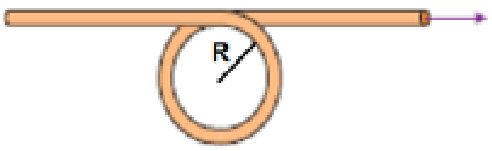
# Chapter 29

Q22.

For what value of the radius R of the loop shown in Figure 9 is the magnitude of the net magnetic field at the center of the loop equals $5.00 \times 10^{-5}$ T. The loop carries a current

Figure 9




A) $2.02 \times 10^{-2}$ m
B) $1.10 \times 10^{-2}$ m
C) $1.30 \times 10^{-2}$ m
D) $1.50 \times 10^{-2}$ m
E) $2.90 \times 10^{-2}$ m

Ans:

$$B_{wire} = \frac{\mu_0 i}{2\pi R};\ B_{loop} = \frac{\mu_0 i}{2R}$$

$$B_{net} = B_{wire} + B_{loop} = \frac{\mu_0 i}{2R}\left(1 + \frac{1}{\pi}\right)$$

$$R = \frac{\mu_0 i}{2B_{net}}\left(1 + \frac{1}{\pi}\right)$$

$$R = \frac{4\pi \times 10^{-7} \times 1.22}{2 \times 5 \times 10^{-5}}(1 + 0.318) = 2.02 \times 10^{-2}\text{m}$$

**182, Final, Q22**

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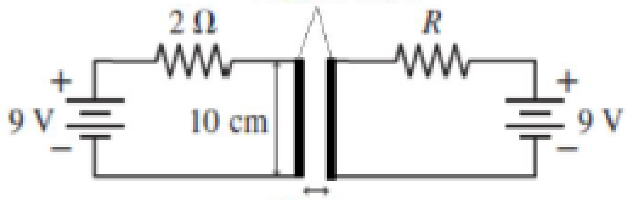
Q23.

The two 10 cm long parallel wires, shown in Figure 10 are separated by 5.0 mm. Figure is drawn not to the scale. For what value of the resistor *R* will the force between the two wires be $5.4 \times 10^{-5}$ N?

Figure 10




A) 3.0 Ω
B) 1.2 Ω
C) 1.9 Ω
D) 2.1 Ω
E) 3.9 Ω

Ans:

$$F = \frac{\mu_0 l i_2 i_R}{2\pi d} = \frac{4\pi \times 10^{-7} \times l \times i_2 \times i_R}{2\pi d}$$

$$F = 2 \times 10^{-7} \times l \times i_2 \times \frac{9}{R} \times \frac{1}{d}$$

$$R = 2 \times 10^{-7} \times l \times i_2 \times \frac{9}{F} \times \frac{1}{d}$$

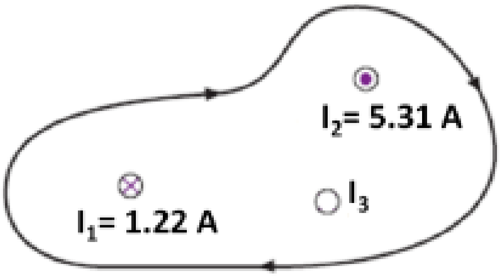
$$R = 2 \times 10^{-7} \times (0.1) \times \left(\frac{9}{2}\right) \times \frac{9}{5.4 \times 10^{-5}} \times \frac{1}{5 \times 10^{-3}} = 3.0\ \Omega$$

**182, Final, Q23**

Q24.

The value of the line integral $\oint \vec{B}.d\vec{s}$ of $\vec{B}$ around the closed path in Figure 11 is $7.54\times10^{-7}$ T.m. What are the direction (into or out of the page) and magnitude of $I_3$?

Figure 11




A) 4.69 A into the page
B) 4.69 A out of the page
C) 3.53 A into the page
D) 2.22 A into the page
E) 1.19 A out of the page

Ans:

$$\oint Bids = \mu_0 i_{encl}$$

$$7.54\times10^{-7} = \mu_0(1.22 - 5.31 + I_3)$$

$$7.54\times10^{-7} = 4\pi\times10^{-7}(-4.09 + I_3)$$

$$I_3 = 4.09 + \frac{7.54}{4\pi} = 4.69\ A$$

**182, Final, Q24**

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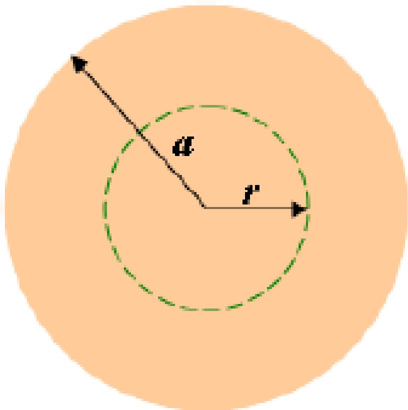
Q25.

Figure 12 shows a cross section of a long cylindrical conducting wire of radius $a$ = 2.00 cm carrying a uniform current I. If the magnitude of the magnetic field due to current in the wire at radial distance $r$ = 1.00 cm from the wire center is $9.00\times10^{-4}$ T, find the magnitude of the total current I in the wire.

Figure 12




A) $1.80\times10^2$ A
B) $1.55\times10^2$ A
C) $1.00\times10^2$ A
D) $2.32\times10^2$ A
E) $1.11\times10^2$ A

Ans:

$$B(r) = \mu_0\frac{I}{2\pi R^2}\times r$$

$$I = \frac{B(r)\times2\pi R^2}{\mu_0\times r} = \frac{B(r)\times2\pi R^2}{4\pi\times10^{-7}\times r}$$

$$I = \frac{B(r)\times R^2}{2r\times10^{-3}} = \frac{9\times10^{-4}\times(0.02)^2}{2\times(0.01)\times10^{-3}} = 180\ A$$

**182, Final, Q25**

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Q26.

A long solenoid has 150 turns/cm and carries a current I = 0.150 A. An electron moves at a constant speed within the solenoid in a circle of radius 2.70 cm perpendicular to the solenoid axis. Calculate the speed of the electron.

A) $1.34 \times 10^7$ m/s
B) $1.00 \times 10^7$ m/s
C) $2.11 \times 10^7$ m/s
D) $2.55 \times 10^7$ m/s
E) $3.12 \times 10^7$ m/s

Ans:

$$B = \mu_0 ni$$

$$qvB = \frac{mv^2}{R} \Rightarrow v = \frac{qR}{m}B = \frac{qR}{m}\mu_0 ni$$

$$v = \frac{qR}{m}\mu_0 ni = \frac{1.6 \times 10^{-19} \times 0.027}{9.11 \times 10^{-31}} \times (4\pi \times 10^{-7} \times 1.5 \times 10^4 \times 0.15)$$

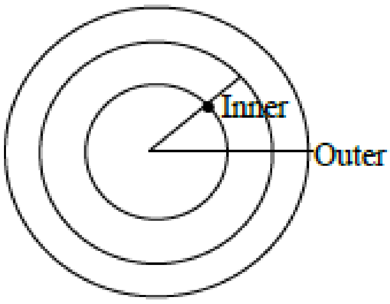
$$v = 1.34 \times 10^7 \text{ m/s}$$

182, Final, Q26

**Q22.**

A long wire of radius $R$ = 4.5 cm carries a uniform current throughout its cross-section. If the magnetic field inside the wire at 3.0 cm from the center is equal to three times the magnetic field at a distance $r$ from the center, where $r > R$, calculate the distance $r$.

A) 20 cm
B) 35 cm
C) 13 cm
D) 46 cm
E) 54 cm




**Ans:**

$$\frac{\mu_0 i_{in}}{2\pi R_{in}} = \frac{3\mu_0 i}{2\pi r_{out}}$$

$$r = \frac{3i \times 3}{i_{in}} = \frac{3i \times 3}{J\pi 3^2} = \frac{i \times \pi \times 4.5^2}{i\pi} = 4.5^2 = 20.25 \text{ cm}$$

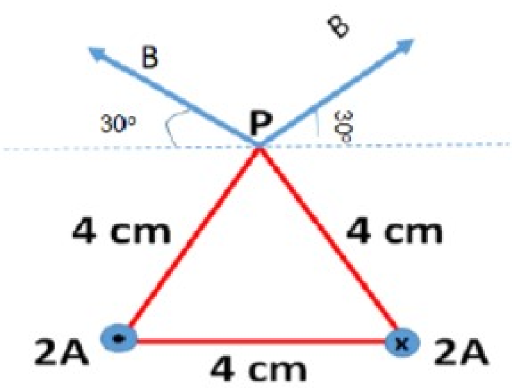
181, Final, Q22

**Q23.**

Two long vertical wires pierce (penetrate) the horizontal plane of the paper at the vertices of an equilateral triangle, each carrying 2.0 A current, one out of the paper and the other into the paper, as shown in **Figure 9**. The magnetic field at point P has a magnitude of:

A) $1.0 \times 10^{-5}$ T
B) $8.2 \times 10^{-5}$ T
C) $1.7 \times 10^{-5}$ T
D) $5.5 \times 10^{-5}$ T
E) $2.9 \times 10^{-5}$ T

Figure 9




**Ans:**

$$|B| = \frac{2\mu_0 i}{2\pi R}\, sin30°$$

$$= \frac{2 \times 4\pi \times 10^{-7} \times 2}{2 \times \pi \times 4 \times 10^{-2}} \times \frac{1}{2}$$
$$= 1 \times 10^{-5}\ \text{T}$$

**181, Final, Q23**

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**Q24.**

Two long parallel wires X and Y are separated by 4.0 cm and carry currents 20 A and 30 A, respectively, along the same direction. Determine the magnitude of the magnetic force on a 2.0 m length of wire Y.

A) $6.0 \times 10^{-3}$ N
B) $4.0 \times 10^{-3}$ N
C) $2.0 \times 10^{-3}$ N
D) $3.0 \times 10^{-3}$ N
E) $7.0 \times 10^{-3}$ N

**Ans:**

$$F = i_y\, L_y \frac{\mu_0 i_x}{2\pi R}$$

$$F = \frac{4\pi \times 10^{-7} \times 30 \times 20 \times 2}{2\pi \times 4 \times 10^{-2}} = 6 \times 10^{-3}\text{N}$$

**181, Final, Q24**

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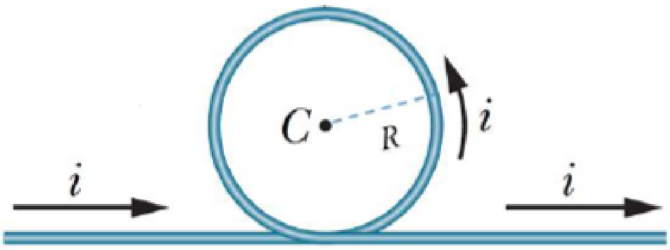
Q25.

In **Figure 10**, part of a long insulated wire carrying current $i = 5.0$ A is bent into a circular section of radius R = 0.1 m. What is the magnetic field at the center C of the circular section?

Figure 10




A) $4.1\times10^{-5}$ T out of the page
B) $4.1\times10^{-5}$ T into the page
C) $5.5\times10^{-5}$ T into the page
D) $5.5\times10^{-5}$ T out of the page
E) $3.7\times10^{-5}$ T out of the page

Ans:

$$\frac{\mu_0 i}{2\pi R}\hat{k} + \frac{\mu_0 i 2\pi}{4\pi R}\hat{k}$$

$$\frac{\mu_0 i}{R}\left(\frac{1}{2\pi} + \frac{1}{2}\right)\hat{k}$$

$$= \frac{4\pi \times 10^{-7} \times 5}{0.1}\left(\frac{1}{2\pi} + \frac{1}{2}\right)\hat{k}$$

$$= 4.1 \times 10^{-5}\text{T out of the Page}$$

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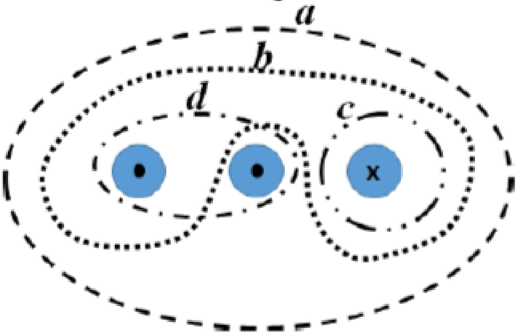
181, Final, Q25

**Q26.**

**Figure 11** shows the cross-sectional view of three wires carrying identical currents i and four Amperian loops (a through d) encircling them. Rank the loops according to the magnitude of $\oint \vec{B}.d\vec{s}$ along each, **greatest first**.

A) d, (a and c) tie, then b
B) a, b, c and d
C) d, (a and b) tie, then c
D) c, (a and b) tie, d
E) b, a, d, c

Figure 11




**Ans:**

$$\oint_a \vec{B} \cdot \vec{ds} = 2i - i = i$$

$$\oint_b \vec{B} \cdot \vec{ds} = i - i = 0$$

$$\oint_c \vec{B} \cdot \vec{ds} = i$$

$$\oint_d \vec{B} \cdot \vec{ds} = 2i$$

**181, Final, Q26**

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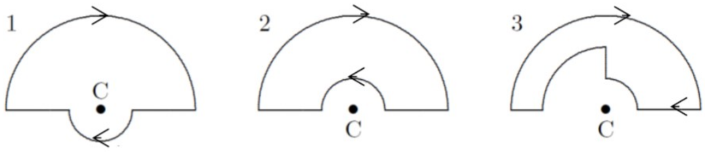
Q23.

FIGURE 10 shows three circuits consisting of concentric circular arcs (either half or quarter circles of radii $r$, $2r$, and $3r$) and radial lengths. The circuits carry the same current. Rank them according to the magnitudes of the magnetic fields they produce at C, GREATEST first.

Figure 10




A) 1, 2, 3
B) 3, 2, 1
C) 1, 3, 2
D) 2, 3, 1
E) 2, 1, 3

Ans:

A

1: B in same direction (Greatest)
2: B is lower (Opposite Direction)
3: B is lowest (Opposite Direction)

**173, Final, Q23**

Q25.

A long solenoid has 100 turns/cm and carries current $i$. An electron moves within the solenoid in a circle of radius 2.50 cm perpendicular to the solenoid axis. If the speed of the electron is $7.50 \times 10^5$ m/s, then Find the current $i$ in the solenoid.

Ans:

$$B = \mu_0 n i \longrightarrow i = \frac{B}{\mu_0 n} = \frac{mv}{qr} \cdot \frac{1}{\mu_0 n} = 0.0136\,A = 13.6\,mA$$

**173, Final, Q25**

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Q26.

FIGURE 12 shows a cross sectional view of two long parallel wires that are separated by distance $d$ = 18.6 cm. Each wire carries 4.23 A, out of the page in wire 1 and into the page in wire 2. In vector notation, find the net magnetic field at point $P$ at distance $R$ = 34.2 cm, due to the two currents.

A) $\vec{B} = +1.25 \times 10^{-6}\,\hat{i}$ T
B) $\vec{B} = +1.25 \times 10^{-6}\,\hat{j}$ T
C) $\vec{B} = +1.25 \times 10^{-6}\,\hat{k}$ T
D) $\vec{B} = -1.25 \times 10^{-6}\,\hat{j}$ T
E) $\vec{B} = -1.25 \times 10^{-6}\,\hat{i}$ T

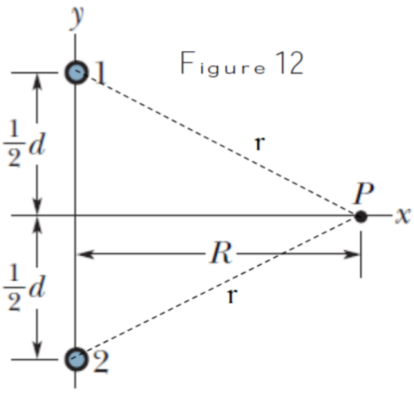

Figure 12

Ans:

$$r = \sqrt{R^2 + \left(\frac{d}{2}\right)^2}$$

$$\vec{B} = (2)\left(\frac{\mu_0 i}{2\pi r}\right)\left(\frac{d/2}{r}\right) = 1.25 \times 10^{-6}\,T i$$

**173, Final, Q26**

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Q27.

A long cylindrical conductor of radius of 3.0 cm carrying a uniform current of $1.0 \times 10^2$ A. Find the magnitude of the magnetic field inside the conductor at a radial distance of 2.0 cm from the wire center.

Ans:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc}$$

$$\Rightarrow B = \frac{\mu_0 i r}{2\pi R^2} = 4.44 \times 10^{-4}\,T$$

**173, Final, Q27**

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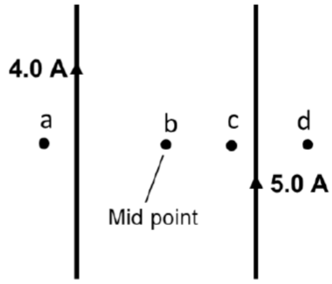
Q23.

Two wires of infinite length are placed parallel to each other in the plane of the paper. One wire carries a current of 4.0 A and other carries a current of 5.0 A as shown in FIGURE 10. Four points are marked on the figure. At which of the point(s) the direction of resultant magnetic field is out of the page? (b is midpoint between the wires)

Figure 10




A) a, b, and c
B) a and c
C) a only
D) a and d
E) b and c

Ans:

*A*

**172, Final, Q23**

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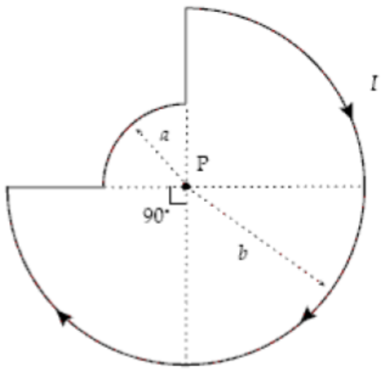
Q24.

In the FIGURE 11, if $a$ = 2.0 cm, $b$ = 4.0 cm, and $I$ = 2.0 A, what is the magnitude of the magnetic field at point P?

Figure 11




A) 39 µT
B) 49 µT
C) 55 µT
D) 69 µT
E) 13 µT

Ans:

$$B = \frac{\mu_0 i}{4\pi a} \cdot \frac{\pi}{2} + \frac{\mu_0 i}{4\pi b} \cdot \frac{3\pi}{2}$$

$$= \frac{\mu_0 i \pi}{8\pi}\left(\frac{1}{a} + \frac{3}{b}\right)$$

$$= \frac{\mu_0 i}{8}\left(\frac{1}{0.02} + \frac{3}{0.04}\right)$$

$$= \frac{4\pi \times 10^{-7}(2)}{8}\left(\frac{1}{0.02} + \frac{3}{0.04}\right)$$

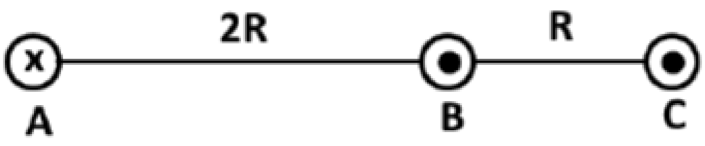
$$= 3.92 \times 10^{-5}\, T = 39.2 \times 10^{-6}\, T$$

**172, Final, Q24**

Q25.

FIGURE 12 shows a cross section of three long parallel wires each carrying a current of 24 A. The currents in wires B and C are out of the paper, while that in wire A is into the paper. If the distance $R = 5.0$ mm, what is the magnitude of the magnetic force on a 4.0 m length of wire A?

Figure 12




A) 77 mN
B) 15 mN
C) 59 mN
D) 12 mN
E) 32 mN

Ans:

$$F = F_B + F_C$$

$$\frac{F}{l} = \frac{\mu_0 i_a i_b}{2\pi(2R)} + \frac{\mu_0 i_a i_c}{2\pi(3R)}$$

$$= \frac{\mu_0 (24)^2}{2\pi}\left[\frac{1}{2R} + \frac{1}{3R}\right]$$

$$= \frac{4\pi \times 10^{-7}(24)^2}{2\pi}\left[\frac{5}{6R}\right]$$

$$F = \left[4\pi \times 10^{-7}(24)^2\left(\frac{5}{6 \times 5 \times 10^{-3}}\right)\right] \times 4 = 0.0768\, N \;\approx 77\, mN$$

**172, Final, Q25**

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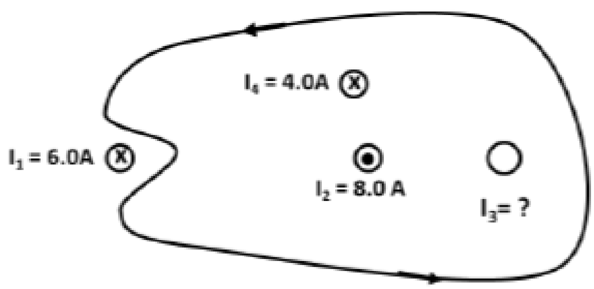
Q26.

The value of the line integral around the closed path shown in FIGURE 13 is $1.4 \times 10^{-5}$ T.m. What are the magnitude and direction of the current $I_3$?

Figure 13




A) 7.1 A out of the page
B) 5.1 A out of the page
C) 4.0 A into the page
D) 7.1 A into the page
E) 5.1 A into the page

Ans:

$$\int B \cdot dl - \mu_0 \left(i_{enc}\right)$$

$$1.4 \times 10^{-5} = \mu_0(8 + I_3 - 4)$$

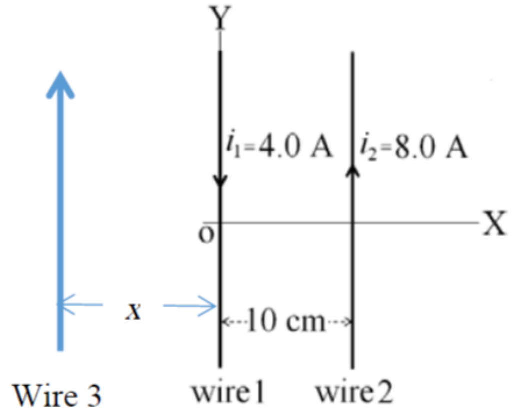
$$I_3 = \frac{1.4 \times 10^{-5}}{4\pi \times 10^{-7}} - 4 = 7.14\, A$$

**172, Final, Q26**

**Q23.**

Wire 1 and wire 2 placed parallel to y axis at x = 0 and x = 10 cm, respectively, and carries currents $i_1 = 4.0\,A$ and $i_2 = 8.0\,A$ in opposite directions as shown in **FIGURE 12**. A third wire carries current in positive y direction is to be placed parallel to wire 1 and wire 2 such that net force per unit length on wire 3 due to wire 1 and wire 2 is zero. Find the position x of wire 3.

Figure 12




A) −10 cm
B) +20 cm
C) +15 cm
D) −5.0 cm
E) −15 cm

**Ans:**

$$|F_{31}| = |F_{32}|$$

$$\frac{\mu_0 i_1 i_3}{2\pi x} = \frac{\mu_0 i_2 i_3}{2\pi(x+0.1)}$$

$$\frac{i_1}{x} = \frac{i_2}{x+0.1}$$

$$4(x+0.1) = 8x \Rightarrow 0.4 = 4x \Rightarrow x = 0.1\,m = 10\,cm$$

**171, Final, Q23**

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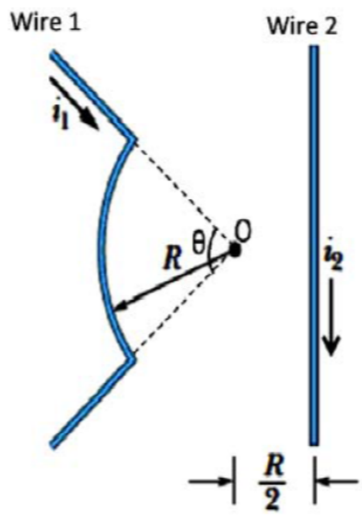
**Q24.**

In **FIGURE 13** wire 1 consist of a circular arc of radius R with central angle of θ = 120° and two radial lengths and carries current $i_1 = 2.00\,A$ in the direction indicated. Wire 2 is long and straight and it carries a current $i_2$ and placed at a distance of R/2 from the center of circular arc. If the net magnetic field at the center of the arc O is zero find the current $i_2$.

Figure 13




A) 1.05 A
B) 2.75 A
C) 0.84 A
D) 1.34 A
E) 2.05 A

**Ans:**

$$|\vec{B}_{wire}| = |B_{arc}|$$

$$\frac{\mu_0 i_2}{2\pi\left(\frac{R}{2}\right)} = \frac{\mu_0 i_1}{4\pi R}\cdot\frac{2}{3}\pi$$

$$i_2 = \frac{i_1 \pi}{6}$$

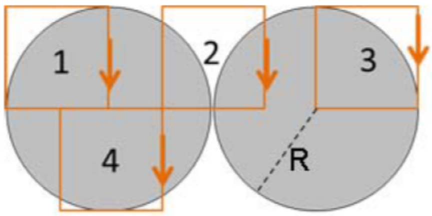
$$i_2 = \frac{2\times\pi}{6} = 1.04719 \approx 1.05\,A$$

**171, Final, Q24**

Q25.

**FIGURE 14** shows a cross section across the diameter of two long cylindrical conducting wires 1 and 2 of same radius R carrying same uniform current but in opposite directions. Four square paths (of side length R) of same dimensions are indicated for the line integral $\oint \vec{B}.d\vec{s}$. Rank the paths according to the magnitude of $\oint \vec{B}.d\vec{s}$ taken in the directions shown, **GREATESR FIRST**.

Figure 14




A) 4, then 1 and 3 tie, 2
B) 1 and 3 tie, 2, 4
C) 4, then 1, 2, and 3 tie
D) 4, 3, 2,1
E) 3, 4,1, 2

Ans:

***A***

**171, Final, Q25**

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Q27.

A solenoid has a length L = 1.55 m and an inner diameter d = 4.15 cm, and carries a current i = 4.80 A. The solenoid consists of six close-packed layers, each with 750 turns along length L. What is the magnitude of magnetic field at its center?

Ans:

$$B = \mu_0 n_i = \mu_0 \frac{N}{l} i$$

**171, Final, Q27**

$$B = 4\pi \times 10^{-7} \frac{750 \times 6}{1.55}(4.8) = 0.01751\ T = 17.5\ mT$$

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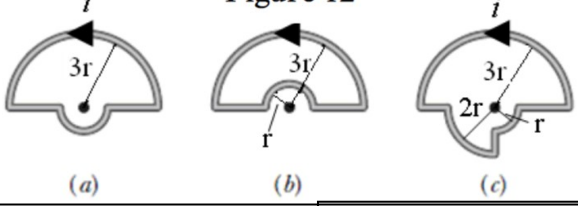
Q23.

**FIGURE 12** shows three circuits consisting of straight radial lengths and concentric circular arcs (either half or quarter circles of radius r, 2r, and 3r). The circuits carry the same current. Rank them according to the magnitude of the magnetic field produced at the center of arcs (the dot), **GREATEST FIRST**.

A) a, c, b
B) c, a, b
C) a and b tie, c
D) c, a and b tie
E) c, b, a

Figure 12

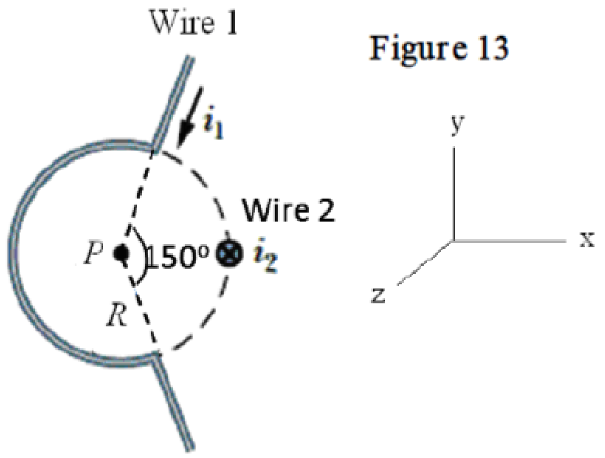



**163, Final, Q23**

**Q24.**

In **FIGURE 13** wire 1 consists of a circular arc of radius $R = 4.00$ cm and two radial lengths and carries a current $i_1 = 5.00$ A in the direction indicated. Wire 2 is a long, straight and perpendicular to the plane of the figure and carries a current $i_2 = 2.00$ A into the page. Find the magnitude of the resultant magnetic field at the center of the arc $P$.

A) $4.69 \times 10^{-5}$ T
B) $2.04 \times 10^{-5}$ T
C) $4.17 \times 10^{-7}$ T
D) $3.42 \times 10^{-5}$ T
E) $3.15 \times 10^{-7}$ T




**Ans:**

$\theta = 210°$;

$180° - \pi$

$$210° - \frac{210}{180}\pi = \frac{7}{6}\pi$$

$$B_1 = \frac{\mu_0 i_1}{4\pi r}\phi \text{ out of the page}$$

$$B_2 = \frac{\mu_0 i_2}{2\pi r}\phi \text{ downward}$$

$$B_1 = \frac{4\pi \times 10^{-7} \times 5}{4\pi \times 0.04} \cdot \frac{7}{6}\pi = 4.5815 \times 10^{-5} \text{ T}$$

$$B_2 = \frac{4\pi \times 10^{-7} \times 2}{2\pi \times 0.04} = 1 \times 10^{-5} \text{ T}$$

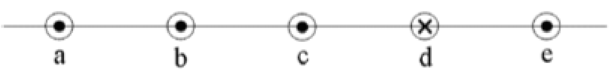
163, Final, Q24

$$B_{net} = \sqrt{B_1^2 + B_2^2} = \sqrt{1^2 + (4.5815)^2 \times 10^{-5}} = 4.689 \times 10^{-5} \text{ T}$$

**Q25.**

Five long, parallel straight wires are placed perpendicular to the plane of the paper at the same separation of 6.00 cm and carry currents in different directions, as shown in **FIGURE 14**. The current through each of the wires **a**, **b** and **e** is 15.0 A. The Current through each of the wires **c** and **d** is 10.0 A. Find the magnitude of the net force per unit length on the wire **c**

Figure 14




A) $8.33 \times 10^{-4}$ N/m
B) $4.17 \times 10^{-4}$ N/m
C) $15.7 \times 10^{-4}$ N/m
D) $2.17 \times 10^{-4}$ N/m
E) $9.43 \times 10^{-5}$ N/m

**Ans:**

Force on c due to a and e are equal in magnitude but opposite in direction

$\therefore F_{net} = F_b + F_d$

$$= \frac{\mu_0 i_b i_c}{2\pi r} + \frac{\mu_0 i_d i_c}{2\pi r} = \frac{\mu_0 i_c}{2\pi r}(i_b + i_d)$$

$$= \frac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.06}(15 + 10) = 8.33 \times 10^{-4}\ N$$

**163, Final, Q25**

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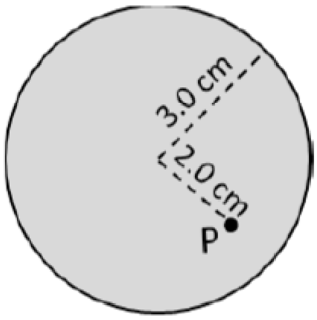
**Q26.**

**FIGURE 15** shows a cross section across a diameter of a long cylindrical conductor of radius of 3.0 cm carrying a uniform current $1.5\times10^2$ A. What is the magnitude of the magnetic field at point P, at a radial distance of 2.0 cm from the center?

A) $6.7 \times 10^{-4}$ T
B) $1.5 \times 10^{-4}$ T
C) $3.2 \times 10^{-4}$ T
D) $9.5 \times 10^{-5}$ T
E) $4.5 \times 10^{-5}$ T

**Figure 15**




**Ans:**

$$\int \bar{B} \cdot \bar{\mu} = \mu_0 i_{enc}$$

$$B \cdot 2\pi(0.02) = \mu_0 \frac{\pi(0.02)^2}{\pi(0.03)^2} \cdot 150$$

$$B = \frac{4\pi \times 10^{-7} \times (0.02)}{2\pi(0.03)^2} \times 150 = 6.666 \times 10^{-4}\ T$$

**163, Final, Q26**

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**Q27.**

A long solenoid has 120 turns/cm and carries current *i*. An electron moves within the solenoid in a circle of radius 2.50 cm perpendicular to the solenoid axis. The speed of the electron is $7.50\times10^5$ m/s. Find the current *i* in the solenoid.

**Ans:**

$$\frac{mv^2}{r} = qvB \Rightarrow B = \frac{mv}{qr} = \frac{9.11 \times 10^{-31} \times 7.5 \times 10^5}{1.6 \times 10^{-19} \times 2.5 \times 10^{-2}} = 1.708125 \times 10^{-4}\ T$$

$$B = \mu_0 n i$$

$$1.708125 \times 10^{-4} = 4\pi \times 10^{-7} \times \frac{120}{10^{-2}}\ i$$

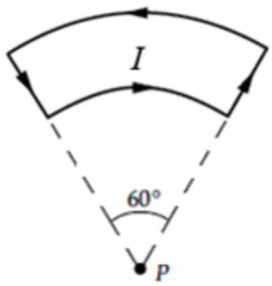
$$i = \frac{1.708125 \times 10^{-4}}{4\pi \times 10^{-7} \times 120 \times 10^2} = 0.011327\ A$$

**163, Final, Q27**

**Q24.**

Two semicircular arcs, in the plane of paper, carry a current I = 8.00 A, shown in **FIGURE 18**. The radius of outer arc is 0.600 m and that of the inner arc is 0.400 m. Find the magnetic field at point P.

Figure 18




A) $6.98 \times 10^{-7}$ T into the page
B) $6.98 \times 10^{-7}$ T out of the page
C) $4.32 \times 10^{-7}$ T into the page
D) $3.49 \times 10^{-6}$ T out of the page
E) 0

**Ans:**

$$B_{net} = B_2 - B_1$$

$$= \frac{\mu_0 i}{4\pi R_2}\frac{\pi}{3} - \frac{\mu_0 i}{4\pi R_1}\frac{\pi}{3}$$

$$= \frac{\mu_0 i \cdot \pi}{3 \times 4\pi}\left[\frac{1}{R_2} - \frac{1}{R_1}\right] = \frac{4\pi \times 10^{-7} \times 8}{12}\left[\frac{1}{0.4} - \frac{1}{0.6}\right]$$

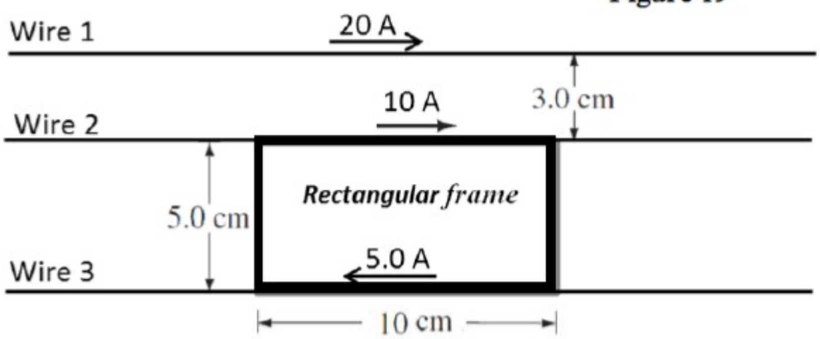
$$= 8.3776 \times 10^{-7}\left[\frac{5}{6}\right] = 6.98 \times 10^{-7}\, T$$

**162, Final, Q24**

**Q25.**

Three long parallel wires 1, 2, and 3 carrying currents of 20 A, 10 A, and 5.0 A, respectively, are placed in the plane of the page, shown in **FIGURE 19**. Parts of wire 2 and wire 3 are fixed on a hard ***insulating*** rectangular frame of dimensions 10 cm × 5.0 cm. Find the net force on the rectangular loop.

Figure 19




A) $1.1 \times 10^{-4}$ N toward wire 1

**Ans:**

$$F_{net} = F_{12} - F_{13} = \frac{\mu_0 i_1 i_2 \times L_2}{2\pi d_2} - \frac{\mu_0 i_1 i_3 \times L_3}{2\pi d_3}$$

$$L_2 = L_3 = 10\ cm$$

$$= \frac{\mu_0 i_1 L_2}{2\pi}\left[\frac{i_2}{d_2} - \frac{i_3}{d_3}\right]$$

$$= \frac{4 \times 10^{-7} \times 20 \times 0.1}{2\pi}\left[\frac{10}{0.03} - \frac{5}{0.08}\right] = 4 \times 10^{-7}[333.33 - 62.5] = 1.1 \times 10^{-4} N$$

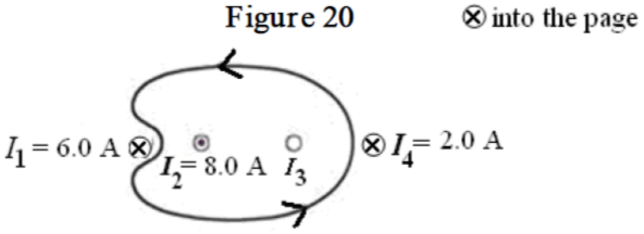
**162, Final, Q25**

Q26.

The value of the line integral of $\vec{B}$ around the closed loop in **FIGURE 20** is 1.38 × $10^{-5}$ T.m. What is the direction and magnitude of current $I_3$?

A) 2.98 A out of the page
B) 19.0 A out of the page
C) 2.98 A into the page
D) 4.20 A into the page
E) 5.65 A out of the page

Figure 20




Ans:

$$\int B \cdot dl = \mu_0 I_{enc}$$

$$1.38 \times 10^{-5} = \mu_0[8 + I_3]$$

$$I_3 + 8 = \frac{1.38 \times 10^{-5}}{\mu_0} = \frac{1.38 \times 10^{-5}}{4\pi \times 10^{-7}} = 10.98$$

$$\Rightarrow I_3 = 2.98\ A \Rightarrow Positve\ means\ out\ of\ the\ page$$

**162, Final, Q26**

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Q27.

A solenoid that is 85.0 cm long has a radius of 2.50 cm and a winding of 1.5×$10^3$ turns. If the solenoid carries a current of 4.20 A, calculate the magnitude of magnetic field inside the solenoid.

Ans:

$$B = \mu_0 n i$$

$$B = 4\pi \times 10^{-7} \times \frac{1500}{85 \times 10^{-2}} \times 4.2 = 9.31 \times 10^{-3}\ T$$

**162, Final, Q27**

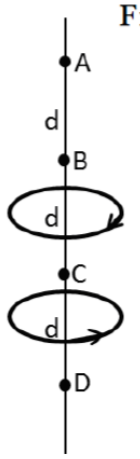
---

Q28.

**FIGURE 21** Shows two circular loops of same radius, centered on vertical axes (perpendicular to the loops) and carrying same current but in opposite directions indicated. Assume the separation between the coils is much greater than their radii and point C is the midpoint between the coils. If the separation between all successive points A, B, C, D is same, rank the points A, B, C, and D, on the vertical axis according to the magnitude of the net magnetic field, **GREATEST FIRST**.

A) B and D tie, A, C
B) C, B and D tie, A
C) B and A tie, C, D
D) A, B and D tie, C
E) A, B, C, D

Figure 21




**Ans:**

*A*

**162, Final, Q28**

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**Q22.**

Two long straight wires are parallel to each other and carry currents of different magnitudes. If the amount of current flowing through each wire is doubled, the magnitude of the force between the wires will be:

A) Four times the magnitude of the original force

**161, Final, Q22**

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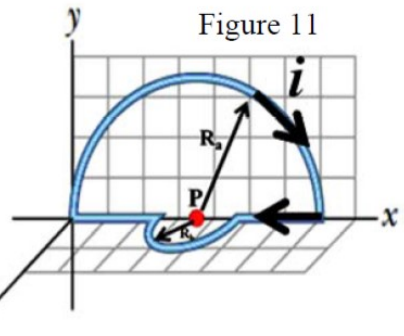
**Q23.**

The current-carrying wire loop in **FIGURE 11** lies in the xy and xz planes and carries current $\boldsymbol{i}$ = 1.43 A. The loop consists of a semicircle of radius $R_a$ = 10.0 cm in the xy plane and another smaller semicircle of radius $R_b$ = 2.30 cm in the xz plane. Find the magnitude of the net magnetic field at the common center P of the two semicircles.

A) 20.0 µT
B) 15.0 µT
C) 10.0 µT
D) 25.0 µT
E) 35.0 µT

Figure 11




**Ans:**

$$|B_a| = \frac{\mu_0 i\phi}{4\pi R_a} = \frac{4\pi \times 10^{-7} \times 1.43 \times \pi}{4\pi \times 0.1} = 4.49\mu T$$

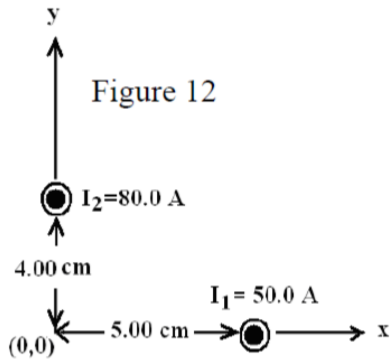
$$|B_b| = \frac{4\pi \times 10^{-7} \times 1.43 \times \pi}{4\pi \times 0.023} = 19.53\mu T$$

$$|B_{net}| = \sqrt{B_a^2 + B_b^2} = \sqrt{(4.49)^2 + (19.53)^2}\mu T = 20.0\mu T$$

**161, Final, Q23**

**Q24.**

Two long straight wires carry currents perpendicular to the xy plane, as shown in **FIGURE 12**. What is the magnitude of the net magnetic field at the origin?




A) 447 μT
B) 155 μT
C) 622 μT
D) 778 μT
E) 251 μT

**Ans:**

$$|B_{1y}| = \frac{\mu_0 I_1}{2\pi \times 0.05} = \frac{4\pi \times 10^{-7} \times 50}{4\pi \times 0.05} = 2 \times 10^{-4}\, T$$

$$|B_{2x}| = \frac{\mu_0 I_2}{2\pi \times 0.04} = \frac{4\pi \times 10^{-7} \times 80}{4\pi \times 0.04} = 4 \times 10^{-4}\, T$$

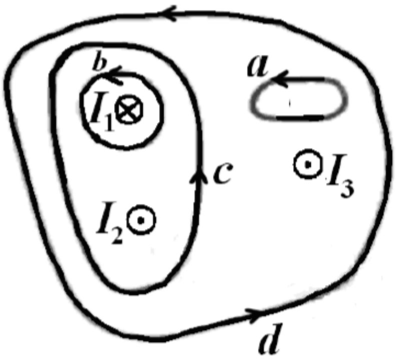
**161, Final, Q24**

$$|B_{net}| = \sqrt{(B_{2x})^2 + (B_{1y})^2} = \sqrt{(4)^2 + (2)^2} \times 10^{-4}\, T = 4.47 \times 10^{-4}\, T = 447 \mu T$$

**Q25.**

**FIGURE 13** shows the cross sectional view of three conductors that carry currents perpendicular to the plane of the figure. The currents have magnitudes $I_1$= 4 A, $I_2$ = 6 A and $I_3$ = 2 A in the directions shown. Four closed paths, labeled ***a*** through ***d***, are shown. Rank the values of the line integrals $\oint \vec{B}.d\vec{s}$ for the four paths, **minimum to maximum**.

Figure 13




A) *b, a , c , d*
B) *a, b, c ,d*
C) *b, c, then d, a tie*
D) *a, c ,b, d*
E) *c, d, a, b*

**Ans:**

$$\oint B \cdot ds = \mu_0 i_{encl}$$

$$\oint_a B \cdot ds = 0$$

$$\oint_b B\, ds = \mu_0(-I_1) = -4\mu_0$$

$$\oint_c B \cdot ds = \mu_0\,(I_2 - I_1) = \mu_0(6-4) = +2\mu_0$$

$$\oint_d B \cdot ds = \mu_0\,(I_2 + I_3 - I_1) = +4\,\mu_0$$

**161, Final, Q25**

Q26.

A long solenoid has 100 turns/cm and carries current $i$. An electron moves within the solenoid in a circle of radius 2.15 cm perpendicular to the solenoid axis. The speed of the electron is $1.25\times10^{7}$ m/s. Find the current $i$ in the solenoid.

**Ans:**

$$B = \mu_0 n_i \Rightarrow i = \frac{B}{\mu_0 n}; n = 100/cm = 10^4/m$$

$$But\ \ evB = \frac{mv^2}{R} \Rightarrow B = \frac{mv}{eR} = \frac{9\times10^{-31}\times1.25\times10^{7}}{1.6\times10^{-19}\times0.0215} = 3.31\times10^{-3}\,T$$

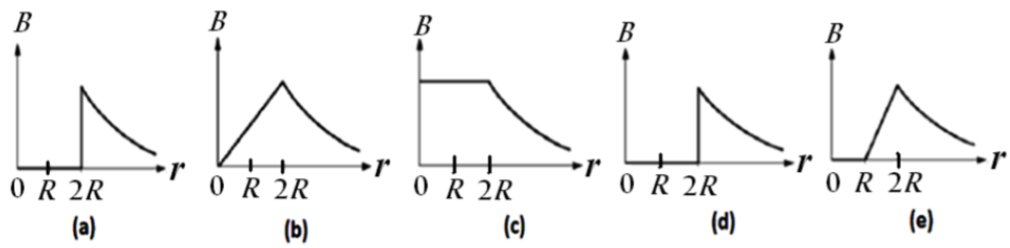
$$i = \frac{B}{\mu_0\cdot n} = \frac{3.31\times10^{-3}}{4\pi\times10^{-7}\times10^{4}} = 26.3\times10^{-24}A$$

**161, Final, Q26**

Q22.

A long, hollow, cylindrical wire with an inner radius R and outer radius 2R carries a uniform current density. Which of the following graphs (**FIGURE 9**) **best** represents the magnitude of the magnetic field as a function of the distance from the center of the wire?

**Figure 9**




A) *e*
B) *a*
C) *b*
D) *c*
E) *d*

**Ans:**

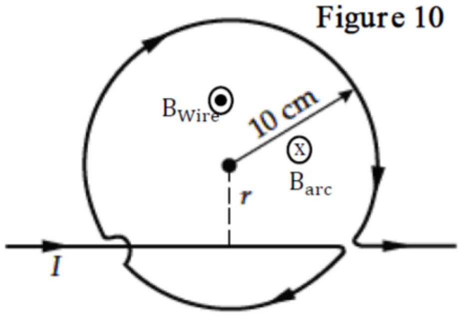
*A*

**153, Final, Q22**

**Q23.**

An infinitely long, straight wire is bent, as shown in **FIGURE 10**. The circular portion has a radius of 10.0 cm and its center is a distance r from the straight part. Find the value of r such that the magnetic field at the center of the circular portion is zero.

Figure 10




A) 3.18 cm
B) 5.22 cm
C) 1.25 cm
D) 2.43 cm
E) 7.08 cm

**Ans:**

$$|B_{wire}| = |B_{arc}|$$

$$\frac{\mu_0 i}{2\pi r} = \frac{\mu_0 i}{2R}$$

$$\frac{1}{2\pi r} = \frac{1}{2 \times 0.1} \Rightarrow r = \frac{0.1}{\pi} = 0.0318\ cm = 3.18\ cm$$

**153, Final, Q23**

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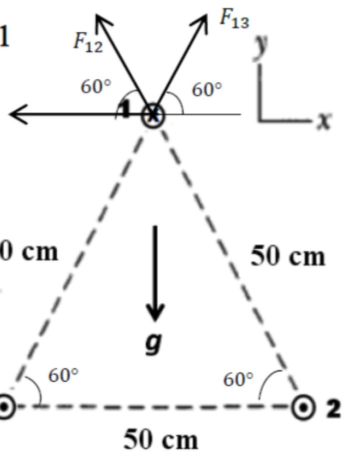
**Q24.**

Three long wires **1**, **2** and **3**, are parallel to z-axis and carry currents of equal magnitudes but in different directions, as shown in **FIGURE 11**.The wires form an equilateral triangle. Wire 1 has a linear mass density 0.150 µg/m. For what value of current is the net magnetic force on wire 1 balanced by its weight.

Figure 11




A) 1.46 A
B) 0.11 A
C) 2.89 A
D) 3.43 A
E) 0.47 A

**Ans:**

$$(F_{13})_y + (F_{12})_y = F_g = \mu \times l \times g$$

$$|F_{13}|_y = |F_{12}|_y = \frac{\mu_0 i^2 \times l \times sin60}{2\pi d}$$

$$|(F_{13})_y| = \frac{4\pi \times 10^{-7} \times i^2 \times l \times 0.866}{2\pi \times 0.5} = l \times 1.732 \times 10^{-7} \times i^2 \times l$$

$$= 2 \times 1.732 \times 10^{-7} \times i^2 \times l = 3.464 \times 10^{-7} \times i^2 \times l$$

$$2|F_{13}| = \mu \times l \times g$$

$$2 \times 3.464 \times 10^{-7} \times l \times i^2 = 0.150 \times 10^{-6} \times l \times 9.8$$

$$i^2 = 2.122 \Rightarrow i = \sqrt{2.122} = 1.456\ A$$

**153, Final, Q24**

**Q25.**

The magnetic dipole moment of the Earth is $8.0 \times 10^{22}$ A.m$^2$. The source of the earth magnetic dipole moment is due to the circulation of ions in the earth interior region. Assume that the ions move in a circular loop of radius 2500 km, what 'current' should the ions produce to obtain the earth magnetic dipole moment?

**Ans:**

$$\mu = iA = i\pi r^2$$

$$i = \frac{\mu}{\pi r^2} = \frac{8.0 \times 10^{22}}{\pi(2500 \times 10^3)^2} = 4.07 \times 10^9 A$$

**153, Final, Q25**

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**Q26.**

A 1.00 m long solenoid has a diameter of 10.0 cm and carries a current of 35.0 A. If the magnetic field inside the solenoid is $100\times10^{-3}$ T, what is the total length of wire of the solenoid?

**Ans:**

Total lenght $L = 2\pi r \times N$ (r is solenoid radius, N is number of turns)

$$B = \mu_0 \frac{N}{l} i \Rightarrow N = \frac{Bl}{\mu_0 i} = \frac{100 \times 10^{-3} \times 1.0}{4\pi \times 10^{-7} \times 35} = 2273.6$$

$$L = N \times 2\pi r = 2273.6 \times 2\pi \times 0.05 = 714.3 \text{ m}$$

**153, Final, Q26**

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**Q27.**

Inside an ideal solenoid carrying current, the magnetic field

A) is uniform.
B) is zero.
C) decreases with distance from the axis of the solenoid.
D) increases with distance from the axis of the solenoid.
E) is perpendicular to the axis of the solenoid.

**Ans:**

A

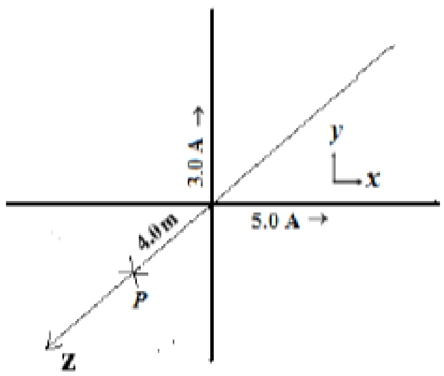
**152, Final, Q27**

**Q23.**

Two long straight wires cross each other perpendicularly without touching, as shown in **FIGURE 11**. Find the net magnetic field due to the two wires at point ***P***, which is along the positive *z* axis.

A) $+0.15\hat{i}-0.25\hat{j}$ (μT)
B) $+0.15\hat{i}+0.25\hat{j}$ (μT)
C) $-0.15\hat{i}-0.25\hat{j}$ (μT)
D) $-0.15\hat{i}+0.25\hat{j}$ (μT)
E) $+0.29\hat{k}$ (μT)

Figure 11




**Ans:**

$$B = \frac{\mu_0 i}{2\pi r}$$

$$B_1 = \frac{4\pi \times 10^{-7} \times 5}{2\pi \times 4} = 0.25\ \mu T\ (-y)$$

$$B_2 = \frac{4\pi \times 10^{-7} \times 3}{2\pi \times 4} = 0.15\ \mu T\ (+x)$$

**152, Final, Q23**

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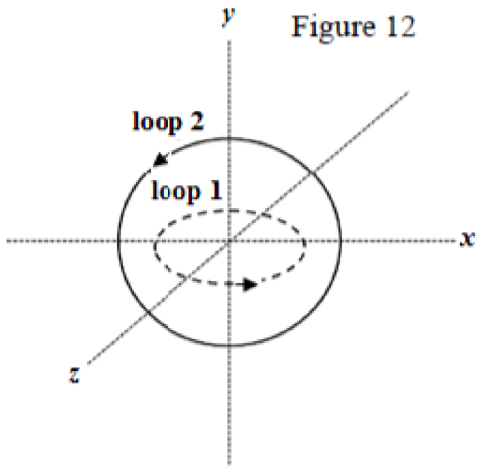
**Q24.**

Two concentric circular loops are placed with their planes perpendicular to each other, as shown in **FIGURE 12**. Loop 1 (in the *xz* plane) has radius 2.0 cm and carries a current of 4.0 A. Loop 2 (in the *xy* plane) has radius 3.0 cm and carries a current of 5.0 A. What is the magnitude of the magnetic field at the center of the loops?

Figure 12

A) 0.16 mT
B) 0.25 mT
C) 0.51 mT
D) 0.46 mT
E) 0.33 mT




**Ans:**

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

$$B_1 = \frac{4\pi \times 10^{-7} \times 4}{2 \times 0.02} = 0.125\ mT$$

$$B_2 = \frac{4\pi \times 10^{-7} \times 5}{2 \times 0.03} = 0.104\ mT$$

$$B_{net} = \sqrt{B_1^2 + B_2^2} = 0.16\ mT$$

**152, Final, Q24**

**Q25.**

Three parallel infinitely-long current-carrying wires are placed as shown, in cross section, in FIGURE 13. If net magnetic force on $I_2$ zero, what should be the current $I_3$?

Figure 13


A) $I_3 = I_1/2$ , into the page
B) $I_3 = I_1/2$ , out of the page
C) $I_3 = 2I_1$ , out of the page
D) $I_3 = 2I_1$ , into the page
E) No current can cancel the magnetic force on $I_2$.

**Ans:**

$I_3$ must be into the page for the two forces to canel.

$F_{21} = F_{23}$:

$$\frac{\mu_0 I_1 I_2}{2\pi \times 2d} = \frac{\mu_0 I_2 I_3}{2\pi d}$$

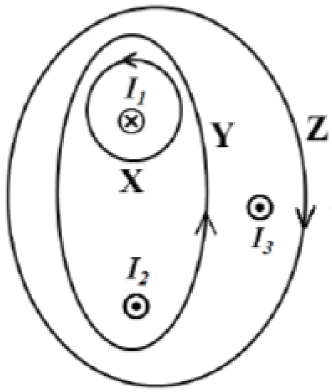
$\Rightarrow I_3 = I_1/2$

**152, Final, Q25**

**Q26.**

FIGURE 14 shows, in cross section, three long wires that carry currents perpendicular to the page. The currents have magnitudes $I_1 = 4.0$ A, $I_2 = 6.0$ A, and $I_3 = 3.0$ A. Three paths (X, Y, Z) are drawn. Rank these paths according to the value of the line integral $\oint \vec{B} . d\vec{s}$ , greatest first.

Figure 14




A) Y, X, Z
B) Z, X, Y
C) Z, Y, X
D) Y, Z, X
E) X, Z, Y

**Ans:**

X: $-4\mu_0$

Y: $+6\mu_0 - 4\mu_0 = +2\mu_0$

Z: $+4\mu_0 - 6\mu_0 - 3\mu_0 = -5\mu_0$

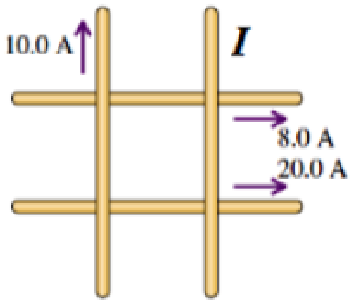
Y, X, Z

**152, Final, Q26**

**Q23.**

Four very long, current-carrying wires in the same plane intersect to form a square 40 cm on each side, as shown in **Figure 9**. Find the magnitude and direction of the current $I$ so that the magnetic field at the center of the square is zero. The wires are insulated from each other.

**Figure 9**




A) 2.0 A, downward
B) 2.0 A, upward
C) 4.0 A, downward
D) 4.0 A, upward
E) 6.0 A, downward

**Ans:**

$$B_c = \frac{\mu_0}{2\pi r} I_{net}$$

$$I_{net} = 0 \text{ for } B_c = 0$$

$$I_{net} = I_2 - I_1 - I_3 + I = 0$$

$$\Rightarrow I = I_1 + I_3 - I_2 = 8 + 10 - 20 = -2\text{ A}$$

↓ downward

**143, Final, Q23**

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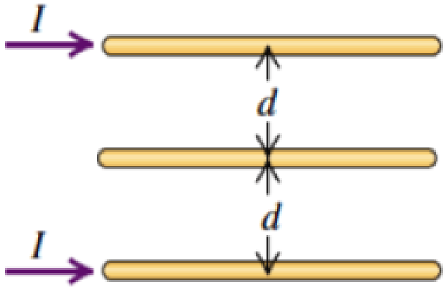
**Q24.**

Three parallel long wires are placed as shown in **Figure 10**. The top and bottom wires carry the same current (2.0 A) in the same direction. What should be the direction and magnitude of the current in the middle wire so that the net magnetic force per unit length on the top wire is zero?

**Figure 10**




A) 1.0 A, to the left
B) 1.0 A, to the right
C) 4.0 A, to the left
D) 4.0 A, to the right
E) 0.50 A, to the left

**Ans:**

The current must be to the left

$$F = \frac{\mu_0 L i_a i_b}{2\pi d}$$

$$\frac{I \cdot I_x}{2\pi d} = \frac{I \cdot I}{4\pi d}$$

$$\Rightarrow I_x = \frac{I}{2} = 1.0\text{ A}$$

**143, Final, Q24**

**Q25.**

In **Figure 11**, current $I = 1.5$ A is set up in a loop having four radial lengths and four quarter circles, with $r = 5.0$ cm and $R = 2r$. What is the magnitude of the magnetic field at the common center point $P$?

A) 14 μT
B) 43 μT
C) 11 μT
D) 45 μT
E) 91 μT

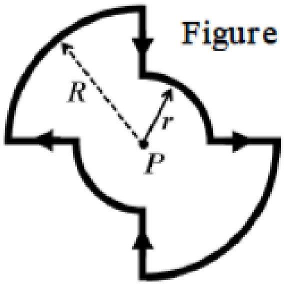


**Figure 11**

**Ans:**

The radial lengths will not contribute.

The quarter circles all contribute magnetic fields in the same direction.

$$B_p = \frac{\mu_0 I \Phi}{4\pi r} + \frac{\mu_0 I \Phi}{4\pi r} + \frac{\mu_0 I \Phi}{4\pi R} + \frac{\mu_0 I \Phi}{4\pi R}$$

$$= \frac{\mu_0 I \Phi}{2\pi r} + \frac{\mu_0 I \Phi}{2\pi R} = \frac{\mu_0 I \Phi}{2\pi r} + \frac{\mu_0 I \Phi}{4\pi r}$$

$$= \frac{3\mu_0 I \Phi}{4\pi r} = \frac{(3\mu_0 I)\left(\frac{\pi}{2}\right)}{4\pi r} = \frac{3\mu_0 I}{8r}$$

$$= \frac{3 \times 4\pi \times 10^{-7} \times 1.5}{8 \times 0.05} = 14\ \mu T$$

**143, Final, Q25**

---

**Q26.**

A solenoid, of length 0.25 m and diameter 15 cm, has 650 turns and carries a current of 0.85 A. What is the magnitude of the magnetic field at the center of the solenoid?

A) 2.8 mT
B) 6.9 mT
C) 4.3 mT
D) 9.8 mT
E) 6.4 mT

**Ans:**

$$n = \frac{N}{L} = \frac{650}{0.25} = 2600\ m^{-1}$$

$$B = \mu_0\, n\, i = 4\pi \times 10^{-7} \times 2600 \times 0.85 = 2.8\ mT$$

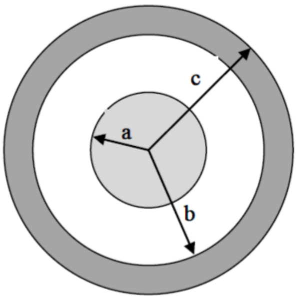
**143, Final, Q26**

---

**Q27.**

A solid conductor of radius **a** is surrounded by a conducting tube of inner radius **b** and outer radius **c**, as shown in cross section in **Figure 12**. The conductor and the tube carry equal but opposite currents, and the region between them is filled with an insulator. Let r be the distance from the center of the solid conductor. At what value of r will the magnetic field have its maximum value?

**Figure 12**




A) r = a
B) r < a
C) a < r < b
D) r = b
E) r = c

**143, Final, Q27**

**Ans:**

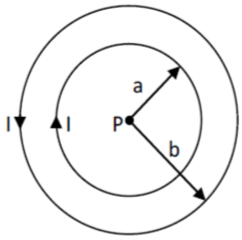
The maximum value of $\vec{B}$ occurs at the surface of the inner conductor

---

**Q22.**

Two concentric circular loops of wire of radii a = 2.0 cm and b = 4.0 cm each carries a current I = 5.00 A in the directions indicated in **Figure 12**. What is the magnetic field at center P?

**Figure 12**




A) 78.5 μT into the page
B) 78.5 μT out of the page
C) 29.3 μT into the page
D) 29.3 μT out of the page
E) 0.60 μT into the page

**Ans:**

$$B=\frac{\mu_o I}{4\pi R}\varphi=\frac{\mu_o I}{4\pi}\left(\frac{1}{a}-\frac{1}{b}\right)\varphi=\frac{4\pi 10^{-7}\times 5}{4\pi}\left(\frac{1}{2/100}-\frac{1}{4/100}\right)(2\pi)$$

$$\mu_0 = 4\pi 10^{-7}; a = \frac{2}{100}; b = \frac{4}{100}\ ;\ I_i = 5$$

$$B = \frac{\frac{\mu_0 I_i}{4\pi}\left(\frac{1}{a}-\frac{1}{b}\right)(2\pi)}{10^{-6}} = 78.5398$$

**142, Final, Q22**

---

**Q23.**

Solenoid 2 has four times the radius and twice the number of turns per unit length as solenoid 1. Find the ratio of the magnitude of the magnetic field in the interior of solenoid 2 to that in the interior of solenoid 1, if the two solenoids carry the same current.

Ans:

$$\frac{N_2}{L} = 2\frac{N_1}{L}\ ;\ B_1 = \mu_0 i\frac{N_1}{L}\ ;\ B_2 = \mu_0 i\frac{N_2}{L}$$

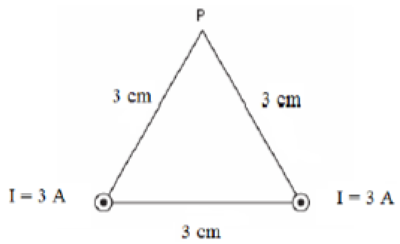
$$\frac{B_2}{B_1} = \frac{\mu_0 i\frac{N_2}{L}}{\mu_0 i\frac{N_1}{L}} = \frac{N_2}{N_1} = 2$$

**142, Final, Q23**

**Q24.**

Two long straight wires penetrate, normally, the plane of the paper at two vertices of an equilateral triangle as shown in **Figure 13**. They each carry 3.0 A, out of the page. The magnetic field at the third vertex (P) has magnitude (in T):

**Figure 13**




A) $3.5 \times 10^{-5}$
B) $2.0 \times 10^{-4}$
C) 0
D) $3.5 \times 10^{-7}$
E) $8.7 \times 10^{-6}$

**Ans:**

$$B = \frac{2\mu_0 \times i \times cos(30)}{2\pi \times R} = \frac{2 \times 1.26 \times 10^{-6} \times 3 \times 0.866}{2\pi \times 0.03}$$

$$B = 3.47\ 10^{-5}\ T$$

**142, Final, Q24**

---

**Q25.**

A long wire has a radius R > 4.0 mm and carries a current that is uniformly distributed over its cross section. The magnitude of the magnetic field due to this current is 0.28 mT at a point 4.0 mm from the axis of the wire, and 0.20 mT at a point outside the wire and at 10 mm from the axis of the wire. What is the radius R of the wire?

Ans:

$$B_{out} = \frac{\mu_o I}{2\pi r_2}; \quad B_{in} = \frac{\mu_o I r_1}{2\pi R^2} \Rightarrow R = \sqrt{r_2 r_1 \frac{B_{out}}{B_{in}}}$$

$$B_{in} = 0.28 \times 10^{-3};\ B_{out} = 0.2 \times 10^{-3};\ r_1 = 4 \times 10^{-3};\ r_2 = 10 \times 10^{-3}$$

$$R = \frac{\sqrt{r_1 r_2 \frac{B_{out}}{B_{in}}}}{10^{-3}} = 5.34522$$

**142, Final, Q25**

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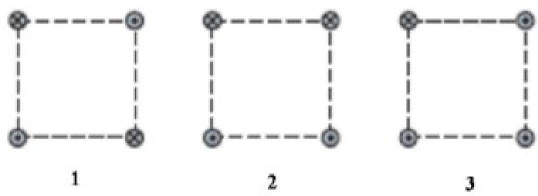
Q22.

**Figure 10** shows three arrangements in which long parallel wires carry equal currents directly into or out of the page at the corners of identical squares. Rank the arrangements according to the magnitude of the net magnetic field at the center of the square, greatest first.

Figure 10




A) 2, 3, 1
B) 1, 3, 2
C) 3, then 1 and 2 tie
D) 1 and 2 tie, 3
E) 3, 2, 1

**Ans:**

$$B = \frac{\mu_0 i}{2\pi r}$$

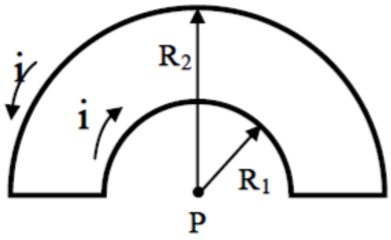
*The direction of B is given by right hand rule.*

**141, Final, Q22**

**Q23.**

In **Figure 11**, a closed loop carries a current $i$ = 0.40 A. The loop consists of two straight wires and two concentric circular arcs of radii $R_1$ = 4.0 m and $R_2$ = 8.0 m. What is the magnetic field at the center P?

Figure 11




A) $1.6\times10^{-8}$ T, into the page
B) $1.6\times10^{-8}$ T, out of the page
C) $4.8\times10^{-8}$ T, into the page
D) $4.8\times10^{-8}$ T, out of the page
E) $3.2\times10^{-8}$ T, into the page

**Ans:**

$$B_P = \frac{\mu_0 i\phi}{4\pi}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\phi = \pi\ rad \ \Rightarrow B_P = 1.6\times10^{-8}\ T$$

**141, Final, Q23**

**Q24.**

Two long parallel wires, separated by a distance of 5.0 cm, carry currents in the same direction. If $I_1$ = 5.0 A and $I_2$= 8.0 A, the magnitude of the force per unit length exerted on each wire by the other is:

**Ans:**

$$F = \frac{\mu_0 L\ I_1 I_2}{2\pi d} \Rightarrow \frac{F}{L} = 1.6\times10^{-4}\ N/m$$

**141, Final, Q24**

**Q25.**

A solenoid is 95 cm long and has a diameter of 4.0 cm and 1200 turns. It carries a current of 3.6 A. The magnitude of the magnetic field inside the solenoid at a distance 1.5 cm from its center is:

**Ans:**

$$B = \mu_0 n i = \mu_0 \frac{N}{L} i = 5.7\ mT$$

**141, Final, Q25**

**Q26.**

A long wire carrying 50 A is perpendicular to the magnetic field lines of a uniform magnetic field of magnitude 2.5 mT. The net magnetic field at a point is zero. Find the distance of the point from the wire.

**Ans:**

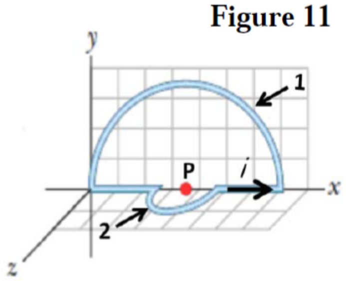
$$B = \frac{\mu_0 i}{2\pi d} \Rightarrow d = \frac{\mu_0 i}{2\pi B} = 4.0\times10^{-3}\ m$$

**141, Final, Q26**

**Q23.**

The loop shown in **FIGURE 11** consists of two semicircles 1 and 2 (with the same center) and two radial lengths. The semicircle 1 lies in the xy plane and has a radius of 10.0 cm, and the semicircle 2 lies in the xz plane and has a radius of 4.00 cm. If the current $i$ in the loop is 0.500 A, what is magnitude of the magnetic field at point P, located at the center of the loops?

**Figure 11**




A) 4.23 μT
B) 3.71 μT
C) 1.37 μT
D) 2.92 μT
E) 6.45 μT

**Ans:**

$$B_{net} = B_2\vec{j} + B_1\vec{k}$$

$$B_1 = \frac{\mu_{0}i}{4R_1} = \frac{4\pi \times 10^{-7} \times 0.5}{4 \times 0.1} = 15.71 \times 10^{-7}T$$

$$B_2 = \frac{\mu_{0}i}{4R_1} = \frac{4\pi \times 10^{-7} \times 0.5}{4 \times 0.04} = 39.27 \times 10^{-7}T$$

$$|B_{net}| = \sqrt{B_1^2 + B_2^2} = \sqrt{(15.71)^2 + (39.27)^2} \times 10^{-7}T = 4.23\mu T$$

133, Final, Q23

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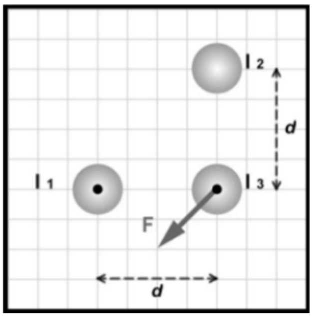
**Q24.**

**FIGURE 12** shows three long, parallel, current-carrying wires carrying equal magnitude of current. The directions of currents $I_1$ and $I_3$ are out of page. The arrow labeled **F** represents the magnetic force per unit length acting on current $I_3$ due to the other two wires and is given by $\mathbf{F} = (-0.220\ \hat{i} - 0.220\ \hat{j})$ (N/m) . What are the magnitude and direction of the current $I_2$, if the distance d = 1.00 mm?

**Figure 12**




A) 33.2 A, into the page
B) 33.2 A, out of the page
C) 22.1 A, into the page
D) 22.1A, out of the page
E) 11.4 A, out of the page

**Ans:**

$$F = -0.22\vec{i} - 0.22\vec{j} = F_{13}\vec{i} - F_{23}\vec{j}$$

$$|F_{23}| = 0.22 = \frac{\mu_0 i^2}{2\pi d} = \frac{{}^{2}4\pi \times 10^{-7}}{2\pi} \times \frac{i^2}{d}$$

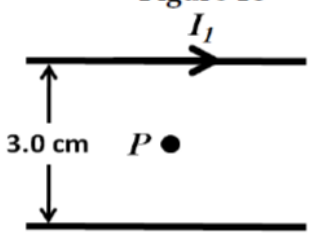
$$i = \sqrt{\frac{0.22 \times d}{2 \times 10^{-7}}} = \sqrt{\frac{0.22 \times 10^{-3}}{2 \times 10^{-7}}} = 33.2 \text{ A into the page}$$

133, Final, Q24

**Q25.**

Two infinitely long current-carrying wires are parallel to each other, as shown in **FIGURE 13**. The magnetic field at point P, which is midway between them, is 0.12 mT out of the page. If the current $I_1$ = 12 A, what is magnitude and direction of $I_2$?

Figure 13




A) 21 A, to the right
B) 21 A, to the left
C) 3.0 A, to the right
D) 3.0 A, to the left
E) 15 A, to the left

**Ans:**

$$B_{net} = -0.12 \times 10^{-3} T = B_1 + B_2$$

$$B_2 = -0.12 \times 10^{-3} - B_1$$

$$B_1 = \frac{\mu_0 i_1}{2\pi d} = \frac{\overset{2}{\cancel{4\pi}} \times 10^{-7} \times 12}{\cancel{2\pi} \times 0.015} = 16 \times 10^{-5}\, T$$

$$B_2 = 0.12 \times 10^{-3} + 0.16 \times 10^{-3} = 0.28 \times 10^{-3}$$

$$B_{12} = \frac{\mu_0 i_2}{2\pi d} \Rightarrow i_2 = \frac{2\pi d B_2}{\mu_0} = \frac{\cancel{2\pi} d B_2}{\underset{2}{\cancel{4\pi}} \times 10^{-7}}$$

$$i_2 = \frac{dB_2}{2 \times 10^{-7}} = \frac{0.015 \times 0.28 \times 10^{-3}}{2 \times 10^{-7}} = 21A$$

**133, Final, Q25**

**Q26.**

Which of the solenoids described below has the **greatest** magnetic field along its axis?

A) a solenoid of length 2L, with 2N turns and a current 2I
B) a solenoid of length L, with N turns and a current I
C) a solenoid of length L, with N/2 turns and a current I
D) a solenoid of length L/2, with N/2 turns and a current I
E) a solenoid of length 2L, with N turns and a current I/2

**133, Final, Q26**

**Q27.**

A cylindrical conductor of radius R = 2.50 cm carries a 2.50 A current along its length. This current is uniformly distributed throughout the cross sectional area of the conductor. Find the distances from the center of the wire (inside and outside the wire) at which the value of magnitude of magnetic field equals half of its maximum value.

**Ans:**

$$B_{out} = \frac{\cancel{\mu_0 i}}{\cancel{2\pi} R_{com}} = \frac{1}{2}\left(\frac{\cancel{\mu_0 i}}{\cancel{2\pi} R}\right) = \frac{1}{2} B_{max} \Rightarrow \frac{1}{R_{com}} = \frac{1}{2R}$$

$$R_{out} = 2R = 2 \times 2.50 = 5.0\ cm$$

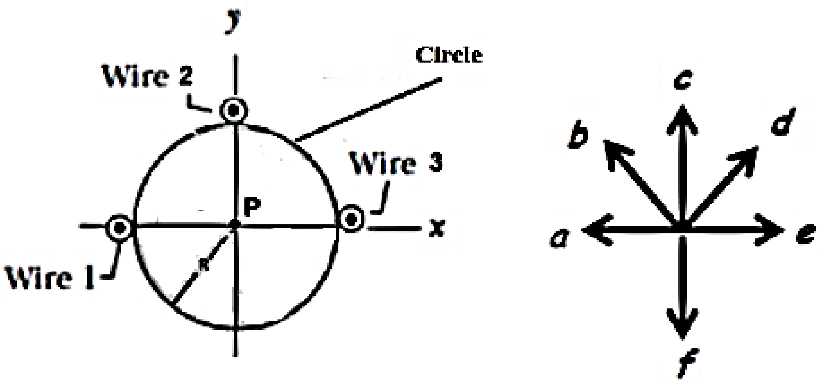
$$B_{in} = \left(\frac{\cancel{\mu_0 i}}{\cancel{2\pi} \cancel{R^2} R}\right) r = \frac{B_{max}}{2} = \frac{1}{2} \times \frac{\cancel{\mu_0 i}}{\cancel{2\pi R}} \Rightarrow \frac{r}{R} = \frac{1}{2} \Longrightarrow r = \frac{R}{2} = \frac{2.50}{2} = 1.25\ cm$$

$B_{in}$ at r = 1.25 cm, $B_{out}$ at r = 5.00 cm

**133, Final, Q27**

Q11.
**Figure 7** shows cross-sectional view of three long parallel straight wires held along a circumference of a circle of radius R = 20.0 cm, located in the plane of the page. All wires are perpendicular to the plane of the page and each wire carries 60.0 mA current out of the page. Determine the magnitude and direction of net magnetic field at point P at the center of the circle.

Fig#




A) $6.00 \times 10^{-8}$ T along direction of e
B) $4.23 \times 10^{-8}$ T along direction of e
C) $6.11 \times 10^{-3}$ T along direction of e
D) $1.23 \times 10^{-7}$ T along direction of c
E) $2.00 \times 10^{-5}$ T along direction of a

**132, Final, Q11**

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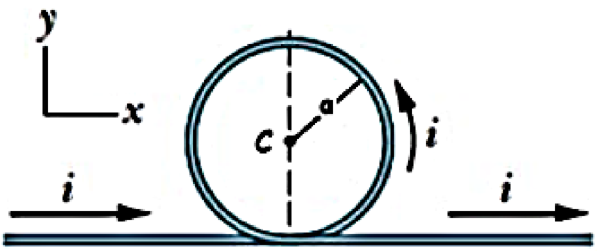
Q12.
A single piece of wire carrying current $i$=3.2 A is bent so it to form a circular loop of radius $a$, as shown in **Figure 8**. If magnitude of the net magnetic field at the loop center is $5.0 \times 10^{-5}$ T, determine the radius $a$ of the circular loop.

Fig#




A) 5.3 cm
B) 7.5 cm
C) 8.2 cm
D) 9.1 cm
E) 1.3 cm

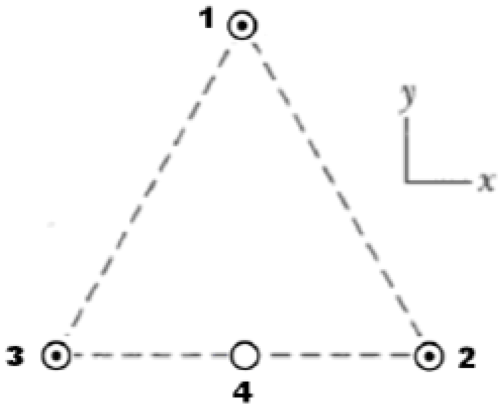
**132, Final, Q12**

---

Q13.

Three long wires 1,2 and 3 are parallel to a z axis, and each carries a current of 2.0 A in the positive z direction (out of page). Their point of intersection with the xy plane form an equilateral triangle with sides of 50 cm, as shown in **Figure 9**. A fourth wire (wire **4**) passes through the midpoint of the base of the triangle and is parallel to the other three wires. If the net magnetic force on wire **1** is zero, what is the magnitude and direction of the current in wire **4**?

Fig#




A) 3.0 A, into the page
B) 3.0 A, out of the page
C) 6.0 A, into the page
D) 6.0 A, out of the page
E) 4.3 A, into the page

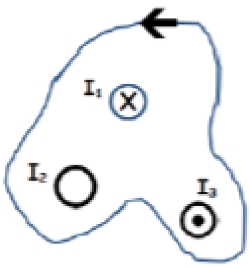
**132, Final, Q13**

---

Q14.

**Figure 10** shows cross sectional areas of three conductors that carry current through the plane of the Figure. The currents have the magnitude $I_1$=6.0 A and $I_3$=2.0 A and directions as shown. If the value of the line integral $\int \vec{B}.d\vec{s}$ is $+3.8 \times 10^{-6}$ T.m, what is magnitude and direction of current $I_2$. The integral involves going around the path in the counterclockwise direction, as shown in the figure.

Fig#




A) 7.0 A out of the page
B) 6.0 A into the page
C) 5.0 A out of the page
D) 8.0 A into the page
E) 9.0 A out of the page

**132, Final, Q14**

Q15.
A 1.0 m long solenoid is 10.0 cm in diameter and carries 51.9 A current to produce 0.15 Tesla magnetic field inside the solenoid (Assume solenoid to be ideal). Determine the number of turns in the solenoid.

A) $2.30 \times 10^3$
B) $3.73 \times 10^3$
C) $1.81 \times 10^2$
D) $5.33 \times 10^6$
E) $1.01 \times 10^2$

132, Final, Q11

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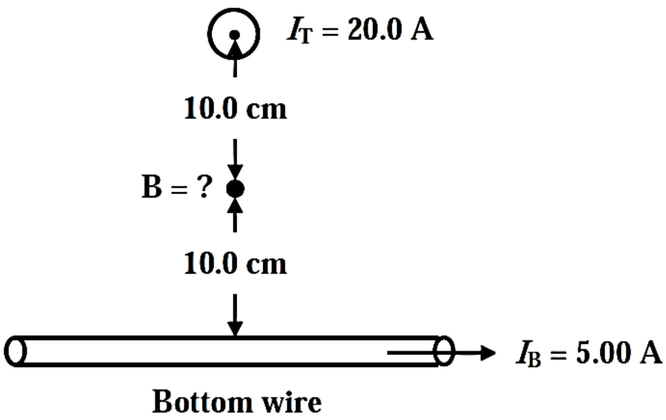
Q23.
Two long wires are oriented so that they are perpendicular to each other, as shown in **FIGURE 5**. What is the magnitude of the magnetic field at a point midway between them if the top one carries a current of 20.0 A, and the bottom one carries a current of 5.00 A?

Fig#

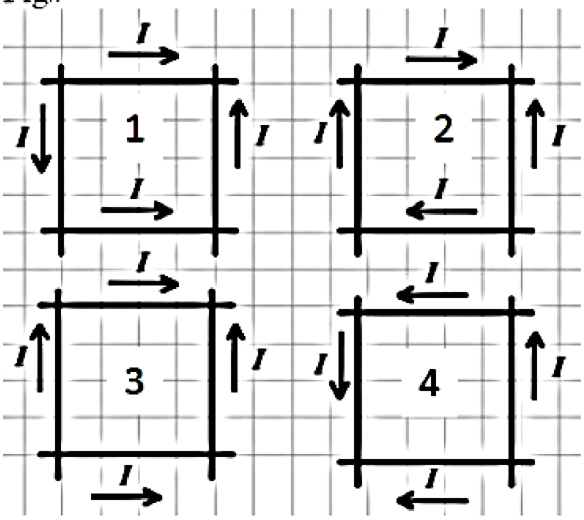



A) $4.12 \times 10^{-5}$ T
B) $5.22 \times 10^{-3}$ T
C) $3.02 \times 10^{-5}$ T
D) $7.47 \times 10^{-3}$ T
E) $6.25 \times 10^{-6}$ T

131, Final, Q23

Q24.
**FIGURE 6** shows four different sets of wires that cross each other without touching. The magnitude of the current is the same in all four cases, and the directions of current flow are as indicated. For which configuration will the magnetic field at the center of the square formed by the wires be equal to zero?

Fig#




A) 3
B) 1
C) 2
D) 4
E) The filed is equal to zero in all four cases

**131, Final, Q24**

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Q25.
A wire with a weight per unit length of 0.080 N/m is suspended directly above a second parallel wire. The top wire carries a current of 30 A, and the bottom wire carries a current of 60 A. Find the separation between the wires so that the top wire will be held in place by magnetic repulsion.

A) 4.5 mm
B) 2.1 mm
C) 5.3 mm
D) 7.5 mm
E) 1.7 mm

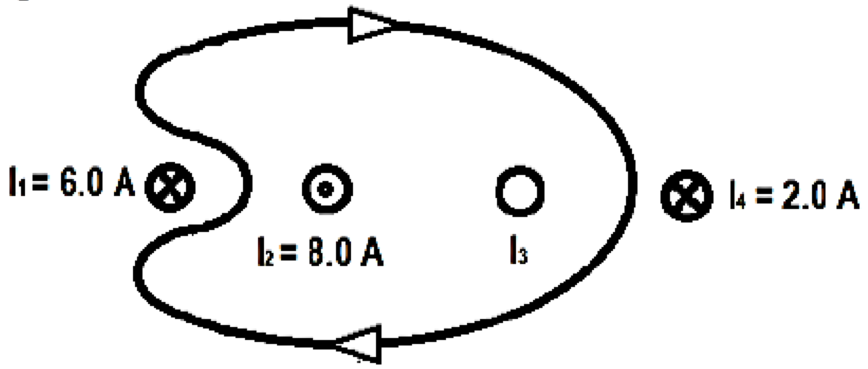
---

**131, Final, Q25**

Q26.

The value of the line integral $\oint \vec{B}.d\vec{s}$ around the closed path in FIGURE 8 is $1.4 \times 10^{-5}$ T.m. What are the direction and magnitude of $I_3$?

Fig#




A) 19 A, into the page
B) 19 A, out of the page
C) 3.1 A, out of the page
D) 3.1 A, into the page
E) 8.0 A, into the page

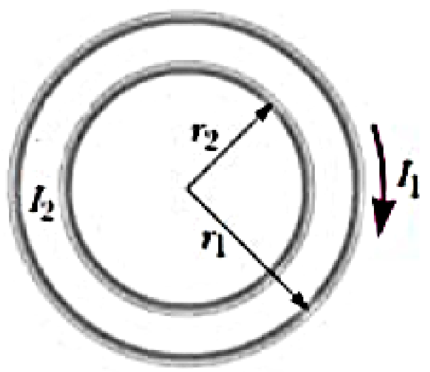
**131, Final, Q26**

---

Q27.

Two coplanar and concentric circular loops of wire carry currents of $I_1 = 6.0$ A and $I_2 = 3.0$ A, as shown in FIGURE 7. If $r_1 = 12$ cm. What are the value of $r_2$ and the direction of $I_2$ such that the net magnetic field at the center of the two loops is zero?

Fig#



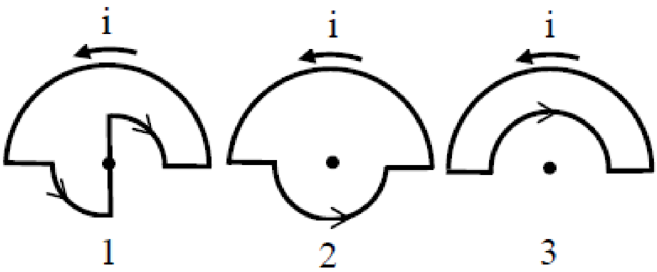

A) $r_2 = 6.0$ cm, Counterclockwise
B) $r_2 = 6.0$ cm, Clockwise
C) $r_2 = 3.0$ cm, Counterclockwise
D) $r_2 = 3.0$ cm, Clockwise
E) $r_2 = 4.0$ cm, Counterclockwise

**131, Final, Q27**

**Q23.**

**Figure 11** shows three circuits consisting of straight radial lengths and concentric circular arcs (either half- or quarter-circles of radii $r$ or $2r$). The circuits carry the same current in the indicated direction. Rank the circuits according to the magnitude of the magnetic field produced at the center of curvature (the dot), greatest first.

**Figure 11**




A) B2, B1, B3
B) B1, B2, B3
C) B3, B2, B1
D) B2, B3, B1
E) B1, B3, B2

**Ans:**

1: Contribution from the big circle only
2: Contribution from both circles
3. Inner circle cancels some of the outer

**123, Final, Q23**

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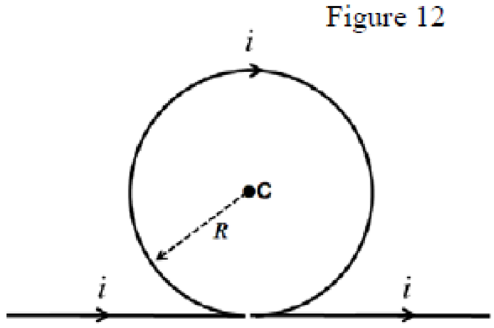
**Q24.**

A wire is bent as shown in **FIGURE 12**, and carries a current $i$ = 15 mA along the indicated directions. What is the magnitude of the magnetic field at the center of the loop, C, if the radius of the loop is $R$ = 5.0 cm?

Figure 12




A) $1.3 \times 10^{-7}$ T
B) $3.3 \times 10^{-6}$ T
C) $1.1 \times 10^{-8}$ T
D) $3.1 \times 10^{-7}$ T
E) $5.3 \times 10^{-8}$ T

**Ans:**

$$\text{Straight: } B_1 = \frac{\mu_0 i}{2\pi R} = \frac{4\pi \times 10^{-7} \times 15 \times 10^{-3}}{2\pi \times 5.0 \times 10^{-2}} = 6.0 \times 10^{-8}\ \text{T}$$

→ Out of page

$$\text{Circle: } B_2 = \frac{\mu_0 i \phi}{4\pi R} = \frac{4\pi \times 10^{-7} \times 15 \times 10^{-3} \times 2\pi}{4\pi \times 5.0 \times 10^{-2}} = 18.8 \times 10^{-8}\ \text{T}$$

→ Into page

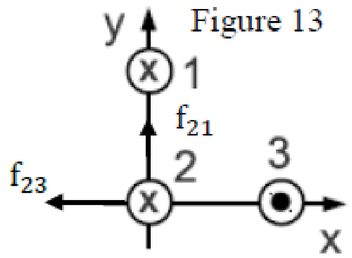
$B_c = B_2 - B_1 = 12.8 \times 10^{-8}$ T → into the page

**123, Final, Q24**

**Q25.**

Three long wires have currents flowing perpendicular to the page with directions as indicated in **FIGURE 13**. Wire 1 is at $y = 2.0$ m on the $y$-axis, wire 2 is located at the origin, and wire 3 is at $x = 2.0$ m on the $x$-axis. If $I_1 = 1.0$ A, $I_2 = 2.0$ A, and $I_3 = 3.0$ A, what is the magnitude of the net force per unit length on wire 2 due to the other two wires?

A) $6.3 \times 10^{-7}$ N/m
B) $5.3 \times 10^{-5}$ N/m
C) $5.3 \times 10^{-9}$ N/m
D) $3.6 \times 10^{-7}$ N/m
E) $1.3 \times 10^{-7}$ N/m




**Ans:**

f = force per unit lenght

$$f_{21} = \frac{\mu_0 I_1 I_2}{2\pi d} = \frac{4\pi \times 10^{-7} \times 1.0 \times 2.0}{2\pi \times 2.0} = 2.0 \times 10^{-7} \frac{N}{m}$$

$$f_{23} = \frac{\mu_0 I_2 I_3}{2\pi d} = \frac{4\pi \times 10^{-7} \times 2.0 \times 3.0}{2\pi \times 2.0} = 6.0 \times 10^{-7} \frac{N}{m}$$

$$f_{2,net} = \sqrt{4.0 + 36} \times 10^{-7} = 6.3 \times 10^{-7} \frac{N}{m}$$

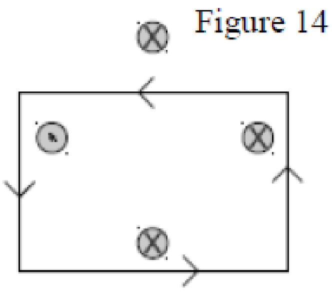
**123, Final, Q25**

---

**Q26.**

Each of the four wires in **Figure 14** carries a 2.0 A current into or out of the page. What is the value of the line integral $\oint \vec{B}.d\vec{s}$ for the indicated path of integration?

A) $-2.5 \times 10^{-6}$ T.m
B) $+2.5 \times 10^{-6}$ T.m
C) $-1.5 \times 10^{-7}$ T.m
D) $+1.5 \times 10^{-7}$ T.m
E) $+5.5 \times 10^{-6}$ T.m




**Ans:**

$$i_{enc} = +2.0 - 2.0 - 2.0 = -2.0 \text{ A}$$

$$\oint \vec{B} . d\vec{s} = \mu_0 . i_{enc} = -2.5 \times 10^{-6} \text{ (T. m)}$$

**123, Final, Q26**

---

**Q27.**

A solenoid with N turns carries a current of 12 A and has a length of 43 cm. If the magnitude of the magnetic field generated at the center of the solenoid is 90 mT, what is the value of *N*?

**Ans:**

$$B = \mu_0 ni = \frac{\mu_0 Ni}{L}$$

$$\Rightarrow N = \frac{BL}{\mu_0 i} = \frac{90 \times 10^{-3} \times 43 \times 10^{-2}}{4\pi \times 10^{-7} \times 12} = 2.6 \times 10^3$$

**123, Final, Q27**

---

**Q24.**

A long, straight, cylindrical conductor of radius R = 12.0 mm carries a current I uniformly distributed over its cross section. If the magnitude of the magnetic field produced at a distance r = 24.0 mm is 0.100 mT, then what is the magnitude of the magnetic field at a distance r = 6.00 mm?

**Ans:**

$$B_0 = \frac{\mu_0 i}{2\pi r}, \text{at } r = 24 \text{ mm}; \quad B = 0.1 \times 10^{-3} = \frac{4\pi \times 10^{-7}}{2\pi\left(\frac{24}{1000}\right)^2} \Rightarrow i = 12 \text{ A}$$

$$B_i = \frac{\mu_0 i}{2\pi R^2} r = \frac{4\pi \times 10^{-7} \times 12}{2\pi\left(\frac{12}{1000}\right)^2} \times \left(\frac{6}{1000}\right) = 1 \times 10^{-4} = 0.1 \text{ mT}$$

**122, Final, Q24**

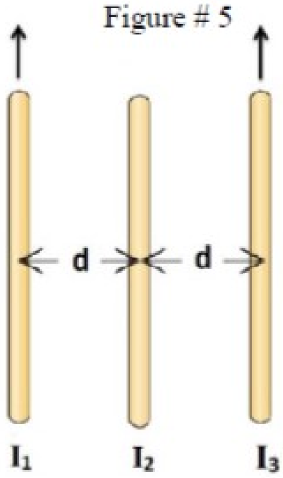
---

**Q25.**

Figure 5 shows three parallel wires separated by a distance d = 0.44 m. The currents are $I_1$= 8.54 A and $I_3$= 6.51 A. Calculate the magnitude and the direction of the current $I_2$ such that the net force per unit length exerted by wire 1 and wire 2 on wire 3 is zero?

A) 4.27 A downward
B) 3.26 A downward
C) 2.81 A upward
D) 5.81 A downward
E) 7.54 A upward

Figure # 5




**Ans:**

$$\frac{F_{13}}{l} + \frac{F_{23}}{l} = 0$$

$$\Rightarrow \frac{\mu_0 I_1 I_s}{2\pi(2d)} + \frac{\mu_0 I_2 I_s}{2\pi d} = 0$$

$$\Rightarrow \frac{I_1}{2} = -I_2 \Rightarrow I_2 = 4.27 \text{ A downward}$$

**122, Final, Q25**

**Q26.**

Two long ideal solenoids with radii 20 mm and 30 mm have the same number of turns per unit length. The smaller solenoid is mounted inside the larger one, along a common axis. The net magnetic field within the inner solenoid is zero. The current in the inner solenoid must be:

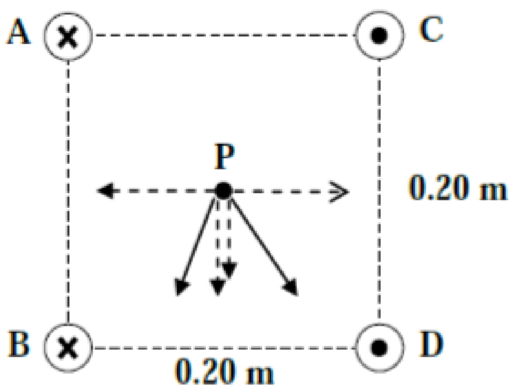
A) the same as the current in the outer solenoid
B) one-third the current in the outer solenoid
C) twice the current in the outer solenoid
D) half the current in the outer solenoid
E) two-thirds the current in the outer solenoid

**122, Final, Q26**

**Q27.**

Four long, parallel wires carry equal currents I = 5.0 A as shown in Figure 6. Currents in wire A and wire B are directed into the page while currents in wire C and wire D are out of the page. Calculate the magnitude and direction of the net magnetic field at point P, located at the center of the square with edge of length 0.20 m.

Figure # 6




A) 20 μT toward the bottom of the page
B) 10 μT toward the left of the page
C) 30 μT toward the right of the page
D) 40 μT toward the top of the page
E) 0

**Ans:**

The horizontal components of the net magnetic field will cancel out the vertical components (downward) will add up.

$$B = 4\left(\frac{\mu_0 i}{2\pi r}\right)\cos 45^\circ$$

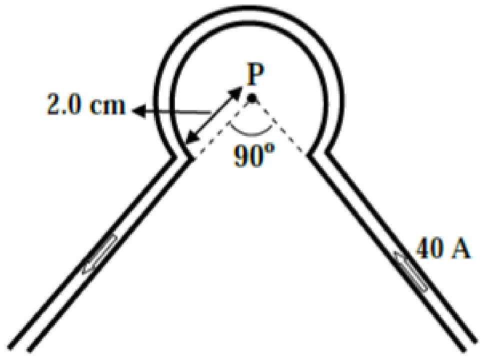
$$= 4\left(\frac{4\pi \times 10^{-7} \times 5}{2\pi \times \sqrt{2}\,(0.1)}\right)\cos 45^\circ = 2 \times 10^{-5}\ \text{T} = 20\mu\text{T}$$

**122, Final, Q27**

**Q28.**

The wire shown in Figure 7 carries a current of 40 A. Find both the magnitude and the direction of the magnetic field at point P.

Figure # 7




122, Final, Q28

**Ans:**

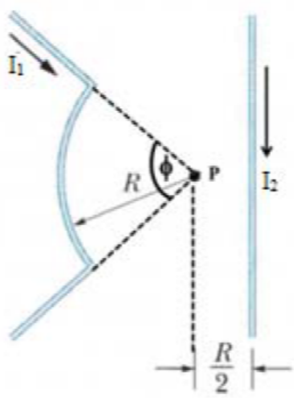
$$B = \frac{\mu_0 i}{4\pi R}\varphi = \frac{(4\pi \times 10^{-7})(40)}{4\pi(0.02)}\frac{3\pi}{2} = 9.4 \times 10^{-4} = 0.94 \text{ mT out of the page}$$

---

**Q24.**

Figure 10 shows two wires each carrying a current in the direction indicated in the figure. Wire 1, which consists of a circular arc of radius R and two radial lengths, carries a current $I_1$= 1.5 A. Wire 2 is long and straight; carries a current $I_2$= 0.4 A and is at a distance R/2 from the center of the arc. For what value of arc angle ϕ the net magnetic field B at point P due to the two currents is zero?

Figure 10




A) $61^0$
B) $55^0$
C) $75^0$
D) $70^0$
E) $51^0$

**Ans:**

$\vec{B}_1$ is out of the page

$\vec{B}_2$ is into the page

$\vec{B}_{net} = 0 \Rightarrow B_1 = B_2$

$$\frac{\mu_0 I_1}{4\pi R}\phi = \frac{\mu_0 I_2}{2\pi\left(\frac{R}{2}\right)}$$

$$\phi = \frac{4I_2}{I_1} = 1.067 \text{ rad} = 61.1\,°$$

121, Final, Q24

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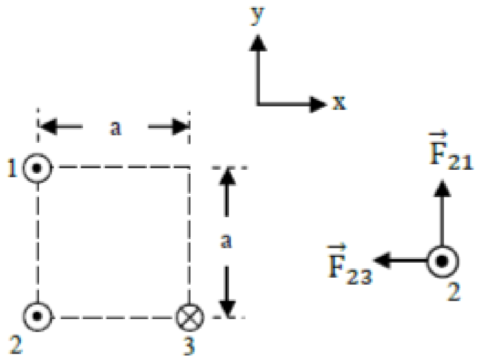
**Q25.**

Three long straight wires are perpendicular to the page. Each wire carries a current of 15 A and are arranged at the three corners of a square of edge length $a = 1.0$ cm, as shown in Figure 11. Find the magnitude of net magnetic force per unit length (in N/m) on wire 2 due to wires 1 and 3.

A) $6.4 \times 10^{-3}$
B) $4.6 \times 10^{-3}$
C) $3.4 \times 10^{-2}$
D) $4.3 \times 10^{-2}$
E) $5.1 \times 10^{-3}$

**Figure 11**




**Ans:**

$$\frac{F_{21}}{l} = \frac{\mu_0 I^2}{2\pi a} = \frac{F_{23}}{l}$$

$$= \frac{4\pi \times 10^{-7} \times (15)^2}{2\pi(0.01)} = 4.5 \times 10^{-3}$$

$$\frac{F_{net}}{l} = \frac{F_{21}}{l}\sqrt{2} = 6.4 \times 10^{-3}\ \text{N/m}$$

121, Final, Q25

---

**Q26.**

A long, straight wire carries a 3.0 A current. This current creates a magnetic field of strength 1.0 T at the surface of the wire. If the wire has a radius R, where within the wire is the magnetic field strength 0.36 T? (Assume the current density is uniform throughout the wire)

A) 0.36 R
B) 0.18 R
C) 0.64 R
D) 0.72 R
E) 0.26 R

**Ans:**

$$B_{surface} = \frac{\mu_0 I}{2\pi R} \qquad B_{inside} = \frac{\mu_0 I}{2\pi R^2} r = B_{surface} \times \left(\frac{r}{R}\right)$$

$$B_{inside} = B_{surface} \times \frac{r}{R} \Rightarrow 0.36 = 1 \times \frac{r}{R}$$

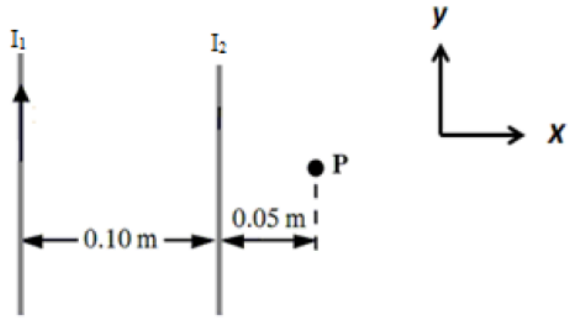
$$\Rightarrow r = 0.36\ R$$

121, Final, Q26

Q27.

Two long, straight wires, separated by 0.10 m, carry currents $I_1$ and $I_2$ as shown in Figure 12. If current $I_1$=18 A and the resultant magnetic field due to these two current carrying wires at point P is zero, then the magnitude and direction of $I_2$ is:

Figure 12




A) 6.0 A, along the negative y-axis
B) 6.0 A, along the positive y-axis
C) 54 A, along the negative y-axis
D) 54 A, along the positive y-axis
E) 9.0 A, along the positive y-axis

**Ans:**

$B_1$ is inside, $B_2$ should be outside

$\Rightarrow$ $i_2$ should be along the negative y − axis

$B_P = 0 = B_2 - B_1$

$\Rightarrow B_2 = B_1$

$$\frac{\mu_0 I_2}{2\pi r_2} = \frac{\mu_0 I_1}{2\pi r_1}$$

$$I_2 = I_1 \frac{r_2}{r_1} = 18 \times \frac{0.05}{0.15} = 6 \text{ A}$$

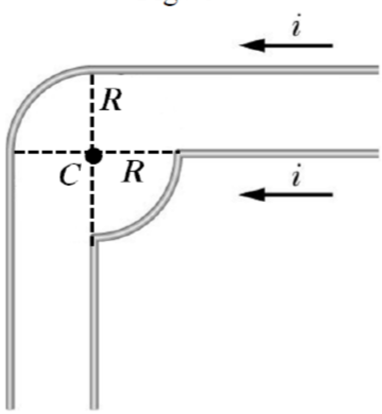
121, Final, Q27

---

**Q23.**

In **FIGURE 9**, two infinitely long wires carry currents $i$. Each follows a 90° 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)?

Fig# 8




A) $\frac{\mu_o i}{2\pi R}$

B) $\frac{\mu_o i}{\pi R}$

C) $\frac{\mu_o i}{4\pi R}$

D) $\frac{\mu_o i}{2\pi R} + \frac{\mu_o i}{16R}$

E) $\frac{\mu_o i}{\pi R} + \frac{\mu_o i}{16R}$

**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:

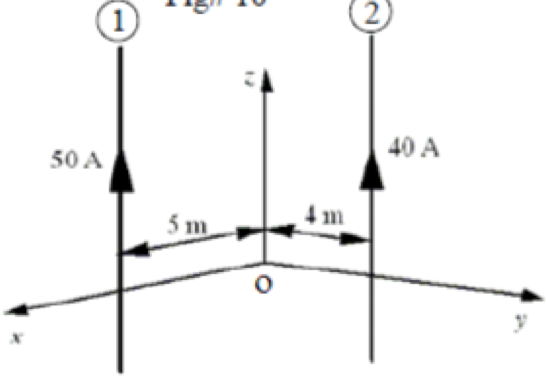
$B_c = 2 \times$ semi − infinite wires

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

113, Final, Q23

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

Ans:

$$\vec{B}_1 = \frac{\mu_0 i_1}{2\pi d_1}\left(-\hat{j}\right)$$

$$= \frac{4\pi\times10^{-7}\times50}{2\pi\times5}\left(-\hat{j}\right) = -2\times10^{-6}\hat{j}(T) = -2\hat{j}\ (\mu T)$$

$$\vec{B}_2 = +\frac{\mu_0 i_2}{2\pi d_2}\hat{i}$$

$$= \frac{4\pi\times10^{-7}\times40}{2\pi\times4}\left(\hat{i}\right) = +2\hat{i}\ (\mu T)$$

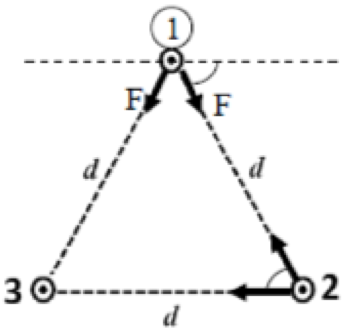
$$\therefore \vec{B}_{net} = \left(2\hat{i}-2\hat{j}\right)\mu T$$

**113, Final, Q24**

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:

$$F = \frac{\mu_0 L i^2}{2\pi d} = \frac{4\pi\times10^{-7}\times2\times25}{2\pi\times6\times10^{-3}}$$

$$= 1.67\times10^{-3}\ N$$

$$F_{net} = 2.F.\sin60 = 2.9\times10^{-3}\ N$$

**113, Final, Q25**

**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 A/cm$^2$, what is the magnitude of the magnetic field at a distance of 2.5 mm from the axis of the wire?

**Ans:**

**113, Final, Q26**

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

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

---

**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 $N$?

**Ans:**

$$B = \mu_0 n_i = \frac{\mu_0 N_i}{L}$$

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

**113, Final, Q27**

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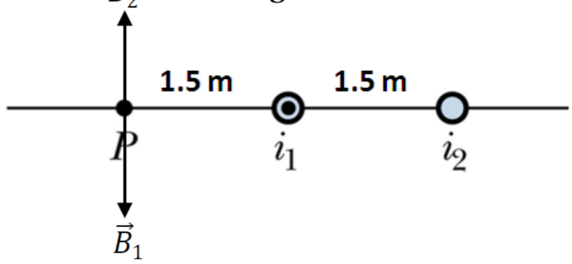
**Q23.** **FIGURE 8** shows cross sections of two long straight wires. The left hand wire carries current $i_1$ = 5.0 A, directed out of the page. In order to produce a zero net magnetic field at point P, what should be the current $i_2$?

A) 10 A, into the page
B) 10 A, out of the page
C) 2.5 A, into the page
D) 2.5 A, out of the page
E) 5.0 A, into the page

**Fig# 8**




**Ans:**

$\vec{B}_1$ is down $\therefore$ $\vec{B}_2$ must be up

$\Rightarrow i_2$ must be into the page

For cancellation: $B_1 = B_2$

$$\frac{\mu_0 i_1}{2\pi d} = \frac{\mu_0 i_2}{(2\pi)(2d)} \Rightarrow i_2 = 2 i_1 = 10\ A$$

**112, Final, Q23**

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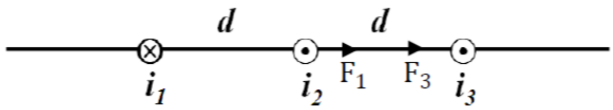
**Q24.** Three long parallel wires are arranged as shown in **FIGURE 9**, where **d** = 50 cm. The current into the page is $i_1$ = 3.0 A. The currents out of the page are $i_2$ = 0.25 A and $i_3$ = 4.0 A. What is the magnitude of the net force per unit length acting on the wire carrying current $i_2$ due to the currents in the other wires?

**Fig# 9**

A) $7.0 \times 10^{-7}$ N/m
B) $1.0 \times 10^{-7}$ N/m
C) $1.8 \times 10^{-7}$ N/m
D) $1.0 \times 10^{-6}$ N/m
E) $2.4 \times 10^{-7}$ N/m



**Ans:**

The two forces are in the same direction.

$$\therefore\ F_{net} = F_1 + F_3 = \frac{\mu_0 i_1 i_2 L}{2\pi d} + \frac{\mu_0 i_2 i_3 L}{2\pi d}$$

$$\therefore\ \text{Force per unit lenght} : f = \frac{\mu_0 i_2}{2\pi d}(i_1 + i_3) = \frac{4\pi \times 10^{-7} \times 0.25}{2\pi \times 0.5}(3+4)$$

$$= 7.0 \times 10^{-7}\ n/m$$

**112, Final, Q24**

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**Q25.** A long straight wire carrying a 3.0-A current enters a room through a window that is 2.0 m high and 1.5 m wide. The absolute value of the path integral $\oint \vec{B}\,.\,\vec{ds}$ around the window frame is

**Ans:**

$$\oint \vec{B}\,.\,\vec{ds} = \mu_0 . z_{enc} = 4\pi \times 10^{-7} \times 3.0 = 3.8 \times 10^{-6}\ T.m$$

**112, Final, Q25**

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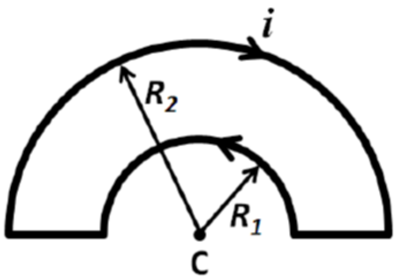
**Q26.** A current is set up in a wire loop that is formed as shown in **FIGURE 10**, where $R_1$ = 2.0 cm and $R_2$ = 4.0 cm. The loop carries a current of 5.0 A, as shown in the figure. What is the magnetic field at the center of the loop (**C**)?

**Fig# 10**




A) $3.9 \times 10^{-5}$ T out of the page
B) $3.9 \times 10^{-5}$ T into the page
C) $1.2 \times 10^{-4}$ T out of the page
D) $1.2 \times 10^{-4}$ T into the page
E) $7.9 \times 10^{-5}$ T into of the page

**Ans:**

$$B_1 = \frac{\mu_0 i_\phi}{4\pi R_1} \longrightarrow \text{out of the page}$$

$$B_2 = \frac{\mu_0 i_\phi}{4\pi R_2} \longrightarrow \text{into the page}$$

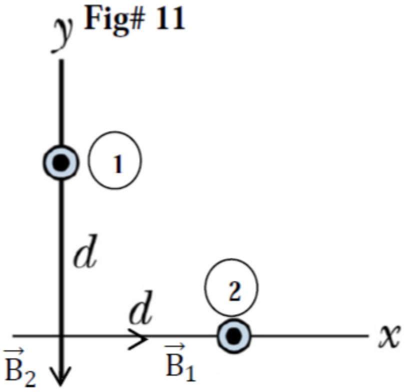
$$B_1 > B_2 \text{ because } R_2 > R_1$$

$$\therefore\ B_c = B_1 - B_2 = \frac{\mu_0 i_\phi}{4\pi}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$= \frac{4\pi \times 10^{-7} \times 5 \times \pi}{4\pi}\left(\frac{1}{2} - \frac{1}{4}\right) \times 10^2 = 3.9 \times 10^5\ T \longrightarrow \text{out of the page}$$

**112, Final, Q26**

**Q27.** Two long wires are placed in the *xy* plane, as shown in **FIGURE 11**. Each wire carries a current of 1.5 A, directed out of the page. If the distance $\boldsymbol{d}$ = 3.0 m, what is the net magnetic field due to these wires at the origin?




A) $(+0.10\hat{\mathbf{i}} - 0.10\hat{\mathbf{j}})$ (μT)

B) $(+0.10\hat{\mathbf{i}} + 0.10\hat{\mathbf{j}})$ (μT)

C) $(-0.10\hat{\mathbf{i}} - 0.10\hat{\mathbf{j}})$ (μT)

D) $(-0.10\hat{\mathbf{i}} + 0.10\hat{\mathbf{j}})$ (μT)

E) zero

**Ans:**

The direction of $\vec{B}_1$ and $\vec{B}_2$ are shown

$\Rightarrow \vec{B}_{net}$ has (+) x − component and (−) y − component

(Both components are equal in value)

$$B_i = \frac{\mu_0 i}{2\pi d} = \frac{4\pi \times 10^{-7} \times 1.5}{2\pi \times 3} = 1.0 \times 10^{-7}\ \text{T} = 0.1\ \mu\text{T}$$

**112, Final, Q27**