CLASS TEST

Sl.: 02DLSK_EE_IJKLM_07092026

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ELECTROMAGNETIC FIELDS

ELECTRICAL ENGINEERING

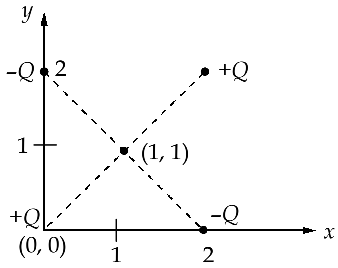
Date of Test : 07/09/2026

ANSWER KEY

1.	(a)	7.	(d)	13.	(d)	19.	(a)	25.	(b)
2.	(b)	8.	(a)	14.	(b)	20.	(c)	26.	(b)
3.	(d)	9.	(d)	15.	(b)	21.	(c)	27.	(d)
4.	(c)	10.	(a)	16.	(d)	22.	(c)	28.	(c)
5.	(c)	11.	(b)	17.	(a)	23.	(b)	29.	(b)
6.	(c)	12.	(d)	18.	(c)	24.	(d)	30.	(c)

DETAILED EXPLANATIONS

1. (a)



The two positive charges Q are diagonally opposite in position and at the same distance from the point (1, 1, 0) fields produced by them are equal and opposite and so their resultant field is zero. Similarly for negative charges.

2. (b)

A medium behaves like dielectric when the $\varepsilon_r >> 1$ and $\sigma \to 1$ so displacement current density is much greater than conduction current density,

i.e., $|J_D| >> |J_C|$

Also, $\omega\varepsilon >> \sigma$ for good dielectric

$$\Rightarrow \quad \frac{\sigma}{\omega\varepsilon} << 1$$

$$\frac{J_C}{J_D} = \frac{\sigma}{\omega\varepsilon} << 1$$

$$\Rightarrow \quad J_C << J_D$$

3. (d)

From Biot savart law,

$$\vec{H} = \int_0^{2\pi} \frac{IRd\phi\hat{a}_\phi \times (-\hat{a}_\rho)}{4\pi R^2}$$

$$= \left(\frac{I}{4\pi}\int_0^{2\pi}\frac{Rd\phi}{R^2}\right)\hat{a}_z$$

$$\vec{H} = \frac{I}{2R}\hat{a}_z$$

4. (c)

Electric field intensity, $\vec{E} = \dfrac{\rho_L}{2\pi\varepsilon_0 r}\hat{a}_y$

$$= \frac{4\times10^{-9}}{2\pi\times8.854\times10^{-12}\times3}\hat{a}_y$$

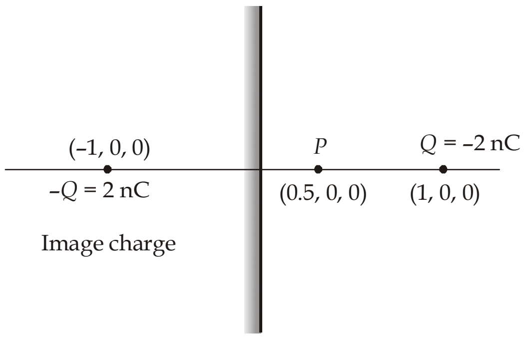
$$\vec{E} = 24\,\hat{a}_y \text{ V/m}$$

5. (c)

Force,
$$\vec{F} = I(\vec{L}\times\vec{B}) = 10(2\hat{a}_z \times 0.02(\hat{a}_y - \hat{a}_x)) = 10(0.04(-\hat{a}_x) - 0.04\hat{a}_y)$$
$$= -0.4\hat{a}_x - 0.4\hat{a}_y$$

Force acting per unit length,
$$\frac{\vec{F}}{L} = \frac{-0.4\hat{a}_x - 0.4\hat{a}_y}{2} = -0.2\hat{a}_x - 0.2\hat{a}_y$$
$$\frac{\vec{F}}{L} = -0.2(\hat{a}_x + \hat{a}_y)$$

6. (c)



Net electric field at point P due to charge Q and $-Q$ are
$$E = E_{\text{due to } Q} + E_{\text{due to } -Q}$$
$$= \frac{-2\times10^{-9}\times9\times10^{9}\times(-0.5\hat{a}_x)}{(0.5)^3} + \frac{2\times10^{-9}\times9\times10^{9}\times(1.5\hat{a}_x)}{(1.5)^3}$$
$$= 80\,\hat{a}_x \text{ V/m}$$

7. (d)

$$\vec{R}_{21} = (\vec{R}_1 - \vec{R}_2) = (1, -2, 3) - (2, -1, 0) = (-1, -1, 3) = -\hat{i} - \hat{j} + 3\hat{k}$$
$$F_{21} = \frac{Q_1Q_2}{4\pi\in_0 |\vec{R}_{21}|^2}\hat{R}_{21} = \frac{25\times20\times10^{-12}\times9\times10^{9}}{\left(\sqrt{1+1+9}\right)^2}\left(\frac{-\hat{i}-\hat{j}+3\hat{k}}{\sqrt{1+1+9}}\right)$$
$$= 0.123(-\hat{i} - \hat{j} + 3\hat{k})\text{N}$$

8. (a)

Vector from the line to the point P
$$\vec{r} = -2u_x + 3u_y$$
$$\vec{E} = \frac{\lambda}{2\pi\in_0 r}\hat{r}$$
$$\vec{E} = \frac{0.1\times10^{-6}}{2\pi\in_0\sqrt{4+9}}\left(\frac{-2\hat{u}_x + 3\hat{u}_y}{\sqrt{13}}\right)$$
$$= -276.92\hat{u}_x + 415.38\hat{u}_y$$

9. (d)

$$\text{Net flux} = \iiint \rho_v \cdot dv = \int_0^{2\pi}\int_0^{\pi}\int_1^{2} \frac{10}{r^2} r^2 \sin\theta\, dr\, d\theta\, d\phi$$

$$= 10 \times 1 \times 2 \times 2\pi = 40\pi \text{ mC}$$

10. (a)

$$E = -N\frac{d\phi}{dt} = -100(3t^2 - 2) \times 10^{-3}$$

$$= -100(12 - 2) \times 10^{-3} = -1 \text{ V}$$

11. (b)

$$\vec{V} = x\cos^2 y\,\hat{i} + x^2 e^z \hat{j} - z\sin^2 y\,\hat{k}$$

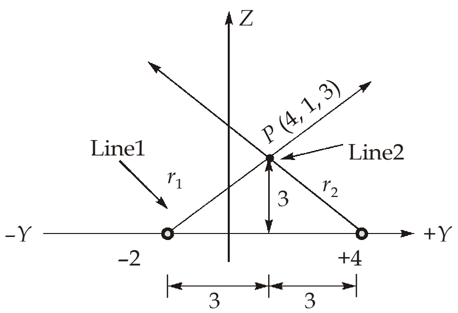
$$\text{Divergence} = \nabla \cdot V$$

$$= \frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z} = \cos^2 y + 0 - \sin^2 y$$

$$= \cos^2 y - \sin^2 y = \cos 2y$$

12. (d)

Let r_1 and r_2 be the directed line segments from the lines 1 and 2 respectively to the point P(in Y-Z plane).



Then, $\quad r_1 = 3\hat{a}_y + 3\hat{a}_z$

and $\quad r_2 = -3\hat{a}_y + 3\hat{a}_z$

$$E_1 = \frac{\lambda}{2\pi\varepsilon_0 r_1}\left(\frac{3\hat{a}_y + 3\hat{a}_z}{r_1}\right) \quad \text{. . . (i)}$$

where, $\quad r_1^2 = 3^2 + 3^2 = r_2^2$ (in magnitude) $= 18 = r^2$

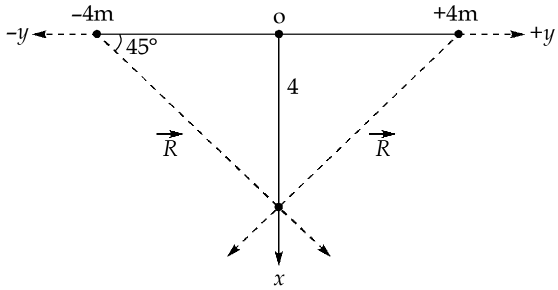
$$E_2 = \frac{\lambda}{2\pi\varepsilon_0 r_2}\left(\frac{-3\hat{a}_y + 3\hat{a}_z}{r_2}\right) \quad \text{. . . (ii)}$$

Adding (i) and (ii), we obtain the resultant field

$$E = E_1 + E_2 = \frac{\lambda}{2\pi\varepsilon_0 r^2}(2 \times 3\hat{a}_z) \quad \text{(replacing } r_1 \text{ and } r_2 \text{ by } r\text{)}$$

$$= \frac{5 \times 10^{-9}}{2\pi\varepsilon_0(18)}(6\hat{a}_z) = 30\hat{a}_z \text{ V/m}$$

13. (d)



The y components of the fields produced by two lines of charge cancel out and only x components will exist in effect.

The resultant field is,

$$\vec{E} = \pm 2\frac{\lambda}{2\pi\varepsilon_0|\vec{R}|}\cdot\frac{\vec{R}}{|\vec{R}|}$$

where, $\vec{R} = 4\hat{a}_x$ and $|\vec{R}| = \sqrt{4^2+4^2} = 4\sqrt{2}$ m

$$\vec{E} = \pm 2\times\frac{4\times 10^{-9}}{2\pi\times 8.854\times 10^{-12}}\times\frac{4\hat{a}_x}{(4\sqrt{2})^2}$$

$$\vec{E} = \pm 18\hat{a}_x \text{ V/m}$$

14. (b)

According to Gausss's law, the electric flux leaving the surface with R = 5 m is equal to the total flux enclosed by the surface.

$\Psi = \Psi_1 + \Psi_2 + \Psi_3$

Ψ_1 = Electric flux leaving the spherical surface with R = 1m

$= 20 \times 10^{-9} \times (4\,\pi R^2)$

$= 20 \times 10^{-9} \times 4\,\pi = 80\,\pi$nC

$\Psi_2 = -9 \times 10^{-9} \times (4\,\pi\,(2)^2)$

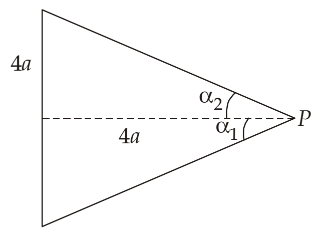
$= -144\,\pi$nC

$\Psi_3 = 2 \times 10^{-9} \times (4\pi \times 9) = 72\,\pi$ nC

$\Psi = 8\,\pi$ nC

15. (b)

For finite length conductor,



$$\overrightarrow{H_P} = \frac{I}{4\pi\rho}(\sin\alpha_1 + \sin\alpha_2)\,\hat{a}_\phi$$

where, $\rho \rightarrow$ Perpendicular distance between wire and point.

$$\alpha_1 = \alpha_2 = \tan^{-1}\left(\frac{4a}{4a}\right) = 45°$$

So, $$\overrightarrow{H_P} = \frac{I}{4\pi(4a)}[\sin 45° + \sin 45°]\,\hat{a}_\phi$$
$$= \frac{I}{16\pi a}\cdot\frac{2}{\sqrt{2}}\,\hat{a}_\phi = \frac{I}{8\sqrt{2}\pi a}\,\hat{a}_\phi$$

16. (d)

$$\vec{D} = r\cos\theta\,\hat{a}_r + r^2\sin\phi\,\hat{a}_\phi + \sin\theta\cos\phi\,\hat{a}_\theta$$

Electric flux crossing the closed surface is

$$\psi = \oint\!\!\oint \vec{D}\cdot ds$$

Electric flux crossing, $r = 4$ spherical surface

$$\psi_{r=4} = \oint\!\!\oint \vec{D}\cdot ds$$

Where, $$ds = r^2\sin\theta d\theta\, d\phi\, \hat{a}_r$$

$$\psi_{r=4} = \int_{\theta=60°}^{\theta=90°}\int_{\phi=30°}^{\phi=45°}(r\cos\theta)(r^2\sin\theta)\,d\phi\,d\theta$$

$$= \int_{\theta=60°}^{\theta=90°}\int_{\phi=30°}^{\phi=45°}\frac{r^3}{2}\sin 2\theta\,d\phi\,d\theta$$

$$= \frac{r^3}{2}[\phi]_{\phi=\pi/6}^{\phi=\pi/4}\int_{\theta=60°}^{\theta=90°}\sin 2\theta\,d\theta$$

$$= \frac{4^3}{2}\left[\frac{\pi}{4}-\frac{\pi}{6}\right]\left[\frac{-\cos 2\theta}{2}\right]_{\theta=60°}^{\theta=90°} = \frac{64}{2}\times\frac{\pi}{12}\times\left[1+\left(-\frac{1}{2}\right)\right]\times\frac{1}{2}$$

$$= \frac{8}{3}\pi\times\frac{1}{2}\times\frac{1}{2} = \frac{2\pi}{3}$$

17. (a)

Let, $$E = E_1,$$

Energy $$E_1 = \frac{Q_1^2}{2C_1}$$

Electrically isolated

$\Rightarrow$ $$Q_2 = Q_1$$
$$d_2 = 2d_1$$

$\Rightarrow$ $$C_2 = \frac{C_1}{2}$$

$$E_2 = \frac{Q_2^2}{2C_2} = \frac{Q_1^2}{\frac{2C_1}{2}} = 2\left(\frac{Q_1^2}{2C_1}\right)$$
$$= 2E_1 = 2E$$

18. **(c)**

Given,

Voltage distribution across capacitance is in the ratio 2 : 3 : 4 and applied voltage is 135 V.

Then,
$$V_{C1} = 30 \text{ V}$$
$$V_{C2} = 45 \text{ V}$$
$$V_{C3} = 60 \text{ V}$$

Hence,
$$C_1 = \frac{4500}{30} = 150\ \mu\text{F}$$
$$C_2 = \frac{4500}{45} = 100\ \mu\text{F}$$
$$C_3 = \frac{4500}{60} = 75\ \mu\text{F}$$

$\therefore$
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$
$$C_{eq} = 33.33\ \mu\text{F}$$

19. **(a)**

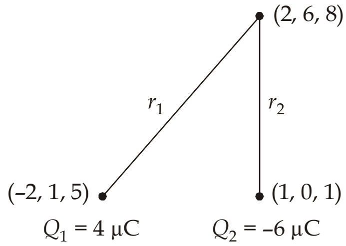
$$\mu_1 = 2\ \mu_0;$$
$$\mu_2 = 5\ \mu_0$$
$$B_2 = 10\hat{a}_\rho + 15\hat{a}_\phi - 20\hat{a}_z \text{ mWb/m}^2$$
$$B_{1n} = B_{2n} = 15\hat{a}_\phi$$
$$H_{1t} = H_{2t}$$
$$B_{1t} = \frac{\mu_1}{\mu_2} B_{2t} = \frac{2}{5}\left(10\hat{a}_\rho - 20\hat{a}_z\right)$$
$$B_{1t} = (4\hat{a}_\rho - 8\hat{a}_z) \text{mWb/m}^2$$
$$W_{m1} = \frac{1}{2} B_1 \cdot H_1 = \frac{B_1^2}{2\mu_1} = \frac{(4^2 + 15^2 + 8^2) \times 10^{-6}}{2 \times 2 \times 4\pi \times 10^{-7}} = \frac{305}{16\pi} \times 10 = 60.68 \text{ J/m}^3$$

20. **(c)**

$$E = \int (v \times B) \cdot dl$$
$$v \times B = -0.15 \sin 10^3 t\ u_x \text{ V/m}$$
$$E = \int_0^{0.25} -0.15 \sin 10^3 t\ dx$$
$$E = -0.15 \sin 10^3 t [x]_0^{0.25}$$
$$E = -0.0375 \sin 10^3\ t \text{ V}$$

21. **(c)**

$$r_1 = (2 - (-2))\hat{i} \times (6 - 1)\hat{j} + (8 - 5)\hat{k}$$
$$= 4\hat{i} + 5\hat{j} + 3\hat{k}$$



$$|r_1| = \sqrt{4^2+5^2+3^2} = 5\sqrt{2}\text{ m}$$

$$r_2 = (2-1)\hat{i}+(6-0)\hat{j}+(8-1)\hat{k}$$

$$= \hat{i}+6\hat{j}+7\hat{k}$$

$$|r_2| = \sqrt{1+36+49} = 9.27\text{ m}$$

$$\vec{E} = \frac{Q_1}{4\pi\epsilon_0 r_1^3}\vec{r}_1 + \frac{Q_2}{4\pi\epsilon_0 r_2^3}\vec{r}_2$$

$$= \frac{9\times10^9\times4\times10^{-6}}{(5\sqrt{2})^3}(4\hat{i}+5\hat{j}+3\hat{k}) - \frac{9\times10^9\times6\times10^{-6}}{(9.27)^3}(\hat{i}+6\hat{j}+7\hat{k})$$

$$= 101.82(4\hat{i}+5\hat{j}+3\hat{k}) - 67.78(\hat{i}+6\hat{j}+7\hat{k}) = 339.5\hat{i}+102.42\hat{j}-169\hat{k}$$

22. (c)

$$H = H_x + H_y$$

$$H = \frac{I}{4\pi\rho}[\cos\alpha_2 - \cos\alpha_1]\hat{a}_\phi$$

$$H_x = \frac{5}{4\pi\times2}(\cos0^\circ - \cos90^\circ)(-\hat{a}_x\times\hat{a}_z) = \frac{5}{8\pi}\hat{a}_y\text{A/m}$$

$$H_y = \frac{5}{4\pi\times2}(\cos0^\circ - \cos90^\circ)(\hat{a}_y\times\hat{a}_z) = \frac{5}{8\pi}\hat{a}_x$$

$$\vec{H} = \frac{5}{8\pi}(\hat{a}_x+\hat{a}_y)\ \text{A/m}$$

23. (b)

$$H = \frac{I}{4\pi\rho}(\cos\alpha_2 - \cos\alpha_1)\hat{a}_\phi$$

$$\rho = \sqrt{5^2+5^2} = \sqrt{50}\text{ m} = \frac{2}{4\pi\sqrt{5^2+5^2}}[\cos\alpha_2 - \cos\alpha_1]\hat{a}_\phi$$

$$\cos\alpha_2 = \frac{10}{\sqrt{50+100}} = \frac{10}{\sqrt{150}}$$

$$\cos\alpha_1 = \cos 90^\circ = 0$$

$$\hat{a}_\phi = \hat{a}_l\times\hat{a}_\rho = \hat{a}_z\times\left(\frac{5\hat{a}_x+5\hat{a}_y}{5\sqrt{2}}\right) = \left(\frac{-\hat{a}_x+\hat{a}_y}{\sqrt{2}}\right)$$

$$\vec{H} = \frac{2}{4\pi\times5\sqrt{2}}\times\left(\frac{10}{\sqrt{150}}-0\right)\times\left(\frac{-\hat{a}_x+\hat{a}_y}{\sqrt{2}}\right) = \frac{1}{20\pi}\left(-\hat{a}_x+\hat{a}_y\right)\times\frac{10}{5\sqrt{6}}$$

$$= \frac{1}{10\pi\sqrt{6}}\left(-\hat{a}_x+\hat{a}_y\right)\text{A/m}$$

24. (d)

As both parallel plate capacitor is connected in series, so same charge flow through it

$$Q = CV$$

(Where, Q = Charge, C = Capacitance, V = Voltage)

Let, $$C_1 = \frac{\varepsilon_{r1}\varepsilon_0 A}{t_1}, \qquad V = V_1$$

and $$C_2 = \frac{\varepsilon_{r2}\varepsilon_0 A}{t_2}, \qquad V = V_2$$

$$C_1 V_1 = C_2 V_2$$

$$\frac{\varepsilon_{r1}\varepsilon_0 A}{t_1}\cdot V_1 = \frac{\varepsilon_{r2}\varepsilon_0 A}{t_2}\cdot V_2$$

$$\frac{4}{2\times 10^{-3}}\cdot V_1 = \frac{2}{1.5\times 10^{-3}}\cdot V_2$$

$$V_2 = 1.5\ V_1$$

Also, $$V_1 + V_2 = 120$$

$$V_1 + 1.5V_1 = 120$$

$$2.5V_1 = 120$$

$\Rightarrow$ $$V_1 = 48 \text{ V}$$

$$V_2 = 120 - 48 = 72 \text{ V}$$

$$Q = C_1 V_1 = C_2 V_2$$

$\Rightarrow$ $$Q = \frac{4\times 8.854\times 10^{-12}\times 20\times 48\times 10^{-4}}{2\times 10^{-3}}$$

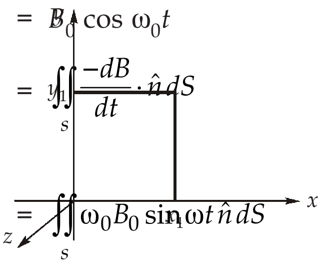
$$= 1699.9 \times 10^{-12} \text{ C} = 1.704 \text{ nC}$$

25. (b)

$$x_1 = y_1 = 1 \text{ m}$$

$$B_0 = \sin \pi x \sin \pi y \ T$$

$$B = B_0 \cos \omega_0 t$$



$$E(t) = \iint_s \frac{-dB}{dt}\cdot \hat{n}\, dS$$

$$= \iint_s \omega_0 B_0 \sin \omega t\, \hat{n}\, dS$$

$$E_{max} = \omega_0 \int_{y=0}^{1}\int_{x=0}^{1} \sin \pi x \sin \pi y\, dx\, dy$$

$$E_{max} = 1000\times 2\pi\times\frac{4}{\pi^2} = \frac{8000}{\pi} \text{V/turns}$$

$$E_{rms} = \frac{1}{\sqrt{2}}\times\frac{8000}{\pi}\times 10 = 18 \text{ kV}$$

26. (b)

$$C = 4\pi \in_0 \left(\frac{ab}{a-b}\right)$$

$$A_a = 4\pi a^2$$

$$A_b = 4\pi b^2$$

$$a = \sqrt{\frac{A_a}{4\pi}}\ ;\ b - \sqrt{\frac{A_b}{4\pi}}$$

$$ab = \frac{\sqrt{A_a A_b}}{4\pi}\ ;$$

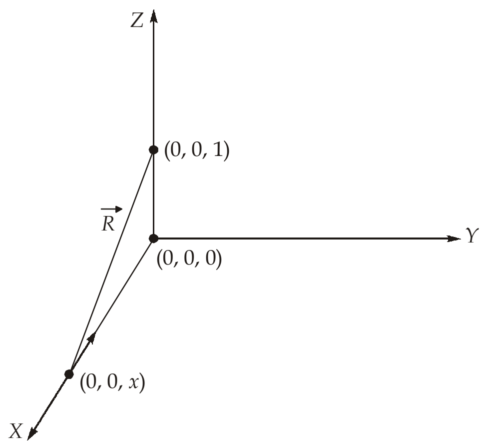
$$a - b = \frac{\sqrt{A_a} - \sqrt{A_b}}{\sqrt{4\pi}}$$

$$C = 4\pi \in_0 \left[\frac{\sqrt{A_a A_b}}{4\pi} \times \frac{\sqrt{4\pi}}{\left(\sqrt{A_a} - \sqrt{A_b}\right)}\right]$$

$$= \sqrt{4\pi} \in_0 \frac{\sqrt{A_a A_b}}{\sqrt{A_a} - \sqrt{A_b}}$$

27. (d)

According to the Biot-Savart's law,



$$\vec{H} = \int \frac{I\,\vec{dL} \times \vec{R}}{4\pi R^3}$$

$$\vec{R} = -x\,\hat{a}_x + \hat{a}_z$$

$$R = \sqrt{1 + x^2}$$

$$\vec{H} = \int_{\infty}^{0} \frac{10\,dx(-\hat{a}_x) \times (-x\hat{a}_x + \hat{a}_z)}{4\pi (x^2 + 1)^{3/2}}$$

$$\vec{H} = \frac{10}{4\pi} \int_{\infty}^{0} \frac{dx}{(x^2 + 1)^{3/2}}\,\hat{a}_y$$

$$\vec{H} = \frac{10}{4\pi} \left.\frac{x}{\sqrt{1 + x^2}}\right|_{\infty}^{0} \hat{a}_y = \frac{10}{4\pi}\,\hat{a}_y$$

28. (c)

The flux in the circuit is,

$$\Psi = \frac{ö}{U} = \frac{N_i\, i_1}{l/\mu S} = \frac{N_1\, i_1\, \mu S}{2\pi \rho_0}$$

ö = magneto motive force

U = reluctance

$$l = \text{mean length}$$
$$S = \text{cross-sectional area of magnetic core}$$

According to Faraday's Law, the emf induced in the second coil is,

$$V_2 = -N_2\frac{d\Psi}{dt} = -\frac{N_1 N_2 \mu S}{2\pi\rho_0}\frac{di_1}{dt}$$

$$V_2 = -\frac{100\times 200\times 500\times(4\pi\times 10^{-7})\times 10^{-3}\times 300\pi\cos 100\pi t}{2\pi(10\times 10^{-2})}$$

$$= -6\pi\cos 100\pi t \text{ V}$$

29. (b)

According to Ampere's law,

$$I_{enc} = \oint_{r=r_0}\vec{H}\cdot dl$$

$$= \int_0^{2\pi}\frac{10^4}{r_0}\left(\frac{4r_0^2}{\pi^2}\sin\frac{\pi}{2} - \frac{2r_0^2}{\pi}\cos\frac{\pi}{2}\right)\cdot r_0\, d\phi$$

$$= 10^4\int_0^{2\pi}\frac{4r_0^2}{\pi^2}d\phi$$

$$I_{enc} = 10^4\cdot\frac{4r_0^2}{\pi}\times 2 = \frac{8}{\pi}\text{ Ampere}$$

30. (c)

The potential is given by:

$$V_{AB} = -\int_B^A \bar{E}\cdot d\bar{l}$$

Now, we know that $\vec{E} = \dfrac{\rho_L}{2\pi\varepsilon_0\rho}\hat{a}_\rho$ for infinite line charge

$$\vec{E} = \frac{10^{-9}}{2\pi\left(\frac{10^{-9}}{36\pi}\right)\rho}\hat{a}_\rho = \frac{18}{\rho}\hat{a}_\rho \text{ V/m}$$

$$d\bar{l} = d\rho\cdot\hat{a}_\rho + \rho d\phi\,\hat{a}_\phi + dz\,\hat{a}_z$$

$$\bar{E}\cdot d\bar{l} = \frac{18}{\rho}d\rho$$

$$V_{AB} = -\int_4^2\frac{18}{\rho}d\rho = \left[-18\ln\rho\right]_4^2 = -18\left[\ln 2 - \ln 4\right]$$

$$= 18\ln 2 = 12.48 \text{ volts}$$

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