{dS}$

The equations which have sources of $\overrightarrow{E}$ and $\overrightarrow{B}$ are

A. (i) , (ii) and (iii)

B. (i) and (ii) only

C. (i) and (iii)only

D. and (iv) onlt

Answer: A

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2. The ratio of the amplitude of the electric field to that of the magnetic field $(|E|/|B|)$ of an electromagnetic wave travelling in vacume is always

A. equal to 1

B. greater than 1

C. less than 1

D. zero

Answer: B

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3. The equation out of four maxweel's equations which show (s) electric field lines do not form closed loops is/are

A. $\oint_s \overrightarrow{E} . \overline{ds} = q/\varepsilon_0$

B. $\oint_s \overline{B} . \bar{d}s = 0$

C. $\oint \overline{E} . d\bar{t} = \frac{d\phi_B}{dt}$

D. None of these

Answer: A

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4. 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.

A. $\frac{q}{A\varepsilon_0}$

B. $\frac{q}{\varepsilon_0}$

C. $2\pi f q_0 \cos 2\pi ft$

D. $\frac{2\pi f q_0}{\varepsilon_0} \cos 2\pi ft$

Answer: C

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5. Which of the following is not an electromagnetic wave?

A. Sound wave

B. Thermal radiation

C. Microwave

D. Gamma ray

Answer: A

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6. The amplitude of the electric field of a plane electromagnetic wave in air is $6.0 \times 10^{-4} Vm^{-1}$. The amplitude of the magnetic field will be

A. $1.8 \times 10^{5} T$

B. $5.0 \times 10^{3} T$

C. $1.0 \times 10^{-4} T$

D. $2.0 \times 10^{-12} T$

Answer: D

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7. The pressure exerted by an electromagnetic wave of intensity I $\left(\text{watt}/\text{m}^2\right)$ on a nonreflecting surface is [c is the velocity of light]

A. Ic

B. Ic^2

C. I/c

D. I/c^2

Answer: C

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8. 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: B

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9. If C the velocity of light, which of the following is correct?

A. $\mu_0\varepsilon_0 = c$

B. $\mu_0\varepsilon_0 = c^2$

C. $\mu_0\varepsilon_0 = \dfrac{1}{c}$

D. $\mu_0 \varepsilon_0 = \frac{1}{c^2}$

Answer: D

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10. An electromagnetic wave of frequency $v = 3.0MHz$ passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4.0$. Then

A. wavelength is double and frequency unchanged

B. wavelength is doubled and frequency becomes half.

C. wawelength is halved and frequency remain unchanged

D. wavelength and frequency both remain unchanged

Answer: C

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11. The velocity of electromagnetic wave is parallel to

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

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

C. $\vec{E}$

D. $\vec{B}$

Answer: B

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12. Radiations of intensity $0.5W/m^2$ are striking a metal plate. The pressure on the plate is

A. $0.166 \times 10^{-8} Nm^{-2}$

B. $0.332 \times 10^{-8} Nm^{-2}$

C. $0.111 \times 10^{-8} Nm^{-2}$

D. $0.083 \times 10^{-8} Nm^{-2}$

Answer: A

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13. The electric field of an electromagnetic wave travelling through vaccum is given by the equation $E = E_0 \sin(kx - \omega t)$ The quantity that is independent of wavelength is

A. $\frac{k}{\omega}$

B. $k\omega$

C. ω

D. k

Answer: A

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14. The magnetic field of an electromagnetic wave is given by $3 \times 10^{-7} \sin\left(10^3 x + 6.28 \times 10^{12} t\right)$. The wave length of the electromagnetic wave is

A. $0.28cm$

B. $3.14cm$

C. $0.63cm$

D. $0.32cm$

Answer: C

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15. An electroagnetic wave is propagating along x-axis. At x = 1 m and t = 10 s, its electric vector $\left|\vec{E}\right| = 6V/m$ then the magnitude of its magnetic vector is

A. $2 \times 10^{-8} T$

B. $3 \times 10^{-7} T$

C. $6 \times 10^{-8} T$

D. $5 \times 10^{-7} T$

Answer: A

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16. If V_g,V_x and V_m are the speeds of gamma rays, x-rays and microwaves respectively in vacuum then

A. $v_\gamma gyv_X > v_m$

B. $v_\gamma < v_X < v_m$

C. $v_\gamma > v_X < v_m$

D. $v_X = v_\gamma = v_m$

Answer: D

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17. The electromagnetic wave having the shortest wavelength is

A. X-rays

B. γ-rays

C. infrared rays

D. microwaves

Answer: B

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18. Electromagnetic radiation of highest frequency is

A. infrared rdiations

B. $\gamma -$ rays

C. radio waves

D. X-rays

Answer: B

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19. An electromagnetic radiation has an energy of 13.2 keV. Then the radiation belongs to region of

A. visible light

B. ultraviolet

C. infrared

D. X-rays

Answer: D

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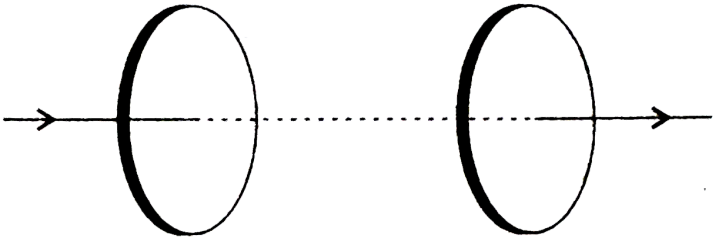
20. A capacitor made of two circular plates each of radius 12 cm and separated by 5 mm. The capacitor is being charged by an external source. The charging current is constant and equal to 0.15 A. The capacitance of the parallel plate capacitor is



A. $0.15pF, 0.87Vs^{-1}$

B. $80.1pF'1.875 \times 10^{9}Vsi^{-1}$

C. $0.15pF, 80.1Vs^{-1}$

D. $1.875pF, 0.15Vs^{-1}$

Answer: B

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21. A parallel- plate capacitor with plate area A and separation between the plates d, is charged by a constant current i. Consider a plane surface of area A/2 parallel to the plates and drawn summetrically between the plates. Find the displacement current through this area.

A. i

B. $i/2$

C. $i/4$

D. $i/8$

Answer: B

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22. A circular ring of radius r is placed in a homogeneous magnetic field perpendicular to the plane of the ring. The field B changes with time according to the equation $B = kt$ where K is constant and r is the time. The electric field in the ring is:

A. $\frac{Kr}{4}$

B. $\frac{Kr}{3}$

C. $\frac{Kr}{2}$

D. $\frac{K}{2r}$

Answer: C

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23. A plane EM wave travelling along z direction is described by

$E = E_0 \sin(kz - \omega t)\hat{i}$ and $B = B_0 \sin(kz - \omega t)\hat{j}$.

show that

(i) The average energy density of the wave is given by $u_{av} = \frac{1}{4}\varepsilon_0 E_0^2 + \frac{1}{4}\frac{B_0^2}{\mu_0}$.

(ii) The time averaged intensity of the wave is given by $I_{av} = \frac{1}{2}c\varepsilon_0 E_0^2$.

A. $c\varepsilon_0 E_0^2$

B. $\frac{1}{2}c\varepsilon_0 E_0^2$

C. $\frac{1}{2}c\varepsilon_0 E_0$

D. $\frac{1}{4}c\varepsilon_0 E_0^2$

Answer: B

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24. 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 pressure is in the range $I/c < P < 2I/c$ for real surfaces.

Answer: B

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25. Imagine an electromagnetic plane wave in vacuum whose electric field (in SI units) is given by

$E_x = 10^2 \sin\pi\left(3 \times 10^6 z - 9z10^{14}t\right), E_y = 0, E_z = 0.$ The frequency and wavelength will be

A. $6.2 \times 10^{14} Hz$ and $530nm$

B. $3.2 \times 10^{15} Hz$ and $630 nm$

C. $4.5 \times 10^{14} Hz$ and $666 nm$

D. $4.5 \times 10^{4} Hz$ and $450 nm$

Answer: C

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

A. infrared rays

B. ultraviolet rays

C. X-rays

D. radiowaves.

Answer: A

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27. The velocity of electromagnetic wave is parallel to

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

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

C. $\overrightarrow{E}$

D. $\overrightarrow{B}$

Answer: B

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28. if $\lambda_{v'}$, λ_x and λ_m represent the wavelengths of visible light X-rays and microwaves respectively then:

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

B. $\lambda_m > \lambda_v \lambda_x$

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

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

Answer: B

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29. 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 phasc and parallcl to cach other.

Answer: C

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30. If the total electromagnetic energy falling on a surface is U then the total momentum delivered (for complate absorption) is

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

B. cU

C. $\frac{U}{c^2}$

D. c^2U

Answer: A

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Wb Jee Workout Category 2 Single Option Correct Type

1. The magnetic field between the plates of a capacitor when $r > R$ is given by-

A. $\frac{\mu_0 I_D r}{2\pi R^2}$

B. $\frac{\mu_0 I_D}{2\pi R}$

C. $\frac{\mu_0 I_D}{2\pi r}$

D. zero

Answer: C

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2. A parallel plate capacitor of plate separation $2mm$ is connected in an electric circuit having source voltage $400V$. If the plate area is $60cm^2$, then the value of displacement current for 10^{-6} sec will be

A. $1.062A$

B. $1.062 \times 10^{-2}A$

C. $1.062 \times 10^{-3}A$

D. $1.062 \times 10^{-4}A$

Answer: B

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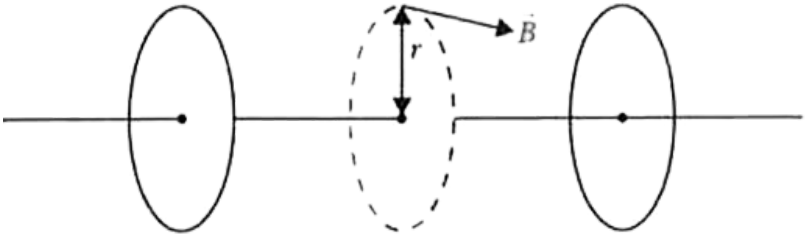
3. The magnetic field strength B at the point between the capacitor plates is indicated in figure. B in terms of the rate of charge of the electric field strength, i.e., dE/dt between the plates is equal to



A. $\frac{\mu_0}{2\pi r}\frac{dE}{dt}$

B. $\frac{\varepsilon_0\mu_0 r}{2}\frac{dE}{dt}$

C. Zero

D. $\frac{\mu_0}{2r}\frac{dE}{dt}$

Answer: B

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4. The magnetic field of a beam emerging from a filter facing a floodlight is given by $B = 12 \times 10^{-8} \sin\left(1.20 \times 10^{7} z - 3.60 \times 10^{14} t\right) T.$

What is the average intensity of the beam?

A. $172 W m^{-2}$

B. $1.72 W m^{-2}$

C. $0.172 W m^{-2}$

D. $17.2 W m^{-2}$

Answer: B

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5. The dielectric constant for air is 1.006. The speed of em wave travelling in air is $a \times 10^8 ms^{-1}$, where a is about:

A. 3

B. 3.88

C. 2.5

D. 3.2

Answer: A

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

A. $3.3 \times 10^{-3} Jm^{-3}$

B. $4.58 \times 10^{-6} Jm^{-3}$

C. $7.37 \times 10^{-9} Jm^{-3}$

D. $81.35 \times 10^{-12} Jm^{-3}$.

Answer: B

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7. A point source of electromagnetic radiation has an average power output of $1500W$. The maximum value of electric field at a distance $3m$ from this source in Vm^{-1} is

A. 500

B. 100

C. $\frac{500}{3}$

D. $\frac{250}{3}$

Answer: B

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8. The electric field of a plane electromagnetic wave varies with time of amplitude $2Vm^{-1}$ propagating along z-axis. The average energy density of the magentic field is (in Jm^{-3})

A. 12.29×10^{-12}

B. 8.86×10^{-12}

C. 17.72×10^{-12}

D. 4.43×10^{-12}

Answer: B

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9. A plane electromagnetic wave travels in free space along X-direction. If the value of $\vec{B}$ (in tesla) at a particular point in space

and time is $1.2 \times 10^{-8}\hat{k}$. The value of $\overrightarrow{E}$ (in Vm^{-1}) at that point is

A. $1.2\hat{j}$

B. $3.6\hat{k}$

C. $1.2\hat{k}$

D. $3.6\hat{j}$

Answer: D

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10. A plane electromagnetic wave moving through free space has an electric field (also referred to as the optical field) given by $E_x = 0, E_y = 0$ and $E_z = 100\sin\left[8\pi \times 10^{14}\left(t - \frac{x}{3 \times 10^8}\right)\right]Vm^{-1}$. The corrsponding flux density is

A. $13.3Wm^{-2}$

B. $11.4Wm^{-2}$

C. $25.0Wm^{-2}$

D. $20.4Wm^{-2}$

Answer: A

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11. In a plane e.m. wave, the electric field oscillates withe amplitude $20Vm^{-1}$. Find (a) energy density of electric field (b) energy density of magnetic field.

A. 8.86×10^{-12}

B. 4.43×10^{-12}

C. 17.72×10^{-12}

D. 2.21×10^{-12}

Answer: D

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12. In a region of free space during the propagation of electromagnetic wave, the electric field at some instnat of time is $\vec{E} = \left(90\hat{i} + 40\hat{j} - 70\hat{k}\right)NC^{-1}$ and the magnetic field is $\vec{B} = \left(0.18\hat{i} + 0.08\hat{j} + 0.30\hat{k}\right)\mu T$. The polynting vector for these field is

A. $\left(14.0\hat{i} - 3.148\hat{j}\right)$

B. $\left(14.\,0\hat{i} - 31.\,48\hat{j}\right)$

C. $\left(1.4\hat{j} + 3.148\hat{j}\right)$

D. $\left(14.0\hat{i} + 31.48\hat{j}\right)$

Answer: B

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13. 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.

A. $4.20 \times 10^{-15} N, 3.82 \times 10^{-16} N$

B. $3.62 \times 10^{-19} N, 1.63 \times 10^{-18} N$

C. $4.32 \times 10^{-17} N, 2.88 \times 10^{-18} N$

D. $5.31 \times 10^{-18} N, 5.62 \times 10^{-18} N$

Answer: C

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14. The electric field of an electromagnetic wave is given by $E = \left(50 NC^{-1}\right)\sin\omega(t - x/c)$.

The energy contained in a cylinder of cross section $10cm^2$ and length l /10 along the x-axis is $5.5 \times 10^{-12}J$. The vlaue of l is

A. 3

B. 9

C. 4

D. 5

Answer: D

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15. The velocity of light in vacuum can be changed by changing

A. frequency

B. amplitude

C. wavelength

D. None of these

Answer: D

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Wb Jee Workout Category 3 One Or More Than One Option Correct Type

1. 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.

A. The volume of the cylinder is $5 \times 10^{-4}m^3$

B. The energy contained in cylinder is $5.5 \times 10^{-12}J$

C. The volume of the cylinder is $3 \times 10^{7}m^3$

D. The energy contained in cylinder is $7 \times 10^{-12}J$

Answer: A::B

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2. 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.

A. The equation for electric field

$$E = \left(30Vm^{-1}\right)\sin\left[\frac{2\pi}{5.0mm}(ct - x)\right]$$

B. The maximum magnetic field is $10^{-7}T$

C. The equation for magnetic field

$$B = \left(10^{-7}T\right)\sin\left[\frac{\pi}{2.5mm}(ct - x)\right]$$

D. The equation for magnetic field $B = \left(10^{-7}T\right)$

$$\sin\left[\frac{2\pi}{5.0mm}(ct - x)\right].$$

Answer: A::B::D

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3. A light beam travelling in the x- direction is described by the electric field $E_y\left(300V\left(m^{-1}\right)\sin\omega(t-(x/c)\right)$. An electron is constrained to move along the y-direction with a speed $\left(2.0\times\left(10^7\right)m\left(s^{-1}\right)\right)$. Find the maximum electric force and the maximum magnetic force on the electron.

A. The maximum electric force on the elctron is $4.8\times10^{-17}N$

B. The maximum magnetic force on the electron is $3.2\times10^{-18}N$

C. The maximum electric force on an electron is $5\times10^{-3}N$

D. The maximum magnetic force on electron is $2.3\times10^{-11}N$.

Answer: A::B

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4. Displacement current goes through the gap between the plates of a capacitor when the charge of the capacitor

A. increases

B. decreases

C. does not change

D. is zero

Answer: A

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5. Which of the following have zero average value in a plane electromagnetic wave?

A. electric field

B. magnetic field

C. electric energy

D. magnetic energy

Answer: A

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6. An electric bulb illuminates a plane surface. The intensity of illumination on the surface at a point 2m away from the bulb is 5×10^{-4} phot. The line joining the bulb to the point makes an angle of 60° with the normal to the surface. calculate the intensity of the bulb in candela ? (1 phot $= 1m/cm^2$).

A. $40\sqrt{3}$

B. 40

C. 20

D. 40×10^{-4}

Answer: B

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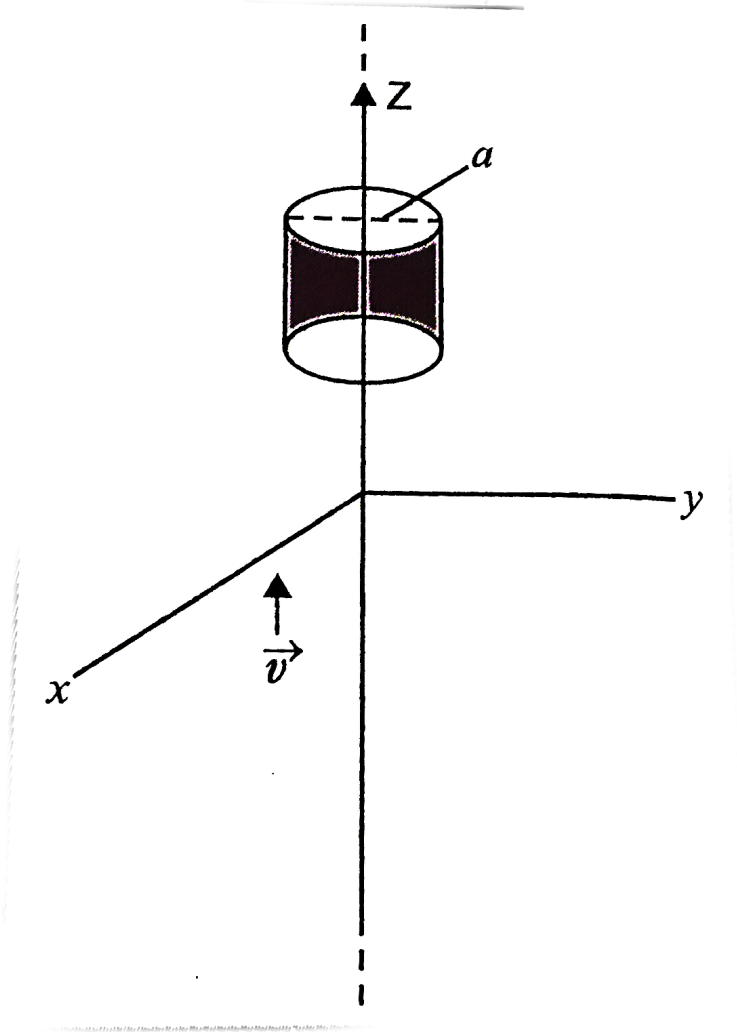
7. An infinitely long thin wire carrying a uniform linear static charge density λ is placed along the z-axis Fig. The wire is set into motion along its length with a uniform velocity $\overrightarrow{v} = v\hat{k}$. Calculate the

poynting vector $\vec{S} = \frac{1}{\mu_0}\left(\vec{E} \times \vec{B}\right)$.



A. $\frac{\lambda v}{4\pi^2 \varepsilon_0 a}\hat{j}$

B. $\frac{-\lambda^2 v}{4\pi^2 \varepsilon_0 a^2}\hat{k}$

C. $\frac{-\lambda^2 v}{4\pi^2 \varepsilon_0 a}$

D. $\frac{\lambda v}{4\pi\varepsilon_0 a^2}\hat{i}$

Answer: B

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8. A beam of light travelling aling x-axis is described by the magnetic field, $B_o = 5.2 \times 10^{-9} T \sin\omega(t - x/c)$. Then,

(Charge on electron $= 1.6 \times 10^{-19} C$)

A. the maximum electric field is $1.56 Vm^{-1}$.

B. the maximum electric field is $2.85 Vm^{-1}$

C. the maximum electric force an alpha particle due to electric field is $2 \times 10^{-10} N$

D. the maximum electric force an alpha particle due to electric field is $5 \times 10^{-19} N$.

Answer: A::D

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9. 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?

A. The average energy density of electric field is $2.21 \times 10^{-12}Jm^{-3}$.

B. The average energy density of total field is $4.42 \times 10^{-12}Jm^{-3}$.

C. The average enerfy density of total field is $6.91 \times 10^{-12}Jm^{-3}$.

D. The amplitude of magnetic field is $3.33 \times 10^{-9} T$.

Answer: A::B::D

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10. Light with an energy flux of $40 W / cm^2$ falls on a non-reflecting surface at normal incidence. If the surface has an area of $20 cm^2$, find the average force exerted on the surface during a 30 min time span.

A. $3.4 \times 10^{-6} N$

B. $4.5 \times 10^{-7} N$

C. $1.2 \times 10^{-6} N$

D. $1.2 \times 10^{-7} N$

Answer: C

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