

**Q1.**

A standing wave on a string is described by:  $y(x,t) = 0.040 (\sin 5\pi x) (\cos 40\pi t)$ , where  $x$  and  $y$  are in meters and  $t$  is in seconds. If the length of the string is 1.0 m, what is the harmonic number of the wave?

- A) 5
- B) 4
- C) 3
- D) 2
- E) 1

**Ans:**

$$k = 5\pi \text{ (m}^{-1}\text{)} \Rightarrow \lambda = \frac{2\pi}{k} = \frac{2\pi}{5\pi} = 0.40 \text{ m}$$

$$\lambda_n = \frac{2L}{n} \Rightarrow n = \frac{2L}{\lambda_n} = \frac{2 \times 1.0}{0.40} = 5$$

**Q2.**

The sound levels of two sound sources differ by 8.2 dB. What is the ratio of the larger to the smaller intensity?

- A) 6.6
- B) 1.6
- C) 0.15
- D) 0.63
- E) 0.91

**Ans:**

$$\beta_1 = 10 \cdot \log(I_1/I_0)$$

$$\beta_2 = 10 \cdot \log(I_2/I_0)$$

$$\beta_2 - \beta_1 = 10 \cdot \log(I_2/I_1) \Rightarrow \frac{I_2}{I_1} = (10)^{\frac{\Delta\beta}{10}}$$

$$\therefore \frac{I_2}{I_1} = (10)^{(8.2/10)} = 6.6$$

**Q3.**

How much water remains unfrozen after 50 kJ is transferred as heat from 250 g of liquid water initially at 0.0 °C?

- A) 100 g
- B) 150 g
- C) 50 g
- D) 200 g
- E) 0

**Ans:**

$$Q = m_i \cdot L_f \text{ \{m}_i \text{ = frozen mass\}}$$

$$\Rightarrow m_i = \frac{Q}{L_f} = \frac{50}{333} = 0.15 \text{ kg} = 150 \text{ g}$$

$$\therefore \text{Remaining Liquid water} = 250 - 150 = 100 \text{ g}$$

**Q4.**

In the  $p$ - $V$  diagram of **FIGURE 1**, the gas does 5 J of work when taken along isotherm **ab**, and 4 J of work when taken along the adiabat **bc**. What is the change in the internal energy of the gas when it is taken along the straight path from **a** to **c**?

- A) -4 J
- B) -5 J
- C) +9 J
- D) -1 J
- E) +1 J

**Ans:**

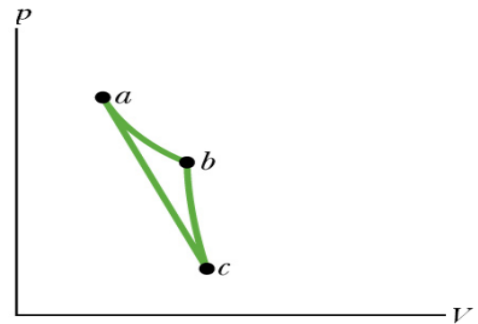
Isotherm:  $\Delta T = 0 \Rightarrow \Delta E_{\text{int}} = 0 \Rightarrow E_a = E_b$

Adiabat:  $Q = 0 \Rightarrow \Delta E_{\text{int}} = -W_{bc} = -4 \text{ J}$

$\therefore E_c - E_b = -4 \text{ J}$

Straight Path:  $\Delta E_{\text{int}} = E_c - E_a = E_c - E_b = -4 \text{ J}$

Fig# 1



**Q5.**

A sample of an ideal gas expands from state **A** to state **B**. Let  $\Delta S_I$  denote the change in entropy of the gas for an irreversible expansion. Let  $\Delta S_R$  denote the change in entropy of the gas for a reversible expansion. Then:

- A)  $\Delta S_I = \Delta S_R$
- B)  $\Delta S_I > \Delta S_R$
- C)  $\Delta S_I < \Delta S_R$
- D)  $\Delta S_I < 0$
- E)  $\Delta S_R < 0$

**Ans:**

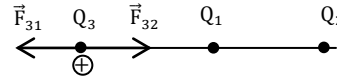
Entropy is a state function

$\Rightarrow \Delta s$  is the same along any path

**Q6.**

A point charge  $Q_1 = +2.00 \mu\text{C}$  is placed on the  $x$ -axis at  $x = +2.00 \text{ cm}$ . Another point charge  $Q_2$  is placed on the  $x$ -axis at  $x = +5.00 \text{ cm}$ . A third point charge  $Q_3$  is placed at the origin. If the net electric force on  $Q_3$  is zero, what is the charge  $Q_2$ ?

- A)  $-12.5 \mu\text{C}$
- B)  $+12.5 \mu\text{C}$
- C)  $-5.00 \mu\text{C}$
- D)  $+5.00 \mu\text{C}$
- E)  $-2.00 \mu\text{C}$



**Ans:**

$Q_2$  must be (-):

$$\text{magnitude: } F_{31} = F_{32} \Rightarrow \frac{kQ_3Q_1}{4} = \frac{kQ_3Q_2}{25}$$

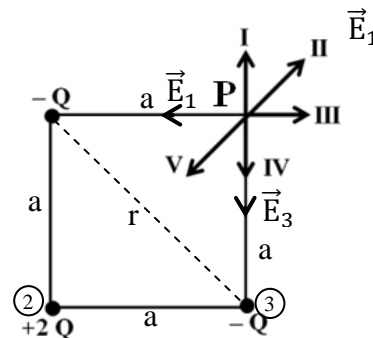
$$\Rightarrow Q_2 = \frac{25}{4} Q_1 = \frac{25}{4} \times 2 = 12.5 \mu\text{C}$$

$$\Rightarrow Q_2 = -12.5 \mu\text{C}$$

**Q7.**

Three charged particles are fixed at the corners of a square, as shown in **FIGURE 2**. Consider point **P**, which is the top right corner of the square. Which of the indicated arrows represents the direction of the net electric field at point **P**?

- A) V
- B) I
- C) II
- D) III
- E) IV



**Ans:**

$$E_1 = E_3 = \frac{kQ}{a^2}$$

$$\Rightarrow E_{13} = \sqrt{2} \cdot \frac{kQ}{a^2} \text{ (Southwest)}$$

$$E_2 = \frac{kQ}{r^2} = \frac{kQ}{2a^2} \text{ (Northeast)}$$

Since  $E_2 < E_{13}$

$$\Rightarrow E_{\text{net}} \text{ is southwest (i.e. V)}$$

**Q8.**

A cylindrical Gaussian surface has a radius of 0.20 m. The axis of the cylinder is along the  $x$  axis, with one end at  $x = 0$  and the other end at  $x = 2.0$  m, as shown in

**FIGURE 12.** The cylinder lies in a region where the electric field is  $\vec{E} = x\hat{i}$  (N/C), where  $x$  is in meters. What is the charge enclosed inside the cylinder?

- A) + 2.2 pC
- B) - 4.4 pC
- C) + 4.4 pC
- D) - 2.2 pC
- E) zero

**Ans:**

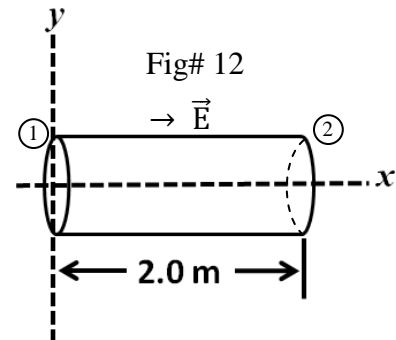
There is no flux through the lateral surface.

at ① :  $E = 0$

at ② :  $\vec{E} = 2\hat{i}$  ,  $\vec{A} = (\pi r^2)\hat{i} = 0.1257\hat{i}$  (m<sup>2</sup>)

$\Rightarrow \phi_{\text{net}} = \vec{E} \cdot \vec{A} = +0.25 \text{ N} \cdot \text{m}^2/\text{C}$

$\phi_{\text{net}} = \frac{q_{\text{enc}}}{\epsilon_0} \Rightarrow q_{\text{enc}} = \epsilon_0 \cdot \phi_{\text{net}} = +2.2 \times 10^{-12} \text{ C}$



**Q9.**

A uniform electric field of magnitude 350 V/m is directed in the negative  $y$  direction. The coordinates of point **A** are  $(-0.20, -0.30)$  m, and those of point **B** are  $(0.40, 0.50)$  m. Calculate the electric potential difference  $V_B - V_A$ .

- A) + 280 V
- B) - 280 V
- C) + 210 V
- D) - 210 V
- E) - 350 V

**Ans:**

$\vec{E} = -350\hat{j}$  (V/m)

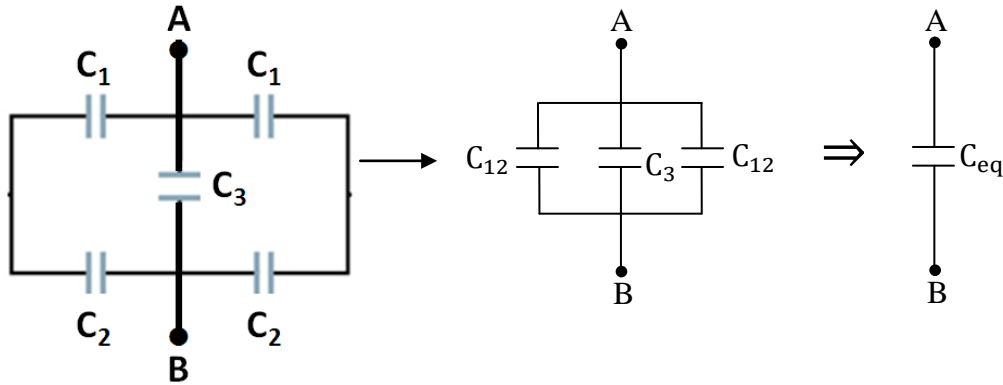
$\vec{r}_A = -0.20\hat{i} - 0.30\hat{j}$ ;  $\vec{r}_B = 0.40\hat{i} + 0.50\hat{j}$  (m)

$V_B - V_A = -\vec{E} \cdot \Delta\vec{r} = -\vec{E} \cdot (\vec{r}_B - \vec{r}_A) = \vec{E} \cdot (\vec{r}_A - \vec{r}_B)$   
 $= (-350\hat{j}) \cdot (-0.60\hat{i} - 0.80\hat{j}) = +280 \text{ V}$

**Q10.**

Consider the combination of capacitors shown in **FIGURE 3**, with  $C_1 = 2.0 \mu\text{F}$ ,  $C_2 = 3.0 \mu\text{F}$ , and  $C_3 = 2.0 \mu\text{F}$ . What is the energy stored by the combination if the potential difference between points **A** and **B** is 60 V?

Fig# 3



- A) 7.9 mJ
- B) 2.0 mJ
- C) 22 mJ
- D) 0.83 mJ
- E) 8.2 mJ

**Ans:**

$$C_{12} = \frac{C_1 \cdot C_2}{C_1 + C_2} = \frac{2 \times 3}{2 + 3} = \frac{6}{5} = 1.2 \mu\text{F}$$

$$C_{\text{eq}} = C_{12} + C_3 + C_{12} = 1.2 + 2 + 1.2 = 4.4 \mu\text{F}$$

$$U = \frac{1}{2} C_{\text{eq}} \cdot V^2 = \frac{1}{2} \times 4.4 \times 10^{-6} \times 3600$$

$$= 7.9 \times 10^{-3} \text{ J} = 7.9 \text{ mJ}$$

**Q11.**

A cylindrical conducting wire has radius  $r_i$  and length  $L_i$ . Its dimensions are changed to  $r_f$  and  $L_f$ . Which of the following changes results in the least resistance?

- A)  $r_f = 2r_i$  and  $L_f = L_i/2$
- B)  $r_f = 2r_i$  and  $L_f = 2L_i$
- C)  $r_f = 2r_i$  and  $L_f = L_i$
- D)  $r_f = r_i/2$  and  $L_f = L_i/2$
- E)  $r_f = r_i/2$  and  $L_f = 2L_i$

**Ans:**

$$R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2}$$

A)  $\frac{1}{4} = \frac{1}{8}$ ; B)  $\frac{2}{4} = \frac{1}{2}$ ; C)  $\frac{1}{4} = \frac{1}{4}$ ; D)  $\frac{1}{2} = 2$ ; E)  $\frac{2}{1} = 8$

**Q12.**

A light bulb utilizes a tungsten filament. The filament has a resistance of  $3.40 \Omega$  at  $20.0^\circ\text{C}$ . The bulb is connected to a  $24.0\text{-V}$  battery. When the bulb reaches its final operating temperature, the filament dissipates a power of  $16.0 \text{ W}$ . What is the operating temperature of the filament? The temperature coefficient of resistivity of tungsten is  $4.50 \times 10^{-3} \text{ K}^{-1}$ . Assume that the dimensions of the filament do not change.

- A)  $2.15 \times 10^3^\circ\text{C}$
- B)  $1.44 \times 10^3^\circ\text{C}$
- C)  $2.37 \times 10^3^\circ\text{C}$
- D)  $1.90 \times 10^3^\circ\text{C}$
- E)  $2.26 \times 10^3^\circ\text{C}$

**Ans:**

$$P = \frac{V^2}{R_f} \rightarrow R_f = \frac{V^2}{P} = \frac{(24)^2}{16} = 36 \Omega \Rightarrow \Delta R = 32.6 \Omega$$

$$\Delta R = \alpha R_i \Delta T \Rightarrow \Delta T = \frac{\Delta R}{\alpha R_i} = \frac{32.6}{4.5 \times 10^{-3} \times 3.4} = 2131^\circ\text{C}$$

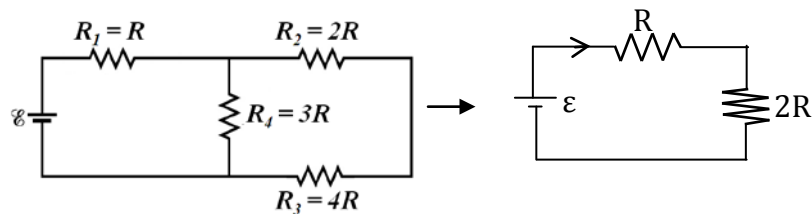
$$\Rightarrow T_f = T_i + \Delta T = 2151^\circ\text{C} = 2.15 \times 10^3^\circ\text{C}$$

**Q13.**

Four resistors are connected to an ideal battery, as shown in **FIGURE 13**. The current supplied by the battery is  $I_0$ . If  $R_3 \rightarrow \infty$ , the current supplied by the battery is

Fig# 13

- A)  $\frac{3I_0}{4}$
- B)  $4I_0$
- C)  $\frac{I_0}{4}$
- D)  $\frac{4I_0}{3}$
- E)  $\frac{15I_0}{11}$



**Ans:**

$$I_0 = \frac{\varepsilon}{R + 2R} = \frac{\varepsilon}{3R}$$

If  $R_3 \rightarrow \infty$ ; the loop on the right is open:

$$\Rightarrow I_x = \frac{\varepsilon}{R + 2R} = \frac{\varepsilon}{4R}$$

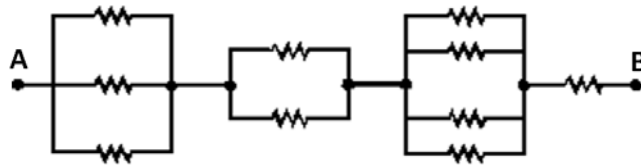
$$\Rightarrow \frac{I_x}{I_0} = \frac{\varepsilon}{4R} \cdot \frac{3R}{\varepsilon} = \frac{3}{4}$$

**Q14.**

Each of the resistors in **FIGURE 4** has a resistance of  $50.0 \Omega$ . The equivalent resistance between points A and B is

- A)  $104 \Omega$
- B)  $210 \Omega$
- C)  $171 \Omega$
- D)  $121 \Omega$
- E)  $111 \Omega$

Fig# 4

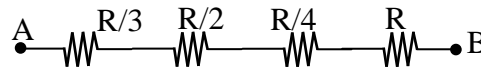


**Ans:**

$$R_{eq} = \frac{R}{3} + \frac{R}{2} + \frac{R}{4} + R$$

$$= \frac{4R + 6R + 3R}{12} + R = \frac{13R}{12} + R$$

$$= \frac{25R}{12} = \frac{25}{12} \times 50 = 104 \Omega$$

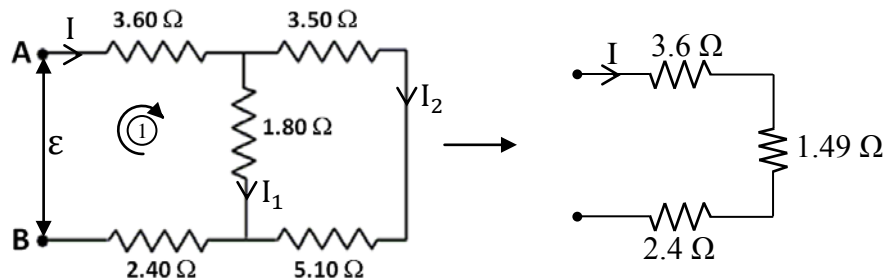


**Q15.**

Five resistors are connected as shown in **FIGURE 5**. The potential difference between points A and B is  $25.0 \text{ V}$ . What is current through the  $1.80\text{-}\Omega$  resistor?

- A)  $2.76 \text{ A}$
- B)  $3.34 \text{ A}$
- C)  $1.67 \text{ A}$
- D)  $0.577 \text{ A}$
- E)  $2.09 \text{ A}$

Fig# 5



**Ans:**

$$I = \frac{25.0}{3.60 + 2.40 + 1.49} = 3.34 \text{ A}$$

Now, consider loop 1:

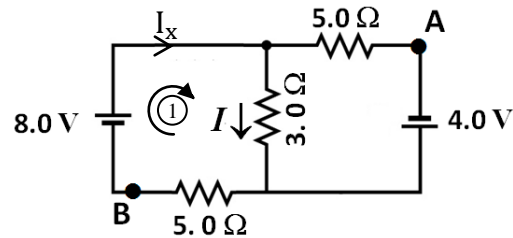
$$+\epsilon - 3.60 I - 1.80 I_1 - 2.40 I = 0$$

$$\Rightarrow I_1 = \frac{\epsilon - 6 I}{1.8} = \frac{25 - (6 \times 3.34)}{1.8} = 2.76 \text{ A}$$

**Q16.**

In the circuit shown in **FIGURE 6**, the current  $I = 0.36$  A. What is the potential difference  $V_A - V_B$ ?

Fig# 6



- A) + 2.9 V
- B) + 1.1 V
- C) - 1.1 V
- D) - 2.9 V
- E) - 4.7 V

**Ans:**

Consider Loop 1:

$$+8.0 - 3.0 I - 5.0 I_x = 0$$

$$\Rightarrow I_x = \frac{8.0 - 3.0 I}{5.0} = \frac{8.0 - 1.08}{5.0} = 1.384 \text{ A}$$

Now, proceed from A  $\rightarrow$  B through the 4.0 V battery:

$$V_A + 4.0 - 5.0 I_x = V_B$$

$$\Rightarrow V_A - V_B = 5.0 I_x - 4.0 = +2.9 \text{ V}$$

**Q17.**

In an RC circuit, a 10- $\mu$ F capacitor is discharged through a resistor  $R$ . If the potential difference across the capacitor plates drops to 37 % of its initial value in 2.0 s, then the resistance of  $R$  is

- A)  $2.0 \times 10^5 \Omega$
- B)  $1.0 \times 10^5 \Omega$
- C)  $5.0 \times 10^5 \Omega$
- D)  $1.0 \times 10^6 \Omega$
- E)  $2.5 \times 10^6 \Omega$

**Ans:**

$$q(t) = q_0 e^{-t/\tau} \Rightarrow V(t) = V_0 e^{-t/\tau}$$

$$0.37 V_0 = V_0 e^{-2t/\tau} \Rightarrow 0.37 = e^{-2/\tau}$$

$$\Rightarrow -\frac{2}{\tau} = \ln 0.37 \Rightarrow \tau = -\frac{2}{\ln 0.37} = 2.01 \text{ s}$$

$$\Rightarrow RC = 2.01 \Rightarrow R = \frac{2.01}{C} = 2.0 \times 10^5 \Omega$$



**Q18.**

What is the magnitude of the magnetic force on a charged particle ( $Q = + 5.0 \mu\text{C}$ ) moving with a speed of 80 km/s in the positive  $x$  direction in a region containing a uniform magnetic field  $\mathbf{B}$  with components  $B_x = 5.0 \text{ T}$ ,  $B_y = 4.0 \text{ T}$ , and  $B_z = 3.0 \text{ T}$ ?

- A) 2.0 N
- B) 1.6 N
- C) 1.2 N
- D) 2.8 N
- E) 0.40 N

**Ans:**

$$\vec{B} = 5.0 \hat{i} + 4.0 \hat{j} + 3.0 \hat{k} \text{ (T)}; \vec{v} = 8 \times 10^4 \hat{i} \text{ (m/s)}$$

$$\vec{v} \times \vec{B} = 32 \times 10^4 \hat{k} - 24 \times 10^4 \hat{j} \text{ (T.m/s)}$$

$$\vec{F}_B = Q(\vec{v} \times \vec{B}) = -1.2 \hat{j} + 1.6 \hat{k} \text{ (N)}$$

$$\Rightarrow F_B = 2.0 \text{ N}$$

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**Q19.**

An ion with a charge of  $+3.3 \times 10^{-19} \text{ C}$  is moving in a region where a uniform electric field of magnitude  $5.0 \times 10^4 \text{ V/m}$  is perpendicular to a uniform magnetic field of magnitude  $0.80 \text{ T}$ . If the ion's acceleration is zero then its speed must be (ignore gravity)

- A)  $6.3 \times 10^4 \text{ m/s}$
- B)  $1.3 \times 10^4 \text{ m/s}$
- C)  $4.0 \times 10^5 \text{ m/s}$
- D)  $3.6 \times 10^5 \text{ m/s}$
- E)  $3.1 \times 10^5 \text{ m/s}$

**Ans:**

$$F_e = F_B: qE = qvB \Rightarrow v = \frac{E}{B}$$

$$\therefore v = \frac{5.0 \times 10^4}{0.80} = 6.3 \times 10^4 \text{ m/s}$$

**Q20.**

A straight wire, of length 1.0 m, carries a current of 1.0 A in the positive z direction in a region where the magnetic field is  $\vec{B} = 3.0\hat{i} + 2.0\hat{j} + 1.0\hat{k}$  (T). The magnitude of the magnetic force on the wire is

- A) 3.6 N
- B) 5.0 N
- C) 4.2 N
- D) 3.0 N
- E) 1.0 N

**Ans:**

$$\begin{aligned} \vec{L} &= 1.0 \hat{k} \text{ (m)} \\ \vec{F}_B &= i\vec{L} \times \vec{B} = (1.0\hat{k}) \times (3.0\hat{i} + 2.0\hat{j} + 1.0\hat{k}) \\ &= +3.0\hat{j} - 2.0\hat{i} \text{ (N)} \Rightarrow F_B = \sqrt{9 + 4} = 3.6 \text{ N} \end{aligned}$$

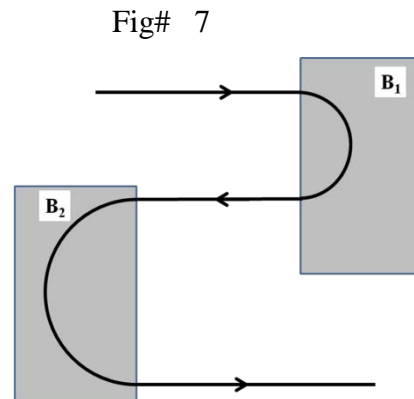
**Q21.**

**Figure 7** shows the path of an electron that passes through two regions containing uniform magnetic fields  $\mathbf{B}_1$  and  $\mathbf{B}_2$ . Its path in each region is a half circle. Which of the following statements is **CORRECT**?

- A)  $\mathbf{B}_1$  has a larger magnitude. ✓
- B)  $\mathbf{B}_1$  has a smaller magnitude. ✗
- C) The magnitudes of the two fields are equal. ✗
- D) The two fields point in the same direction. ✗
- E) The electron spends the same time in both ✗ fields.

**Ans:**

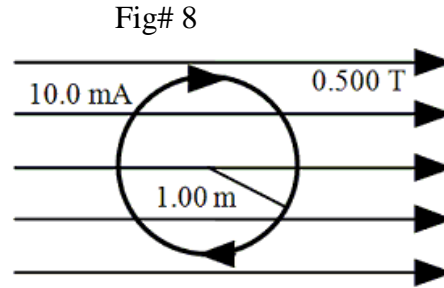
$$\begin{aligned} \text{Radius: } evB &= \frac{mv^2}{R} \\ \Rightarrow R &= \frac{mv}{eB} \Rightarrow R \propto \frac{1}{B} \\ \text{Period: } T &= \frac{2\pi R}{v} = \frac{2\pi}{v} \cdot \frac{mv}{eB} \\ \Rightarrow T &\propto \frac{1}{B} \end{aligned}$$



**Q22.**

A single circular loop of radius 1.00 m carries a current of 10.0 mA. It is placed in a uniform magnetic field of magnitude 0.500 T that is directed parallel to the plane of the loop, as shown in **FIGURE 8**. What is the magnitude of the torque exerted on the loop by the magnetic field?

- A)  $1.57 \times 10^{-2}$  N.m
- B)  $3.14 \times 10^{-2}$  N.m
- C)  $6.28 \times 10^{-2}$  N.m
- D)  $9.28 \times 10^{-2}$  N.m
- E) Zero



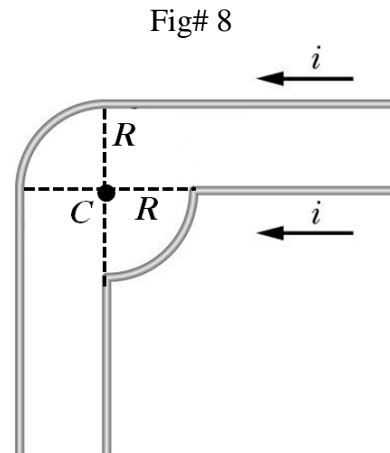
**Ans:**

$$\begin{aligned} \vec{\tau} &= \vec{\mu} \times \vec{B} = i\vec{A} \times \vec{B} \\ &= (10.0 \times 10^{-3})(\pi \times 1.0) (-\hat{k}) \times (0.5 \hat{i}) \\ &= (5\pi \times 10^{-3}) (-\hat{k} \times \hat{i}) = -5\pi \times 10^{-3} \hat{j} \\ \Rightarrow \tau &= 5\pi \times 10^{-3} = 1.57 \times 10^{-2} \text{ N.m} \end{aligned}$$

**Q23.**

In **FIGURE 9**, two infinitely long wires carry currents  $i$ . Each follows a  $90^\circ$  arc on the circumference of the same circle of radius  $R$ . What is the magnitude of the net magnetic field at the center of the circle (point C)?

- A)  $\frac{\mu_0 i}{2\pi R}$
- B)  $\frac{\mu_0 i}{\pi R}$
- C)  $\frac{\mu_0 i}{4\pi R}$
- D)  $\frac{\mu_0 i}{2\pi R} + \frac{\mu_0 i}{16R}$
- E)  $\frac{\mu_0 i}{\pi R} + \frac{\mu_0 i}{16R}$



**Ans:**

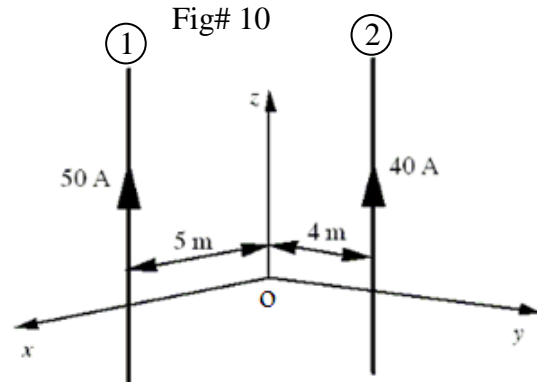
- \* The magnetic fields due to the circular sections cancel.
- \* The straight lower current does not produce any magnetic field
- \* We are left with the top straight wire:

$$B_c = 2 \times \text{semi - infinite wires}$$

$$= 2 \times \frac{\mu_0 i}{4\pi R} = \frac{\mu_0 i}{2\pi R}$$

Q24.

**FIGURE 10** shows two long, thin wires, parallel to the  $z$  axis, carrying currents in the positive  $z$  direction. The 50-A wire is in the  $x$ - $z$  plane and is 5 m from the  $z$  axis. The 40-A wire is in the  $y$ - $z$  plane and is 4 m from the  $z$  axis. What is the net magnetic field at the origin  $O$  due to the two wires?



- A)  $(2\hat{i} - 2\hat{j}) \mu\text{T}$
- B)  $(2\hat{i} + 2\hat{j}) \mu\text{T}$
- C)  $(2\hat{i} + 3\hat{j}) \mu\text{T}$
- D)  $(2\hat{i} - 3\hat{j}) \mu\text{T}$
- E)  $(3\hat{i} + 2\hat{j}) \mu\text{T}$

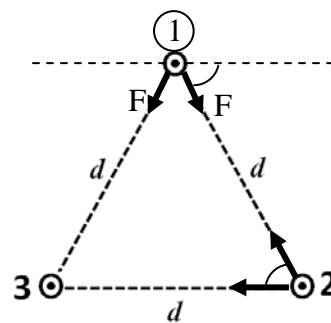
Ans:

$$\begin{aligned} \vec{B}_1 &= \frac{\mu_0 i_1}{2\pi d_1} (-\hat{j}) \\ &= \frac{4\pi \times 10^{-7} \times 50}{2\pi \times 5} (-\hat{j}) = -2 \times 10^{-6} \hat{j} (\text{T}) = -2\hat{j} (\mu\text{T}) \\ \vec{B}_2 &= +\frac{\mu_0 i_2}{2\pi d_2} \hat{i} \\ &= \frac{4\pi \times 10^{-7} \times 40}{2\pi \times 4} (\hat{i}) = +2\hat{i} (\mu\text{T}) \\ \therefore \vec{B}_{\text{net}} &= (2\hat{i} - 2\hat{j}) \mu\text{T} \end{aligned}$$

Q25.

**FIGURE 11** shows a cross section of three parallel wires each carrying a current of 5.0 A out of the paper. If the distance  $d = 6.0$  mm, what is the magnitude of the net magnetic force on a 2.0-m length of wire 1?

Fig# 11



- A) 2.9 mN
- B) 3.3 mN
- C) 2.1 mN
- D) 3.9 mN
- E) 1.7 mN

Ans:

$$\begin{aligned} F &= \frac{\mu_0 I_i^2}{2\pi d} = \frac{4\pi \times 10^{-7} \times 2 \times 25}{2\pi \times 6 \times 10^{-3}} \\ &= 1.67 \times 10^{-3} \text{ N} \\ F_{\text{net}} &= 2 \cdot F \cdot \sin 60 = 2.9 \times 10^{-3} \text{ N} \end{aligned}$$

**Q26.**

A long, solid, cylindrical wire carries a uniformly distributed current. If the radius of the wire is 3.5 mm, and the magnitude of the current density is  $1.5 \text{ A/cm}^2$ , what is the magnitude of the magnetic field at a distance of 2.5 mm from the axis of the wire?

- A)  $2.4 \times 10^{-5} \text{ T}$
- B)  $3.3 \times 10^{-5} \text{ T}$
- C)  $1.3 \times 10^{-5} \text{ T}$
- D)  $6.9 \times 10^{-5} \text{ T}$
- E) zero

**Ans:**

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{\text{enc}} \Rightarrow B(2\pi r) = \mu_0 J \cdot A = \mu_0 J \cdot \pi r^2$$

$$B = \frac{\mu_0 J r}{2} = \frac{4\pi \times 10^{-7} \times 1.5 \times 10^4 \times 2.5 \times 10^{-3}}{2} = 2.4 \times 10^{-5} \text{ T}$$

**Q27.**

A solenoid with  $N$  turns carries a current of 2.000 A, and has a length of 34.00 cm. If the magnitude of the magnetic field generated at the center of the solenoid is 9.000 mT, what is the value of  $N$ ?

- A) 1218
- B) 1591
- C) 2318
- D) 3183
- E) 2078

**Ans:**

$$B = \mu_0 n i = \frac{\mu_0 N i}{L}$$

$$\Rightarrow N = \frac{B \cdot L}{\mu_0 \cdot i} = \frac{9 \times 10^{-3} \times 0.34}{4\pi \times 10^{-7} \times 2} = 1218$$

**Q28.**

A conducting loop is held in a uniform magnetic field, with the plane of the loop perpendicular to the field lines. Which of the following will **NOT** cause a current to be induced in the loop?

- A) Keeping the orientation of the loop fixed and moving it within the field. ✓
- B) Shrinking the loop. ✗
- C) Changing the shape of the loop. ✗
- D) Rotating the loop about an axis perpendicular to the field lines. ✗
- E) Pulling the loop out of the field. ✗

**Q29.**

A 50-turn coil is positioned in a magnetic field so that the normal to the plane of the coil makes an angle of  $60^\circ$  with the direction of the field. When the magnetic field is increased uniformly from  $200 \mu\text{T}$  to  $600 \mu\text{T}$  in  $0.40 \text{ s}$ , an emf of magnitude  $80 \text{ mV}$  is induced in the coil. What is the cross sectional area of the coil?

- A)  $3.2 \text{ m}^2$
- B)  $1.6 \text{ m}^2$
- C)  $4.4 \text{ m}^2$
- D)  $2.5 \text{ m}^2$
- E)  $2.1 \text{ m}^2$

**Ans:**

$$\epsilon_{\text{ind}} = \frac{\Delta\phi}{\Delta t} = \frac{\Delta}{\Delta t} (NBA \cos\theta) = N A \cos\theta \frac{\Delta B}{\Delta t}$$

$$\Rightarrow A = \frac{\epsilon_{\text{ind}}}{N \cdot \cos\theta (\Delta B / \Delta t)} = \frac{\epsilon_{\text{ind}} \cdot \Delta t}{N \cdot \cos\theta \cdot \Delta B} = \frac{80 \times 10^{-3} \times 0.40}{50 \times 0.5 \times 400 \times 10^{-6}} = 3.2 \text{ m}^2$$

**Q30.**

A conducting bar of length  $L$  moves to the right on two frictionless rails with constant velocity  $v$ , as shown in **FIGURE 14**. A uniform magnetic field directed into the page has a magnitude of  $0.30 \text{ T}$ . Assume  $R = 9.0 \Omega$ ,  $L = 0.35 \text{ m}$ , and  $v = 2.0 \text{ m/s}$ . What is the current induced in the resistor?

- A)  $0.023 \text{ A}$ , counterclockwise
- B)  $0.023 \text{ A}$ , clockwise
- C)  $0.21 \text{ A}$ , clockwise
- D)  $0.21 \text{ A}$ , counterclockwise
- E)  $0.047 \text{ A}$ , clockwise

**Ans:**

$$\epsilon_{\text{ind}} = BLv$$

$$i_{\text{ind}} = \frac{BLv}{R} = \frac{0.3 \times 0.35 \times 2}{9.0} = 0.023 \text{ A counterclockwise}$$

