CLASS TEST

Sl. 02 SK_ABCD_10072022[G]

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# ELECTRICAL ENGINEERING

# Electromagnetic Fields

**Duration : 1:00 hr.** **Maximum Marks : 50**

Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

**DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO**

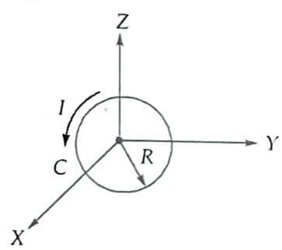
**Q. No. 1 to Q. No. 10 carry 1 mark each**

**Q.1** Two positive charges Q coulomb each are placed at points (0, 0, 0) and (2, 2, 0) while two negative charges Q coulomb each in magnitude are placed at points (0, 2, 0) and (2, 0, 0). The electric field at the point (1, 1, 0) is______.

(a) Zero (b) $\frac{Q}{8\pi\varepsilon_0}$

(c) $\frac{Q}{4\pi\varepsilon_0}$ (d) $\frac{Q}{16\pi\varepsilon_0}$

**Q.2** The magnetic field intensity $\vec{H}$ at the center of the current carrying circular loop shown in the figure below is




(a) $-\frac{I}{R}\hat{a}_z$ (b) $-\frac{I}{2R}\hat{a}_z$

(c) $\frac{I}{R}\hat{a}_z$ (d) $\frac{I}{2R}\hat{a}_z$

**Q.3** If a vector field $\vec{A}$ is said to be solenoidal, then which one of the following relations is true?

(a) $\oint_L \vec{A}.\vec{dL} = 0$ (b) $\nabla \times \vec{A} \neq 0$

(c) $\oint_s \vec{A}.\vec{ds} = 0$ (d) $\nabla \times \vec{A} = 0$

**Q.4** Two identical co-axial circular coils carry the same current $I$ but in opposite directions. The magnitude of the magnetic flux density $\vec{B}$ at a point on the axis midway between the coils is

(a) zero
(b) same as that produced by one coil
(c) twice that produced by one coil
(d) half that produced by one coil

**Q.5** The continuity equation for static fields is given by

(a) $\nabla.\vec{J} = \frac{\partial \rho_v}{\partial t}$ (b) $\nabla \times \vec{J} = 0$

(c) $\nabla.\vec{J} = 0$ (d) $\nabla \times \vec{E} = 0$

**Q.6** If volume charge density,

$$\rho_v = \begin{cases} \frac{10}{r^2}\text{mC/m}^3 & 1\text{m} < r < 4\text{m} \\ 0 & \text{otherwise} \end{cases}$$

then the net flux crossing surface, $r$ = 2 m is,

(a) $20\pi$ mC (b) $80\pi$ mC
(c) $40\pi^2$ mC (d) $40\pi$ mC

**Q.7** Which of the following correctly describes the relationship between the vector potential $\vec{A}$ of a magnetic field and an electric field intensity $\vec{E}$ for time varying fields?

(a) $\vec{E} = \frac{\partial \vec{A}}{\partial t}$ (b) $\vec{E} = -\frac{\partial \vec{A}}{\partial t}$

(c) $\vec{E} = \int \vec{A}.dt$ (d) $\vec{E} = -\int \frac{\partial \vec{A}}{\partial x}.dt$

**Q.8** Two point charges $Q_1$ = 25 μC and $Q_2$ = 20 μC are located at (1, –2, 3) m and (2, –1, 0) m respectively. Force on charge $Q_1$ due to $Q_2$ is

(a) $0.423(-\hat{i} + \hat{j} + 3\hat{k})$N (b) $0.123(-\hat{i} + 3\hat{j} + \hat{k})$N

(c) $0.527(-\hat{i} - \hat{j} + 3\hat{k})$N (d) $0.123(-\hat{i} - \hat{j} + 3\hat{k})$N

**Q.9** If $\vec{r} = x\hat{a}_x + y\hat{a}_y + z\hat{a}_z$ is the position vector of point (x, y, z), then $\nabla(\ln|r|)$ is

(a) $|r|\vec{r}$ (b) $|r|^2\vec{r}$

(c) $\frac{\vec{r}}{|r|}$ (d) $\frac{\vec{r}}{|r|^2}$

**Q.10** The flux through each turn of a 100 turn coil is ($t^3 - 2t$) mWb, where $t$ is in seconds. The induced emf at $t = 2s$ is
(a) –1 V (b) –2 V
(c) 1 V (d) 2 V

**Q. No. 11 to Q. No. 30 carry 2 marks each**

**Q.11** A vector $\vec{P}$ is given by $\vec{P} = x^3 y\vec{a}_x - x^2y^2\vec{a}_y - x^2yz\vec{a}_z$ Which of the following statements is TRUE?
(a) $\vec{P}$ is solenoidal, but not irrotational
(b) $\vec{P}$ is irrotational, but not solensoidal
(c) $\vec{P}$ is neither solenoidal nor irrotational
(d) $\vec{P}$ is both solenoidal and irrotational

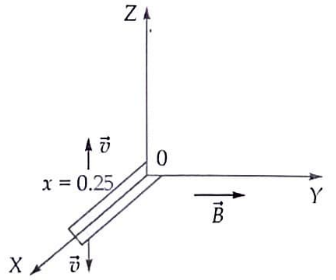
**Q.12** In a current free region with relative permeability of 1, the magnetic scalar potential is given as $V_m = x^2y + y^2x + z$. The magnitude of magnetic flux density at (1, 0, 1) is ________
(a) 1.77 μT (b) 2.44 μT
(c) 3.88 μT (d) 4.89 μT

**Q.13** An infinitely long line oriented parallel to z-axis carries a uniformly distributed charge of 0.1 μC/m. It is situated at $x = 1$ m, $y = -5$ m. The electric field $\vec{E}$ at (–1, –2, 5) m is
(a) $-276.92\hat{u}_x + 415.38\hat{u}_y$
(b) $-173.58\hat{u}_x + 275.40\hat{u}_y$
(c) $-279\hat{u}_x + 180\hat{u}_y$
(d) $-157.35\hat{u}_x + 372\hat{u}_y$

**Q.14** The induced voltage in the conductor of figure shown below is

$B = 0.05\hat{u}_y T$

$v = 3\sin 10^3 t\hat{u}_z$ m/sec




(a) $-0.0375 \cos 10^3 t$ V
(b) $0.0375t$ V
(c) $-0.0375 \sin 10^3 t$ V
(d) $-37.5 \sin 10^3 t$ V

**Q.15** Three surface charge distributions are located in free space as follows:
10 μC/m² at $x = 2$, –20 μC/m² at $y = -3$ and 30 μC/m² at $z = 5$
The magnitude of $E$ at point $P(5, -1, 4)$ is
(a) $2.11 \times 10^6$ V/m (b) $3.45 \times 10^3$ V/m
(c) $4.23 \times 10^5$ V/m (d) $7.13 \times 10^6$ V/m

**Q.16** Consider a straight conductor of length 2 m. Carrying a current of 10 A in the +z direction. If the conductor is placed in a field of $\vec{B} = 0.02(\hat{a}_y - \hat{a}_x)\text{Wb/m}^2$, then the force on per unit length of the conductor is
(a) $-0.4(\hat{a}_x + \hat{a}_y)$ N/m
(b) $-0.4(\hat{a}_x - \hat{a}_y)$ N/m
(c) $-0.2(\hat{a}_x + \hat{a}_y)$ N/m
(d) $0.2(\hat{a}_x + \hat{a}_y)$ N/m

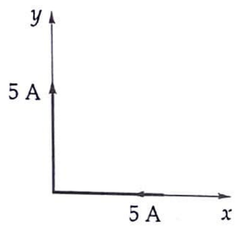
**Q.17** If $\mu_1 = 2\mu_0$ for region-1 ($0 < \phi < \pi$) and $\mu_2 = 5\mu_0$ for region-2 ($\pi < \phi < 2\pi$) and $B_2 = 10\hat{a}_\rho + 15\hat{a}_\phi - 20\hat{a}_z$ mWb/m², then the energy density in region-1 is
(a) 60.68 J/m³ (b) 30.58 J/m³
(c) 120.76 J/m³ (d) 75.63 J/m³

**Q.18** In a ferromagnetic material $\mu = 4.5\mu_0$, $B = 4y\hat{a}_z$ mWb/m² value of bound current density $J_b$ is
(a) 2475.72 A/m² (b) 3530.72 A/m²
(c) 4715.37 A/m² (d) 1513.37 A/m²

**Q.19** If the two capacitors having capacitance of 100 μF and 50 μF respectively are connected in parallel, then the total energy stored with a steady applied potential difference of 1000 V is
(a) 16.66 J (b) 250 J
(c) 375 J (d) 75 J

**Q.20** The point charges in free space are located as follows :
$+5 \times 10^{-8}$C at (0, 0)m ; $+4 \times 10^{-8}$ C at (3,0) m and $-6 \times 10^{-8}$ C at (0, 4) m the potential at point (3, 4) m is ________ .
(a) 0 (b) 15 V
(c) –3 V (d) 3 V

**Q.21** An infinitely long conductor is bent into an $L$ shape as shown in figure. If a direct current of 5 A flows in the conductor, then the magnetic field intensity at (0, 0, 2) is




(a) $\frac{5}{16\pi}(\hat{a}_y + \hat{a}_z)$ A/m
(b) $\frac{5}{32\pi}(\hat{a}_x + \hat{a}_y)$ A/m
(c) $\frac{5}{8\pi}(\hat{a}_x + \hat{a}_y)$ A/m
(d) $\frac{7}{16\pi}(\hat{a}_x + \hat{a}_z)$ A/m

**Q.22** Line $x = 0$, $y = 0$, $0 \le z \le 10$ carries current 2A along $a_z$. The magnetic field intensity $\vec{H}$ at point (5, 5, 0) is $|\vec{H}|(-\hat{a}_x + \hat{a}_y)$A/m, then the value of $|\vec{H}|$ is
(a) $\frac{1}{20\pi\sqrt{3}}$ (b) $\frac{1}{10\pi\sqrt{6}}$
(c) $\frac{1}{30\pi\sqrt{2}}$ (d) $\frac{1}{30\pi\sqrt{6}}$

**Q.23** In cylindrical coordinates, $V = 0$ at $\rho = 4$ mm and $V = V_0$ at $\rho = 12$ mm. If $E = -6\,\hat{a}\rho$ kV/m at $\rho = 8$ mm, then the value of $V_0$ is
(a) 12 ln 3 V (b) 16 ln 3 V
(c) 48 ln 2 V (d) 48 ln 3 V

**Q.24** In cylindrical coordinates, $V = 0$, at $\rho = 2$ m and $V = 60$ V at $\rho = 5$ m due to charge distribution $\rho_v = \frac{10}{\rho}$ pC/m$^3$. If $\epsilon_r = 3.6$, then $E$ at $\rho = 1$ m is (Take ln 2.5 = 0.9163).
(a) $-66.19\hat{a}_\rho$ V/m (b) $-20.13\hat{a}_\rho$ V/m
(c) $105.54\,\hat{a}_\rho$ V/m (d) $2.31\,\hat{a}_\rho$ V/m

**Q.25** A stationary 10 turn square coil of 1 metre-side is situated with its lower left corner coincident with the origin and with sides $x_1$ and $y_1$ along $x$-axis and $y$-axis. If the field $B$ is normal to the plane of coil and has its amplitude given by

$$B_0 = \sin\frac{\pi x}{x_1}\sin\frac{\pi y}{y_1}\,T$$

The rms value of emf induced in the coil if $B$ varies harmonically at a frequency of 1 kHz
(a) 14 kV (b) 18 kV
(c) 22 kV (d) 28 kV

**Q.26** If the area of outer and inner two concentric spheres be $A_a$ and $A_b$ respectively and the dielectric between two spheres being air, then the capacity of a spherical condenser (capacitor) is
(a) $\sqrt{4\pi}\,\epsilon_0\left(\frac{A_a A_b}{A_a - A_b}\right)$
(b) $\sqrt{4\pi}\,\epsilon_0\,\frac{\sqrt{A_a A_b}}{\sqrt{A_a} - \sqrt{A_b}}$
(c) $\epsilon_0\sqrt{4\pi}\,\frac{\sqrt{A_a A_b}}{(A_a - A_b)}$
(d) $4\pi\,\epsilon_0\,\frac{\sqrt{A_a A_b}}{\sqrt{A_a - A_b}}$

**Q.27** Two uniformly distributed line charges of $\lambda$ = 5nc/m each are parallel to the X-axis, one at $z = 0$ and $y = -2$m and the other $z = 0$ and y = 4 m. The field E at (4, 1, 3) m is______
(a) $30\,\hat{a}_x$ (b) $30\,\hat{a}_y$
(c) $6\,\hat{a}_z$ (d) $30\,\hat{a}_z$

**Q.28** Two uniform line charges of $\lambda$ = 4nC/m each are parallel to the z-axis at $x = 0$, $y = \pm$ 4m. The electric field $\vec{E}$ at (± 4, 0, z) is

(a) $\left(24\hat{a}_x + 18\hat{a}_y\right)$ V/m

(b) $\pm 24\hat{a}_y$ V/m

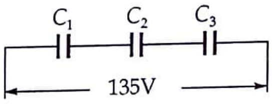
(c) $\pm 24\hat{a}_x$ V/m

(d) $\pm 18\hat{a}_x$ V/m

**Q.29** A circuit has 2000 turns enclosing a magnetic circuit 30 cm$^2$ in section. A current of 5 A in the circuit produces a field of flux density 1(Tesla) and when current is doubled, flux density increases only by 50%. The mean value of inductance of the circuit between 5 A and 10 A is

(a) 0.4 H
(b) 0.5 H
(c) 0.6 H
(d) 0.7 H

**Q.30** If the charge on each of the capacitors shown in figure is 4500 μC the voltage distribution across $C_1$, $C_2$, $C_3$ is in the ratio 2 : 3 : 4 the total capacitance is




(a) 22.41 μF
(b) 42.51 μF
(c) 33.33 μF
(d) 39.26 μF

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