Welcome to the Physics class

Principles of Physics II

Lecture 22

Problems

PHY 112 (4) Summer Semester 2023

Exam on 7th September, 2023 at 11:00 am in room no UB 20204

Syllabus for TERM FINAL Examination

Chapter 25 to Chapter 30 and, Chapter 37
Capacitance to Maxwell's Equations and Relativity
HRW 10 Edition Extended

PHY112	04	Professor Dr. A. F. M. Yusuf Haider	YUH	UB20204	ST DAY 2 Friday	08-09-2023	11:00 am	12:30 pm

1125 PHY112 4 8-Sep-23 11:00 AM 1:00 PM UB20204

••36 GO In Fig. 27-47, $\mathscr{E}_1 = 6.00$ V, $\mathscr{E}_2 = 12.0$ V, $R_1 = 100\ \Omega$, $R_2 = 200\ \Omega$, and $R_3 = 300\ \Omega$. One point of the circuit is grounded ($V = 0$). What are the (a) size and (b) direction (up or down) of the current through resistance 1, the (c) size and (d) direction (left or right) of the current through resistance 2, and the (e) size and (f) direction of the current through resistance 3? (g) What is the electric potential at point A?

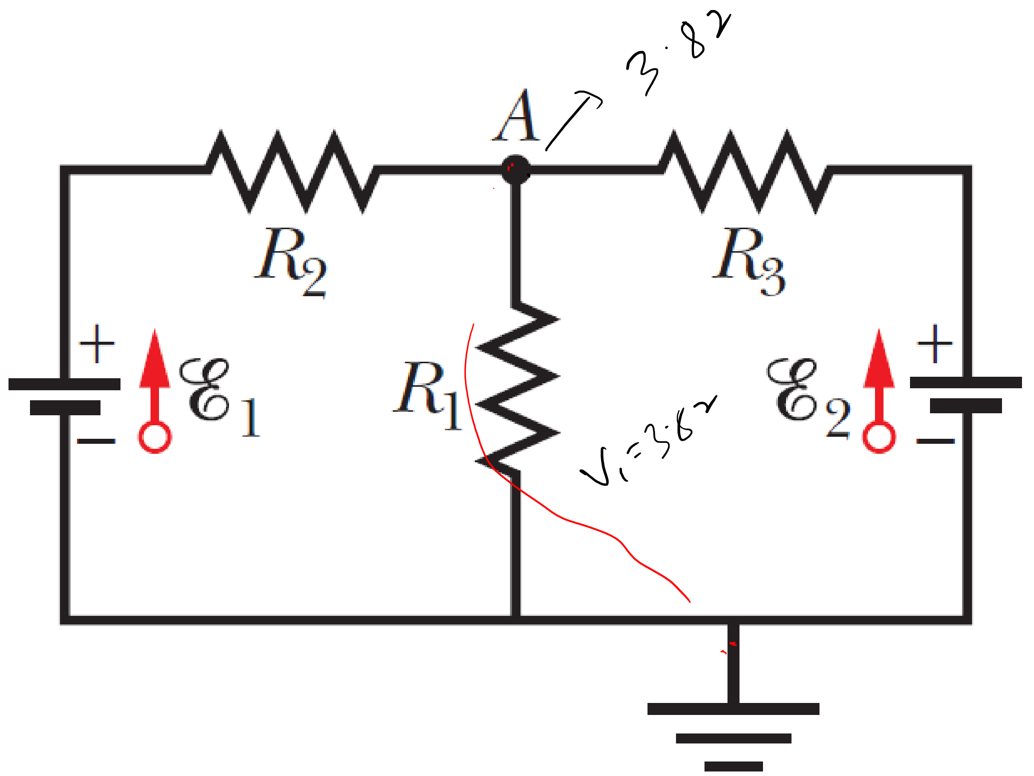
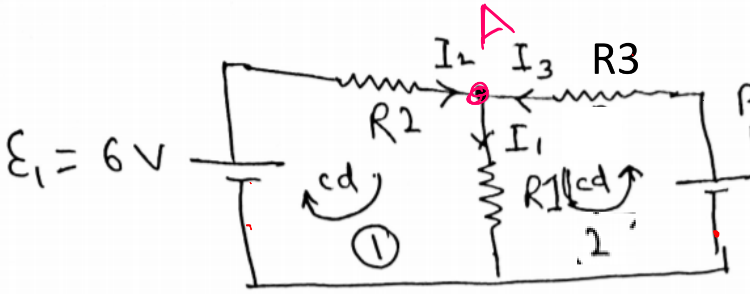


Figure 27-47 Problem 36.

do it yourself

Ch 27 / No 36



$R1 = 100\,\Omega$; $R2 = 200\,\Omega$
$R3 = 300\,\Omega$
$\mathcal{E}2 = 12V$

Junction rule at A $\quad I_1 = I_2 + I_3 \quad$ (1)

From loop 2 : $\quad \mathcal{E}2 - I_3 R3 - (I_2 + I_3) R1 = 0 \quad$ (2)

From 1 : $\quad \mathcal{E}1 - I_2 R_2 - (I_2 + I_3) R1 = 0 \quad$ (3)

Subtract (3) from (2) $\quad \mathcal{E}2 - \mathcal{E}1 + I_2 R2 - I_3 R3 = 0$

$\therefore \quad I_3 R3 - I_2 R2 = \mathcal{E}2 - \mathcal{E}1$

$300 I_3 - 200 I_2 = 12 - 6 = 6 \quad$ (4)

$\therefore \quad I_3 = \dfrac{6 + 200 I_2}{300}$

From equ^n (2) $\quad 12 - \dfrac{6 + 200 I_2}{\cancel{300}} \times \cancel{300} - \left(I_2 + \dfrac{6 + 200 I_2}{300}\right) \times 100 = 0$

$12 - 6 - 200 I_2 - 100 I_2 - 2 - \dfrac{200}{3} I_2 = 0$

$6 - 300 I_2 - 2 - 66.67 I_2 = 0$

$366.67 I_2 = 4 \Rightarrow \boxed{I_2 = 0.0109\ A}$

From eqn^n (4) $\quad 300 I3 - 200 I2 = 6$

$300 I3 = 6 + 200 \times 0.0109$

$\therefore \quad = 6 + 2.1818 = 8.1818$

$I_3 = \dfrac{8.1818}{300}$ Amp

$\therefore \quad I3 = \frac{8.1818}{300} = 0.0273$

(a) $I_1 = I_2 + I_3 = 0.0109 + 0.0273 = 0.0382$ A

(b) Current through R1 is downward.

(c) $I_2 = 0.0109$ A.

(d) Rightward (direction of I2)

(e) $I_3 = 0.0273$ A

(f) direction of I3 is leftward.

(g) The voltage across R1

$$\boxed{V1 = I1 \times R1 = 0.0382 \times 100 = 3.82\ V}$$

A long wire carries a 10 A current from left to right. An electron 1.0 cm above the wire is traveling to the right at a speed of $1 \times 10^7\ m/s$. What are the magnitude and the direction of the magnetic force on the electron?

Sol^n:-

$\vec{F}_M = q\vec{v}\times\vec{B}$ Lorentz force

we know

$$\boxed{B = \frac{\mu_0 I}{2\pi r}}$$

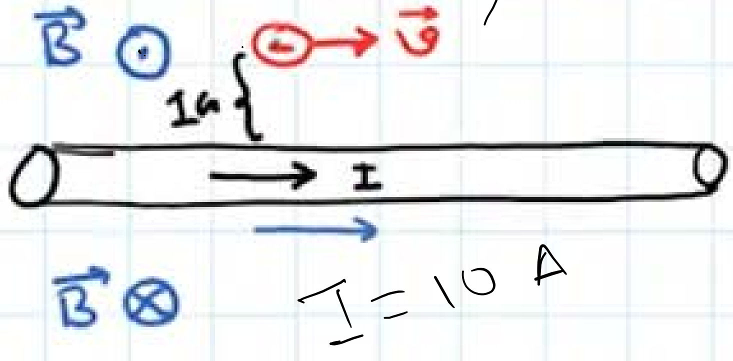
$$B = \frac{4\pi\times10^{-7}\times 10\,A}{2\pi\times 1\times10^{-2}}$$

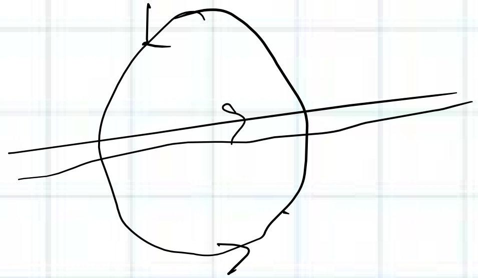
$r = 1\,cm = 1\times10^{-2}\,m$

$$\boxed{B = 2\times10^{-4}\,T}$$

$$\vec{B} = 2\times10^{-4}\,\hat{k}\,T$$

$\vec{v} = 1\times10^{7}\,\hat{i}\ m/s$





$$F_M = e\vec{v}\times\vec{B}$$

$$e = -1.6\times10^{-19}\ C$$
$$v = 1\times10^{7}\ \hat{i}$$

$$\vec{B} = 2\times10^{-4}\ \hat{k}\ T$$

$$\vec{F}_M = (-1.6\times10^{-19})\cdot\{1\times10^{7}\hat{i}\times2\times10^{-4}\hat{k}\}$$

$$\Rightarrow \vec{F}_M = -3.2\times10^{-16}(\hat{i}\times\hat{k})$$

$$\hat{k}\times\hat{i} \Rightarrow$$

$$\Rightarrow \vec{F}_M = -3.2\times10^{-16}(-\hat{j})$$

$$\Rightarrow \boxed{\vec{F}_M = 3.2\times10^{-16}\ N\ \hat{j}}$$

<u>Ans</u>

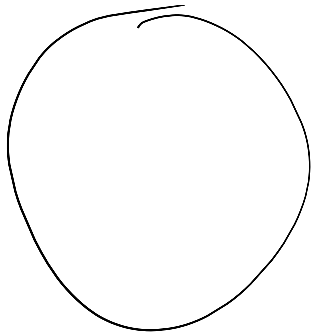
$$\hat{i}\times\hat{j} = \hat{k}$$
$$\hat{j}\times\hat{i} = -\hat{k}$$

Chapter: 28: Magnetic fields

••28 A particle undergoes uniform circular motion of radius 26.1 μm in a uniform magnetic field. The magnetic force on the particle has a magnitude of 1.60×10^{-17} N. What is the kinetic energy of the particle?

$F_c = F_B$

1.6×10^{-17}



(1)

Chapter 28 Magnetic fields

(28)

$$F_B = \frac{mv^2}{r} \qquad F_B = 1.6 \times 10^{-17}\ \text{N}$$

$$r = 26.1 \times 10^{-6}\ \text{m.}$$

$$\therefore \quad mv^2 = F_B \cdot r$$

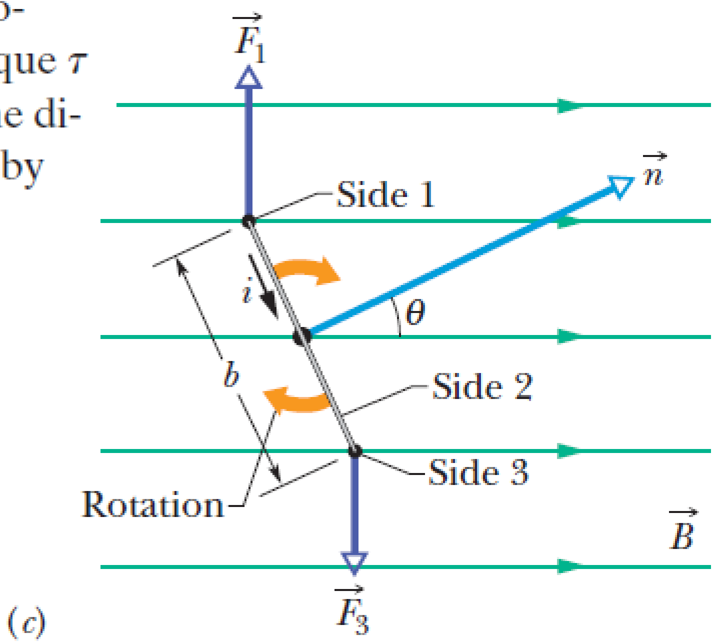
$$K = \frac{1}{2} mv^2 = \frac{1}{2} F_B r$$

$$= \frac{1}{2} \times 1.6 \times 10^{-17} \times 26.1 \times 10^{-6}$$

$$= 20.88 \times 10^{-23} \text{ Joules.}$$

•56 A circular wire loop of radius 15.0 cm carries a current of 2.60 A. It is placed so that the normal to its plane makes an angle of 41.0° with a uniform magnetic field of magnitude 12.0 T. (a) Calculate the magnitude of the magnetic dipole moment of the loop. (b) What is the magnitude of the torque acting on the loop?

Figure 28-19 A rectangular loop, of lengtl and width b and carrying a current i, is located in a uniform magnetic field. A torque τ acts to align the normal vector $\vec{n}$ with the direction of the field. (a) The loop as seen by



(c)

Circular loop of single turn $\Rightarrow N = 1$

ch 28

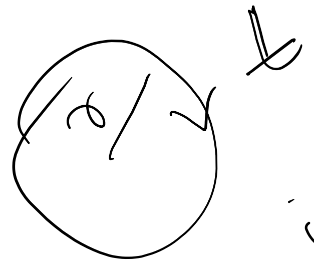
(56) (a) $\mu = NAi$ $N = 1,\ A = \pi r^2$

$\mu = 1.\pi r^2 i = \pi \times (0.15\,m)^2 \times 2.6\,A.$

$= 0.184\ A.m^2$

(b) $\tau = |\vec{\mu} \times \vec{B}| = \mu B \sin\theta$

$= 0.184 \times 12T \times \sin 41 = 1.45\ N.m.$



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

77 SSM In Fig. 28-55, an electron moves at speed $v = 100$ m/s along an x axis through uniform electric and magnetic fields. The magnetic field $\vec{B}$ is directed into the page and has magnitude 5.00 T. In unit-vector notation, what is the electric field?

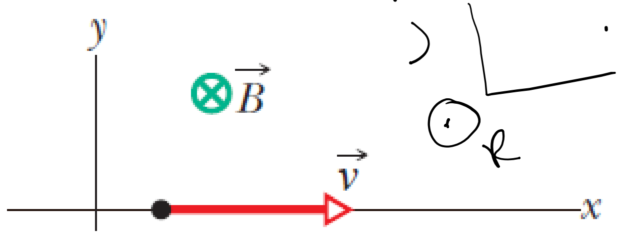


Figure 28-55 Problem 77.

77

$F_{electron} = \vec{F} = -e(\vec{E} + \vec{v} \times \vec{B})$

Condition implies $|\vec{F}| = 0$

~~$\therefore E = vB \sin 90 = vB = 100 \times 5$~~

Now $\vec{v} = v\hat{i}$ $\quad \vec{B} = B(-\hat{k})$

$\therefore v \times B = vB(\hat{i} \times (-\hat{k}))$

$= +vB\hat{j}$

$\hat{i} \times \hat{k} = -\hat{j}$

$\hat{i} \times (-\hat{k}) = \hat{j}$

$\therefore$ ~~To balance this F_B, E must be in $(-\hat{j})$ direction~~

$\therefore$ ~~$\vec{E} = -500\hat{j}$~~

$\vec{E} + \vec{v} \times \vec{B} = 0$ Since $|\vec{F}| = 0$

$\vec{E} = -\vec{v} \times \vec{B} = -vB\hat{j}$

$= -500\hat{j}$ N/C

Electron will move in a straight line under both electric field and magnetic field ⊥r to each other. In many experiments a velocity selector for charged particles with a speed given by $v = \frac{E}{B}$ can pass through. $\Rightarrow E = vB$

$v = 100$ m/sec

$B = 5$ T

$vB = 100 \times 5$

$= 500$

•11 In Fig. 29-42, two long straight wires are perpendicular to the page and separated by distance $d_1 = 0.75$ cm. Wire 1 carries 6.5 A into the page. What are the (a) magnitude and (b) direction (into or out of the page) of the current in wire 2 if the net magnetic field due to the two currents is zero at point P located at distance $d_2 = 1.50$ cm from wire 2?

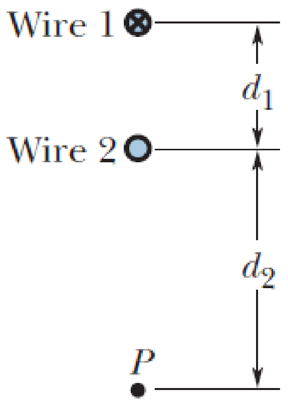


Figure 29-42 Problem 11.

1

Chapter 29

(3)

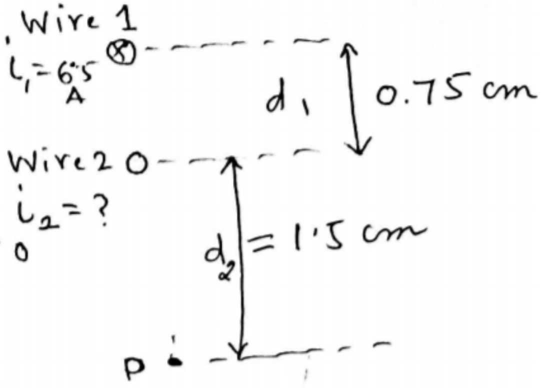
(11)

$$B_{P_1} = \frac{\mu_0 i_1}{2\pi r_1}$$

$i_1 = 6.5$ A

$r_1 = d_1 + d_2 = 0.75 + 1.50$

$= 2.25$ cm.



$$B_{P_2} = \frac{\mu_0 i_2}{2\pi r_2}$$ where $r_2 = d_2 = 1.5$ cm.

(a) Net force at P $\Rightarrow |B_{P_1}| = |B_{P_2}|$

2

$$\therefore \frac{\mu_0 i_1}{2\pi r_1} = \frac{\mu_0 i_2}{2\pi r_2}$$

$$\therefore i_2 = \left(\frac{r_2}{r_1}\right) i_1 = \left(\frac{1.5}{2.25}\right) 6.5\text{ A}$$

$$\therefore \boxed{i_2 = 4.3\text{ A}}$$

(b) Using the right-hand rule, we see that the current i_2 carried by wire 2 must be out of the page.

Chapter 29: Magnetic Fields due to current

$$B = \frac{\mu_0 i}{2\pi r} \quad \text{(outside straight wire).} \tag{29-17}$$

of the page after being rotated 90° counterclockwise as indicated?

••21 GO Figure 29-49 shows two very long straight wires (in cross section) that each carry a current of 4.00 A directly out of the page. Distance $d_1 = 6.00$ m and distance $d_2 = 4.00$ m. What is the magnitude of the net magnetic field at point P, which lies on a perpendicular bisector to the wires?

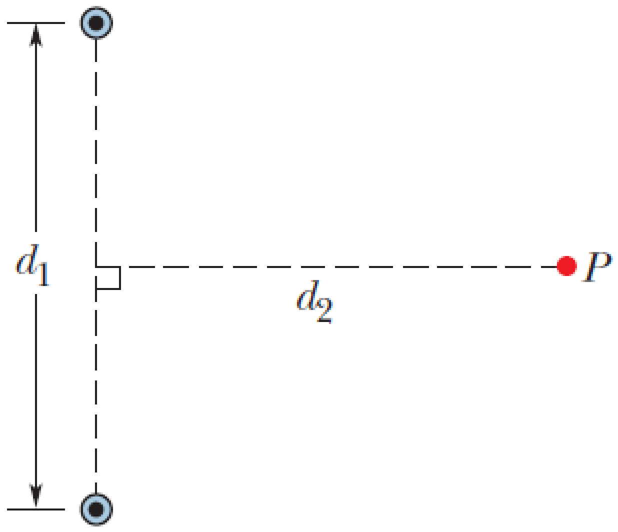
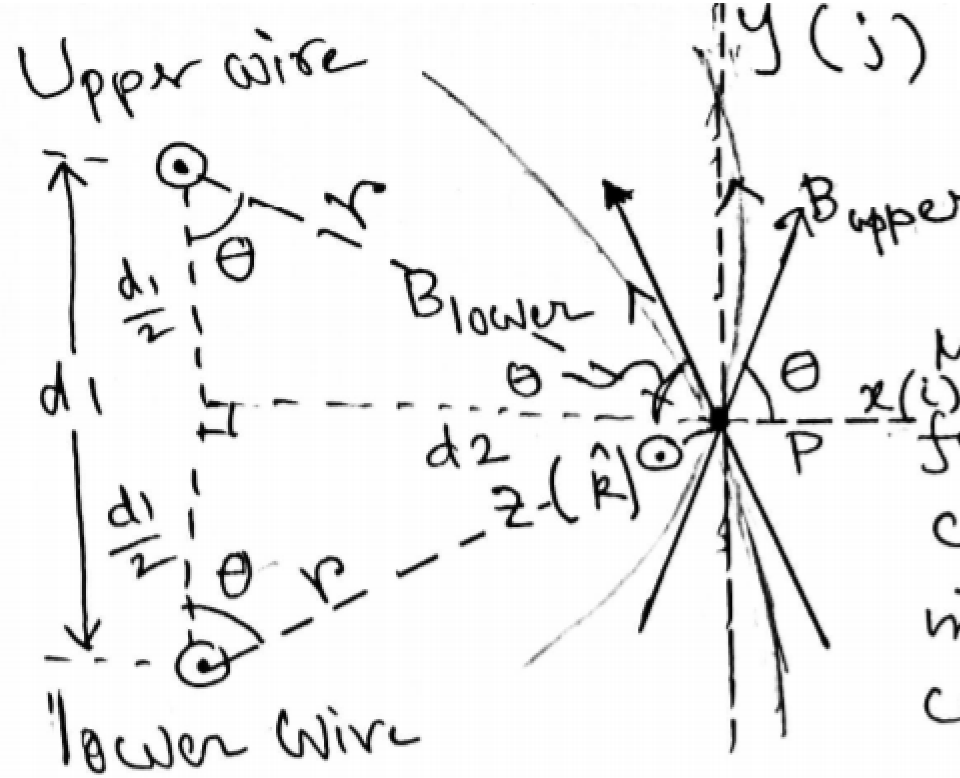


Figure 29-49 Problem 21.

(21)



Magnetic lines of forces are circles concentric with individual current carrying wires.

The magnetic field direction due to the current carrying wires at point P are the tangents to the circular lines of forces at P due to upper and lower current carrying wires. x, y, z coordinate system are as shown.

The x-components of the magnetic fields are equal and opposite, hence cancels out, and there is no z component

The y-components are equal and in the same direction so they add up to give a net y component

$$|B_{net}| = \{|B_{upper}| + |B_{lower}|\} \sin\theta$$

$$= \left\{\frac{\mu_0 i}{2\pi r} + \frac{\mu_0 i}{2\pi r}\right\} \sin\theta \qquad (1)$$

$\underline{i = 4.0 \text{ Amp}}$

$$r = \sqrt{d_2^2 + \left(\frac{d_1}{2}\right)^2} =$$

$$= \sqrt{4^2 + \left(\frac{6}{2}\right)^2} = \sqrt{25 \text{ m}^2}$$

$\underline{r = 5 \text{ m}}$

Problem 21 Contd.

$$\mu_0 = 4\pi \times 10^{-7}\ T \cdot m/A.$$

$$\tan\theta = \frac{d_2}{d_1/2} \qquad \theta = \tan^{-1}\left(\frac{d_2}{\frac{d_1}{2}}\right)$$

$$= \tan^{-1}\left(\frac{4}{3}\right) = 53.1$$

$$\therefore |B_{net}| = 2\frac{\mu_0 i}{2\pi r}\sin\theta$$

$$= \frac{\mu_0 i}{\pi r}\sin 53.1^\circ$$

$$\therefore |B_{net}| = \frac{4\pi \times 10^{-7} \times 4}{\pi \times 5}\sin 53.1^\circ$$

$$= 2.56 \times 10^{-7}\ T.$$

•12 In Fig. 29-43, two long straight wires at separation $d = 16.0$ cm carry currents $i_1 = 3.61$ mA and $i_2 = 3.00i_1$ out of the page. (a) Where on the x axis is the net magnetic field equal to zero? (b) If the two currents are doubled, is the zero-field point shifted toward wire 1, shifted toward wire 2, or unchanged?

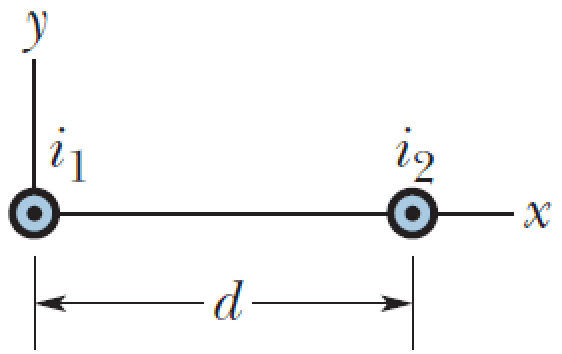
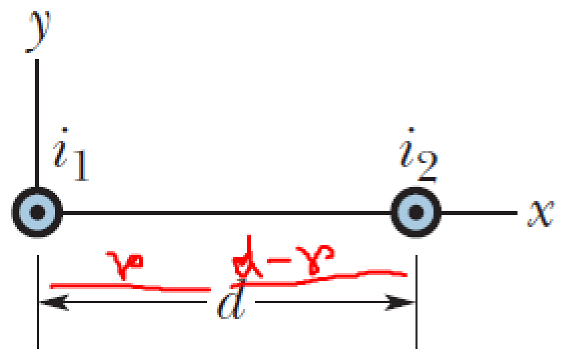


Figure 29-43 Problem 12.

(12) (a) Since they carry current in the same direction, then (by the right hand rule) the only region in which their fields might cancel is between them. Let the point be "r" away from the ~~current~~ wire carrying current i_1 and d-r away from the wire carrying current $3.00i_1$ then the ~~cancelt~~ canceling of their fields leads to



$$\frac{\mu_0 i}{2\pi r} = \frac{\mu_0 (3i)}{2\pi (d-r)}$$

$$\frac{1}{r} = \frac{3}{d-r} \Rightarrow r = \frac{d}{4} = \frac{16}{4} = 4.0\text{ cm}$$

(b) Doubling the current does not change the location of zero magnetic field. Because i on both side becomes 2i and cancels out.