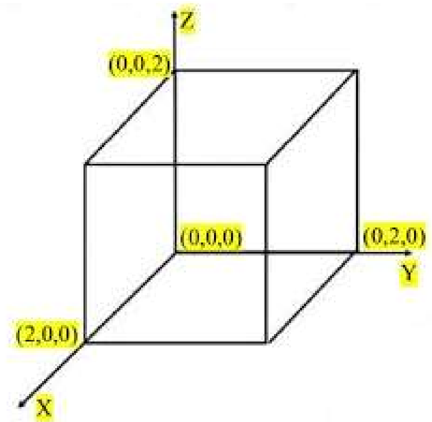
Q 1

10 points

The charge contained within the cube (see figure), in which the electric field is given by $\vec{E} = K(4x^2\hat{x} + 3y\hat{y} + 2z^3\hat{z})$, where ϵ_0 is the permittivity of free space, is



$(A)\ 28K\epsilon_0$ $(B)\ 36K\epsilon_0$ $(C)\ 152K\epsilon_0$ $(D)\ 96K\epsilon_0$

- ○ Option 1
- ○ Option 2
- ◉ Option 3
- ○ Option 4

Q2

10 points

Which one of the following statement is wrong?

(A) Coulomb gauge is given by $\vec{\nabla} \cdot \vec{A} = 0$ and Lorentz Gauge is given by: $\vec{\nabla} \cdot \vec{A} = -\mu_0\epsilon_0 \frac{\partial V}{\partial t}$

(B) Using Coulomb gauge $\vec{A}$ cannot be determined from $\vec{J}$ alone.

(C) Lorentz gauge enables us to write: $\nabla^2 V - \mu_0\epsilon_0 \frac{\partial^2 V}{\partial t^2} = -\frac{\rho}{\epsilon_0}$ *and* $\nabla^2 \vec{B} - \mu_0\epsilon_0 \frac{\partial^2 \vec{B}}{\partial t^2} = -\mu_0 \vec{J}$

(D)Equations $\vec{B} = \vec{\nabla} \times \vec{A}$ and $\vec{E} = -\vec{\nabla} V - \frac{\partial \vec{A}}{\partial t}$ do not uniquely define the scalar and vector potentials.

- ○ Option 1
- ○ Option 2
- ◉ Option 3
- ○ Option 4

Q3

10 points

An infinitely long straight conductor along Z axis carries an alternating current. The direction of energy flow (due to the electromagnetic field) at (0,5,1) is along:

$(A) -\hat{\mathbf{x}}$ $(B)\ \hat{\mathbf{z}}$ $(C)\ \hat{\mathbf{y}}$ $(D) -\hat{\mathbf{y}}$

- ○ Option 1
- ○ Option 2
- ○ Option 3
- ◉ Option 4

Q4

10 points

An infinitely long straight conductor along $\boldsymbol{Z}$ axis carries a steady current $\boldsymbol{i}$ in positive $\boldsymbol{Z}$ direction. Magnetic field at a distance ρ from the wire is $\frac{\mu_0 i}{2\pi\rho}\hat{\varphi}$. Then $\overleftrightarrow{\boldsymbol{T}}$ at a point (x, y, z) will be $\frac{\mu_0 i^2}{8\pi^2}$ times:

$$(\boldsymbol{A})\ \frac{1}{(x^2+y^2)^2}\begin{bmatrix} y^2-x^2 & -2xy & 0 \\ -2xy & x^2-y^2 & 0 \\ 0 & 0 & -x^2-y^2 \end{bmatrix} \qquad (\boldsymbol{B})\ \frac{1}{(x^2+y^2)^2}\begin{bmatrix} x^2-y^2 & -2xy & 0 \\ -2xy & y^2-x^2 & 0 \\ 0 & 0 & -x^2-y^2 \end{bmatrix}$$

$$(\boldsymbol{C})\ \frac{1}{(x^2+y^2)^2}\begin{bmatrix} y^2-x^2 & 2xy & 0 \\ 2xy & x^2-y^2 & 0 \\ 0 & 0 & -x^2-y^2 \end{bmatrix} \qquad (\boldsymbol{D})\ \frac{1}{(x^2+y^2)^2}\begin{bmatrix} y^2-x^2 & 2xy & 0 \\ -2xy & x^2-y^2 & 0 \\ 0 & 0 & -x^2-y^2 \end{bmatrix}$$

- (selected) Option 1
- Option 2
- Option 3
- Option 4

Q5

10 points

A uniformly charged solid sphere of radius R has charge Q. Electric field at an internal point is $\vec{\boldsymbol{E}} = \frac{Q}{4\pi\epsilon_0 R^3}\vec{\boldsymbol{r}}$. T_{zz} and T_{yz}, at $(r, \theta, \varphi) = \left(\frac{R}{2}, \frac{\pi}{4}, \frac{\pi}{4}\right)$, will be given in the units of $\frac{\epsilon_0}{2}\left(\frac{Q}{8\pi\epsilon_0 R^2}\right)^2$, by:

($\boldsymbol{A}$) $T_{zz} = 0$ and $T_{yz} = \frac{1}{\sqrt{2}}$

($\boldsymbol{B}$) $T_{zz} = -1$ and $T_{yz} = 0$

($\boldsymbol{C}$) $T_{zz} = 1$ and $T_{yz} = -1$

($\boldsymbol{D}$) $T_{zz} = -1$ and $T_{yz} = \frac{1}{\sqrt{2}}$

- (selected) Option 1
- Option 2
- Option 3
- Option 4

Q6

10 points

In a plane electromagnetic wave the electric and magnetic fields are given by: $\vec{\boldsymbol{E}} = 6\sqrt{3\pi}\cos(\omega t - kz)\,\hat{\boldsymbol{\imath}}$ V/m and $\vec{\boldsymbol{B}} = \left(6\sqrt{3\pi}/c\right)\cos(\omega t - kz)\,\hat{\boldsymbol{\jmath}}$ N/(A.m), where $c = 3 \times 10^8$m/s. The momentum density $\vec{\boldsymbol{p}}_{e.m.}(t)$ of the electromagnetic fields at (0,0,0) is:

(A) $10^{-17} \times \sin^2 \omega t\,\hat{\boldsymbol{k}}\ \ kgs^{-1}m^{-2}$

(B) $10^{-17} \times \cos^2 \omega t\,\hat{\boldsymbol{k}}\ \ Nsm^{-3}$

(C) $\frac{1}{3\times10^{25}}\cos^2 \omega t\,\hat{\boldsymbol{k}}\ \ Nm^{-4}$

(D) $\frac{\epsilon_0}{3\times10^{25}}\cos^2 \omega t\,\hat{\boldsymbol{k}}\ \ Nsm^{-3}$

- ○ Option 1
- ◉ Option 2
- ○ Option 3
- ○ Option 4

Q7

10 points

In the above problem, at (0,0,0), the momentum flux density crossing XY and YZ planes are respectively:

(A) $3 \times 10^{-9} \cos^2 \omega t \ \hat{\boldsymbol{i}}$ and $3 \times 10^{-9} \cos^2 \omega t \ \hat{\boldsymbol{k}} \quad kg\, m^{-1} s^{-2}$

(B) $\mathbf{0}$ and $3 \times 10^{-9} \cos^2 \omega t \ \hat{\boldsymbol{k}} \quad Nm^{-2}$

(C) $\mathbf{0}$ and $-3 \times 10^{-9} \cos^2 \omega t \ \hat{\boldsymbol{k}} \ \ kg\, m^{-1} s^{-2}$

(D) $-3 \times 10^{-9} \cos^2 \omega t \ \hat{\boldsymbol{i}}$ and $-3 \times 10^{-9} \cos^2 \omega t \, \hat{\boldsymbol{k}} \ \ Nm^{-2}$

- ○ Option 1
- ◉ Option 2
- ○ Option 3
- ○ Option 4

Q8

10 points

In the problem (6), at (0,0,0), the energy flux density is:

(A) $9 \times 10^{-9} \cos^2 \omega t\ \hat{\boldsymbol{k}}\ J\, m^{-2} s^{-1}$

(B) $3 \times 10^{-9}\, c\ \cos^2 \omega t\ \hat{\boldsymbol{k}}\ N m^{-2} s^{-2}$

(C) $0.9 \cos^2 \omega t\ \hat{\boldsymbol{k}}\ \ W m^{-2}$

(D) $0.09 \cos^2 \omega t\ \hat{\boldsymbol{k}}\ \ W m^{-2}$

- ○ Option 1
- ○ Option 2
- ◉ Option 3
- ○ Option 4

Q9

10 points

In the problem (6), at (0,0,0), the stress tensor is given by:

$$(\boldsymbol{A})\ \overleftrightarrow{\boldsymbol{T}} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times 3 \times 10^{-9} \cos^2 \omega t\ \ Nm^{-2}$$

$$(\boldsymbol{B})\ \overleftrightarrow{\boldsymbol{T}} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix} \times 3 \times 10^{-9} \cos^2 \omega t\ \ kg\, m^{-1} s^{-2}$$

$$(\boldsymbol{C})\ \overleftrightarrow{\boldsymbol{T}} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \times 3 \times 10^{-9} \cos^2 \omega t\ \ Nm^{-2}$$

$$(\boldsymbol{D})\ \overleftrightarrow{\boldsymbol{T}} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \times 3 \times 10^{-9} \cos^2 \omega t\ \ kg\, m^{-1} s^{-2}$$

- ○ Option 1
- ◉ Option 2
- ○ Option 3
- ○ Option 4