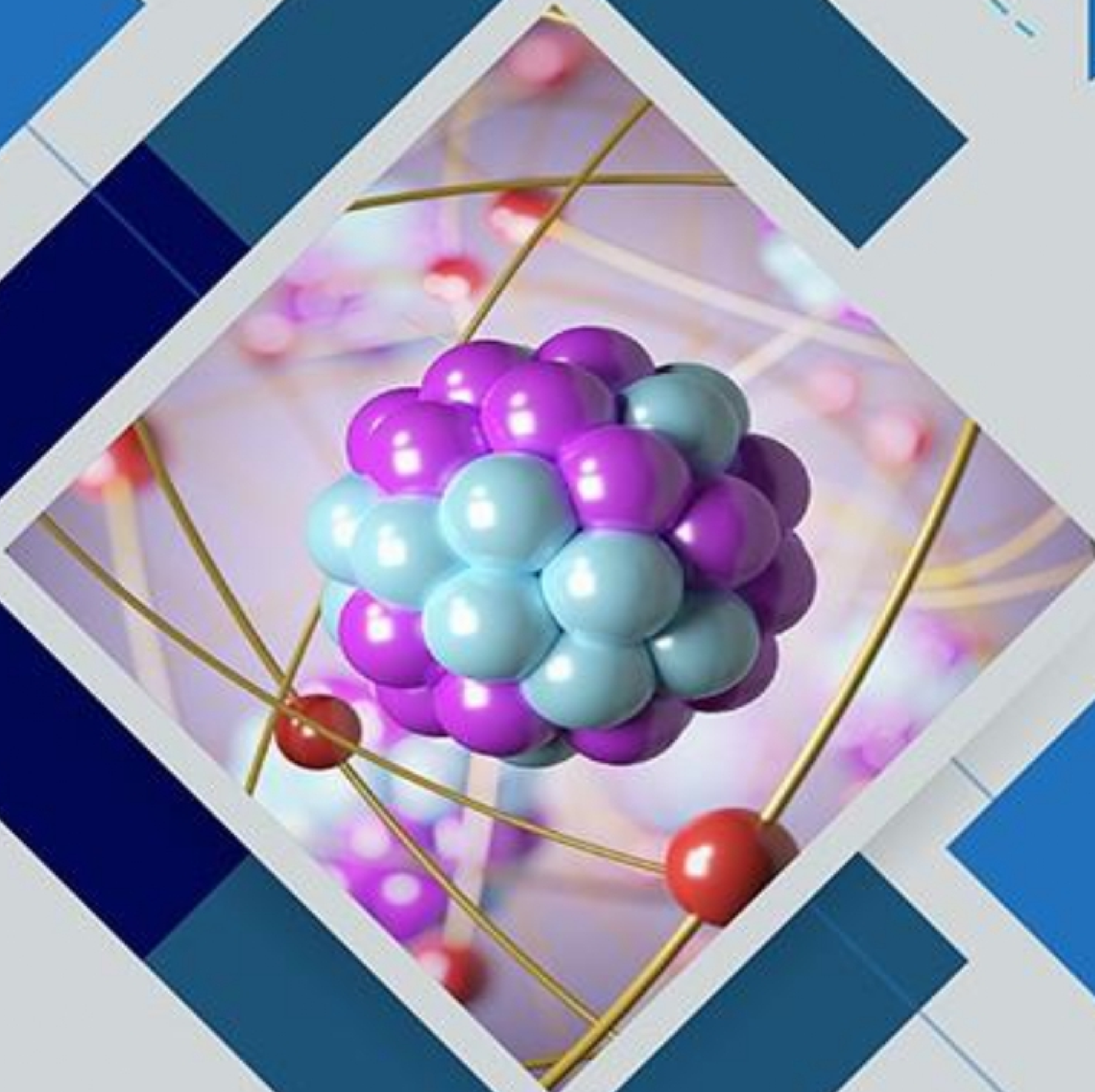
اسألني عن الهندسة



اسألني عن الفيزياء2

إعداد: عمر الحمري

اسألني عن الهندسة

CHAPTER 27:

MAGNETIC FIELD AND MAGNETIC FORCES

Magnetic Field and Magnetic Forces

إن الشحنة الكهربائية محاطة بمجال كهربائي وتحيط المجالات المغناطيسية بالمغانط وحركة الشحنات الكهربائية تولد مجالا مغناطيسيا حولها.

عندما يتحرك جسيم مشحون في مجال مغناطيسي فإنه يتأثر بقوة مغناطيسية $(\vec{F_M})$ تتناسب طرديا مع كل من شحنة الجسم (q)، والمجال المغناطيسي $(\vec{B})$، وسرعة الجسيم $(\vec{V})$ التي يتحرك بها داخل المجال المغناطيسي، ومع $(\sin\theta_{VB})$ فإن القوة المغناطيسية يعبر عنها بالعلاقة:

$$\vec{F_M} = q\,\vec{V} \times \vec{B}$$

$$F = qVB\sin\theta_{VB}$$

Where:

$\vec{F_M}$: *Magnetic force on a moving charged particle*

q: *Particle's charge*

$\vec{V}$: *Particle's velocity*

$\vec{B}$: *Magnetic field*

$F_{max}: \theta = 90^{\circ}$ (إذا طلب في السؤال أكبر قيمة للقوة المغناطيسية)

تنعدم القوة المغناطيسية في حالتين $(F = 0)$:

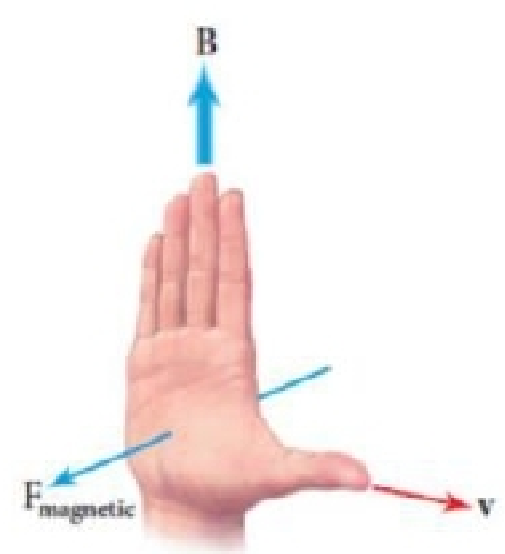
1)إذا كان الجسم ساكن لا يتحرك $(at\ rest\ (V = 0))$.

2)إذا كانت السرعة موازية لخطوط المجال $(\theta = 0^{\circ} or\ \theta = 180^{\circ}\ (V\&B\ in\ parallel))$.

∗Direction of force: (Right Hand Rule)

لتحديد اتجاه القوة المغناطيسية باستخدام قاعدة اليد اليمنى بحيث يشير الابهام الى السرعة وتشير باقي الأصابع الى اتجاه المجال المغناطيسي عندها يشير المتجه العامودي على باطن الكف والخارج منه الى اتجاه القوة المغناطيسية. أما إذا كانت الشحنة سالبة فإننا نطبق قاعدة اليد اليمنى ثم يكون اتجاه القوة المغناطيسية عكس الاتجاه الناتج.

$$B = \frac{F}{qV\sin\theta_{VB}} = \frac{N}{C * (m/s)} = tesla(T)$$



Unit of B *is tesla* (T)

Ex: if $\vec{V}$ given by $\vec{V} = 3\hat{i} - 2\hat{j} + 4\hat{k}$ and $\vec{B} = 5\hat{i} + 3\hat{j} + 6\hat{k}$ and $q = 4\mu C$,find:

1) $\vec{F}$ *as vector*

2) F *as magntiude*

3) angle between $\vec{V}$ & $\vec{B}$

Solution:

1) $\vec{F_M} = q\,\vec{V} \times \vec{B}$

$\vec{V} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -2 & 4 \\ 5 & 3 & 6 \end{vmatrix}$, from physics 1

$\vec{V} \times \vec{B} = (-12 - 12)\hat{i} - (18 - 20)\hat{j} + (9 - -10)\hat{k}$

$\vec{V} \times \vec{B} = -24\hat{i} + 2\hat{j} + 19\hat{k}$

$\vec{F_M} = q\,\vec{V} \times \vec{B}$

$\vec{F} = 4 * 10^{-6} * (-24\hat{i} + 2\hat{j} + 19\hat{k})$

$\vec{F} = -96 * 10^{-6}\ \hat{i} + 8 * 10^{-6}\hat{j} + 76 * 10^{-6}\ \hat{k}$ Newton

2) $\left|\vec{F_M}\right| = \sqrt{(-96)^2 + (8)^2 + (76)^2} * 10^{-6}$

$\left|\vec{F_M}\right| = \sqrt{941} * 10^{-6} \Rightarrow \left|\vec{F}\right| = 1.22 * 10^{-6}\ N$

From physics 1

3) $\left|\vec{F_M}\right| = q\ \left|\vec{V}\right|\left|\vec{B}\right| sin\theta$

$\left|\vec{V}\right| = \sqrt{(3)^2 + (-2)^2 + (4)^2} = \sqrt{29}$

$\left|\vec{B}\right| = \sqrt{(5)^2 + (3)^2 + (6)^2} = \sqrt{70}$

$1.22 * 10^{-6} = 4 * 10^{-6} * \sqrt{29} * \sqrt{70} * sin\theta$

$sin\theta = \frac{1.22 * 10^{-6}}{4 * 10^{-6} * \sqrt{29} * \sqrt{70}}$

$sin\theta = 0.6808$

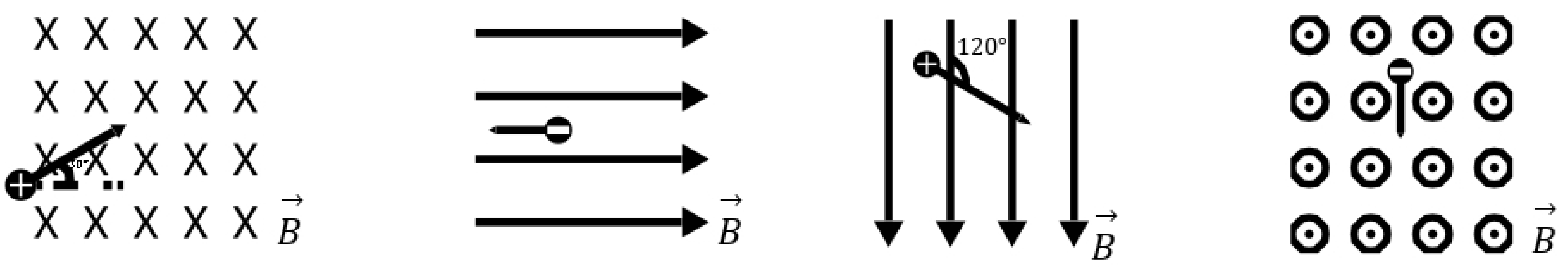
$\theta = \sin^{-1}(0.6806)$

$\theta = 42.908°$

{Done by: Omar Mohammad}

Ex: in figure, find $\vec{F}_M$ if ($|q| = 6\,\mu C, |V| = 5\,m/s, |B| = 3\,tesla$)

1) 2) 3) 4)



Solution:

1)

$\left|\vec{F}_M\right| = q\,\left|\vec{V}\right|\left|\vec{B}\right| sin\theta, \theta = 90°$

$\left|\vec{F}_M\right| = 6 * 10^{-6} * \; 5 * 3 * sin90°$

$\left|\vec{F}_M\right| = 90 * 10^{-6}\; N\;(120°)\; RHR$

2)

$\left|\vec{F}_M\right| = q\,\left|\vec{V}\right|\left|\vec{V}\right| sin\theta, \theta = 180°$

$\left|\vec{F}_M\right|$=0, because $\vec{V}$ & $\vec{B}$ are parallel

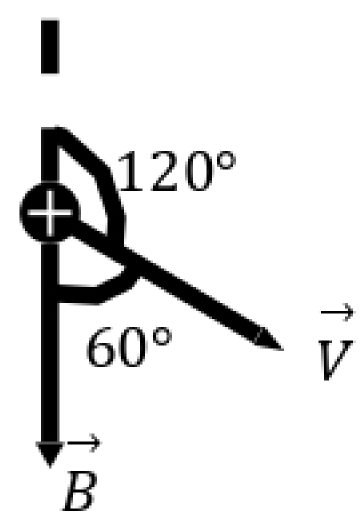
3)

$\left|\vec{F}_M\right| = q\,\left|\vec{V}\right|\left|\vec{B}\right| sin\theta, \theta = 60°$

$\left|\vec{F}_M\right| = 6 * 10^{-6} * \; 5 * 3 * sin60°$

$\left|\vec{F}_M\right| = 90 * 10^{-6} * \frac{\sqrt{3}}{2}$

$\left|\vec{F}_M\right| = 45\sqrt{3} * 10^{-6}\; N\;\left(-\hat{k}\right)\; RHR$



4)

$\left|\vec{F}_M\right| = q\,\left|\vec{V}\right|\left|\vec{B}\right| sin\theta, \theta = 90°$

$\left|\vec{F}_M\right| = 6 * 10^{-6} * \; 5 * 3 * sin90°$

$\left|\vec{F}_M\right| = 90 * 10^{-6}\; N\;\left(\hat{i}\right)$ ($LHR\;OR\;RHR$ but take the opposite of direction that get)

Motion of charged particles In a Magnetic field

عندما يتحرك الجسيم داخل المجال المغناطيسي $(\vec{B})$ باتجاه لا يوازي المجال المغناطيسي فإنه يتأثر بقوة مغناطيسية $(\vec{F_M})$ اتجاهها دائما عامودي على اتجاه المجال المغناطيسي $(\vec{B})$ وسرعة الجسيم $(\vec{V})$، وإذا كان متجه السرعة $(\vec{V})$ عامودي على متجه المجال المغناطيسي $(\theta = 90°)$ فإن القوة المغناطيسية $(\vec{F_M})$ تجبر الجسيم على الحركة في مسار دائري. لذلك تعد القوة المغناطيسية قوة مركزية تكسب الجسيم تسارعا مركزيا باتجاهه $(The\ centripetal\ acceleration\ is\ \frac{v^2}{R})$.

$$|F_M| = |F_C| = a_{centripetal} * m = \frac{v^2}{R} * m = qvB$$

$$R = \frac{v * m}{|q| * B}$$

Where:

R: Radius of a circular orbit in a magnetic field.
v: Particle's speed
m: Particle's mass
B: Magnetic-field magnitude
q: Particle's charge

ملاحظات:

*If the charge q is negative, the particle moves clockwise around the orbit in a magnetic field.

*السرعة الزاوية $(angular\ speed\ (\omega))$:

The angular speed v of the particle can be found from $v = R\omega$.

$$\omega = \frac{v}{R} = v * \frac{|q| * B}{v * m}$$

$$\omega = \frac{|q| * B}{m}\ (rad/s)$$

يمكن حساب عدد الدورات بالنسبة لزمن عن طريق:

$$f = \frac{1}{T_\circ}$$

Where:

$T_\circ$: Time period and it is time to make one rotation (الزمن الدوري).
$f(\ frequency)$: the number of rotations in one second.

$$T_\circ = \frac{2\pi}{\omega} = \frac{2\pi m}{qB}\ s$$

$$f = \frac{\omega}{2\pi} = \frac{qB}{2\pi m}\ Hz$$

$$\omega = 2\pi f$$

Ex: if $q = 6\mu C$ enter uniform magnetic field $|B| = 3\ tesla$ with constant speed $|V| = 12\ m/s$

$(m = 3 * 10^{-4}\ kg, \theta = 90°)$, find:

1) $|F_M|$
2) $|F_C|$
3) $|a_C|$
4) radius
5) angular speed (ω)
6) Time period $(T_\circ)$
7) $Frequency\ (f)$

Solution:

1)

$\left|\vec{F}_M\right| = q\ \left|\vec{V}\right|\left|\vec{B}\right| sin\theta, \theta = 90°$

$\left|\vec{F}_M\right| = 6 * 10^{-6} *\ 12 * 3 * sin90° = 216 * 10^{-6}\ N$

2)

$\left|\vec{F}_M\right| = \left|\vec{F}_C\right| = 216 * 10^{-6}\ N$

3)

$\left|\vec{F}_C\right| = \frac{mV^2}{r}, a = \frac{V^2}{r}$

$\left|\vec{F}_C\right| = ma$

$a = \frac{F}{m} = \frac{216 * 20^{-6}}{3 * 10^{-4}} = 72 * 20^{-2}$

4)

$r = \frac{mV}{qB} = \frac{3 * 10^{-4} * 12}{6 * 10^{-6} * 3}$

$r = 200\ m$, this is large value because values are randomly chosen.

5)

$\omega = \frac{qB}{m} = \frac{6 * 10^{-6} * 3}{3 * 10^{-4}}$

$\omega = 6 * 10^{-2}\ rad/s$

6)

$T_\circ = \frac{2\pi m}{qB}$ or $\omega = 2\pi f, T_\circ = \frac{1}{f}$

$T_\circ = \frac{2\pi}{\omega} = \frac{2\pi}{6 * 10^{-2}}$

$T_\circ = 104.71\ s$

7)

$f = \frac{1}{T_\circ}$

$f = \frac{1}{104.71} = 9.54 * 10^{-3}\ Hz$

EX: A magnetron in a microwave oven emits electromagnetic waves with frequency $f = 2450\ MHz$. What magnetic field strength is required for electrons to move in circular paths with this frequency?
Solution:

$$\omega = \frac{|q| * B}{m}$$

$$\omega = 2\pi f = 2\pi * 2450 * 10^{6}$$

$$\omega = 1.54 * 10^{10} (rad/s)$$

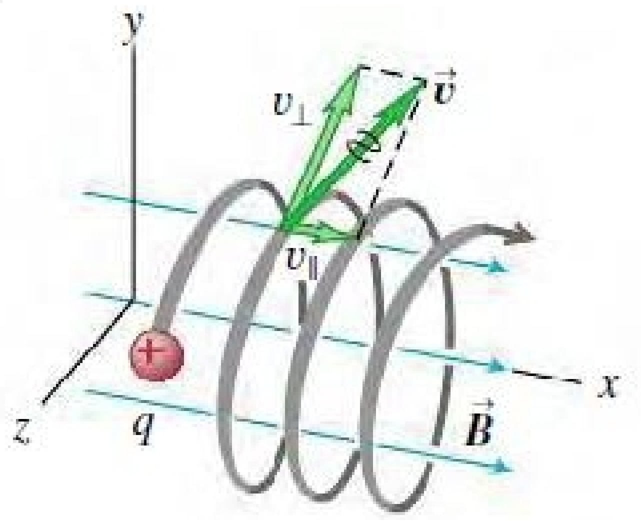
$$B = \frac{m * \omega}{|q|} = \frac{(9.11 * 10^{-31}) * 1.54 * 10^{10}}{1.6 * 10^{-19}}$$

$$B = 0.0877\ T$$

EX: As shown the charged particle is a proton ($q = 1.60 * 10^{-19}\ C,\ m = 1.67 * 10^{-27}\ kg$) and the uniform, 0.5 T magnetic field is directed along the x-axis. At t = 0 the proton has velocity components v_x = 1.50 * 10^5 m/s, v_y = 0, and v_z = 2.00 * 10^5 m/s. Only the magnetic force acts on the proton.
(a)At $t = 0$, find the force on the proton and its acceleration.
(b)Find the radius of the resulting helical path, the angular speed of the proton, and the pitch of the helix (the distance traveled along the helix axis per revolution).
Solution:

At (t = 0): $\vec{V} = (1.50 * 10^5)\hat{i} + (2.00 * 10^5)\hat{k}$ $\quad\quad \vec{B} = 0.5\,\hat{i}$

$$\vec{F}_M = q\,\vec{V} \times \vec{B} = 1.60 * 10^{-19} * (((1.50 * 10^5)\hat{i} + (2.00 * 10^5)\hat{k}) \times 0.5\,\hat{i})$$



$$\vec{F}_M = 1.60 * 10^{-19} * (0\hat{i} + (2.00 * 10^5 * 0.5)\,\hat{j}) = 1.60 * 10^{-14} N\hat{j}$$

$$\vec{F}_M = \vec{a} * m$$

$$\vec{a} = \frac{1.60 * 10^{-14}}{1.67 * 10^{-27}} = 9.58 * 10^{12}\ (m/s^2)$$

b)

Since v_y = 0, the component of velocity perpendicular to $\vec{B}$ is v_z

$$R = \frac{2.00 * 10^5 * 1.67 * 10^{-27}}{1.60 * 10^{-19} * 0.5} = 4.18\ mm$$

$$\omega = \frac{v}{R} = \frac{2.00 * 10^5}{4.18 * 10^{-3}} = 4.79 * 10^7\ (rad/s)$$

$$T_\circ = \frac{2\pi}{\omega} = \frac{2\pi}{4.79 * 10^7} = 1.31 * 10^{-7}$$

The pitch is the distance traveled along the x-axis in this time

$$d = T_\circ * v_x = 1.31 * 10^{-7} * 1.50 * 10^5 = 19.7\ mm$$

لأن اتجاه القوة المغناطيسية عامودي باستمرار على متجه الازاحة فإن القوة المغناطيسية لا تبذل شغلا عليه فتبقى طاقتها الحركية ثابتة أي أن سرعتها لا تتغير ولكن يغير اتجاهها.

$W = F \text{ d } cos\theta \text{ ,} \theta \text{ } between \text{ F and V}$

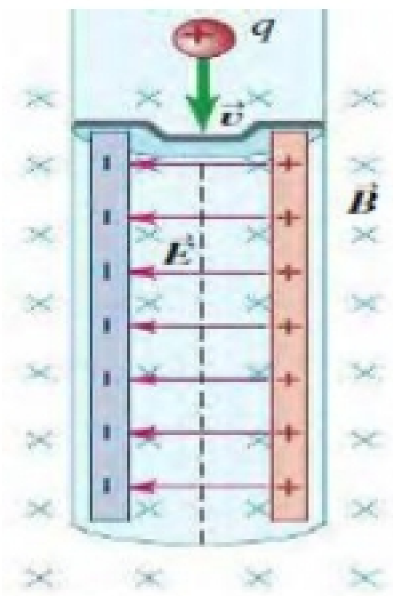
$W = F \text{ d}, \theta = 90°$

$W = \triangle k \text{ , W} = 0 \text{ when F is perpendicular to V}$

So, V is not change in value it changes in direction only because F is always perpendicular to V & B

Lorentz's law:

تحتوي بعض الأجهزة الكهربائية على مجالين متعامدين، مجال كهربائي منتظم ومجال مغناطيسي منتظم وفي هذه الحالة فإن الجسيمات المشحونة المتحركة في المجالين المتعامدين تتأثر بقوتين معا احداهما كهربائية والأخرى مغناطيسية، وتسمى القوة المحصلة للقوتين الكهربائية والمغناطيسية بقوة لورنتز.



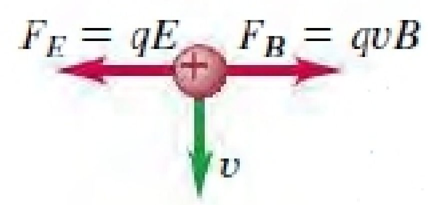
Region that has magnetic and electric field

$F_L = F_M + F_E$

$F_L = qVB + qE$

$F_L = q(VB + E)$

Note: magnetic field effect on moving charge but electric field not depended on moving.



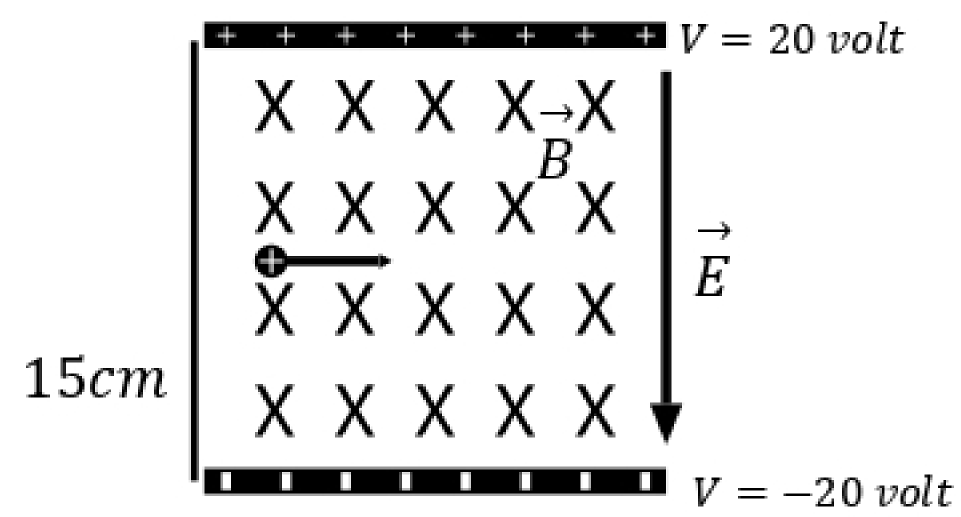
Ex: in figure shown, find:

1) F_M 2) E

3) F_E 4) $Lorentz's\ force$

5) V if q moving in straight line

$(q = 4\mu C, V = 15\ m/s, B = 15\ tesla)$



Solution:

1)

$\left|\vec{F_M}\right| = q \left|\vec{V}\right| \left|\vec{B}\right| sin\theta, \theta = 90°\ RHR$

$\left|\vec{F_M}\right| = 4 * 10^{-6} * 15 * 15 * sin90°$

$\left|\vec{F_M}\right| = 9 * 10^{-4}\ N \left(\hat{j}\right)\ RHR$

2) $E = \frac{\Delta V}{d}$

$E = \frac{20 - -20}{15 * 10^{-2}}$

$E = 2.66 * 10^{2}\ v/m$

3)

$F_E = qE$

$F_E = 4 * 10^{-6} * 2.66 * 10^{2}$

$F_E = 10.66 * 10^{-4}\ N\ (-\hat{j})$, with $\vec{E}$

4)

$F_L = F_M + F_E$

$F_L = 9 * 10^{-4} \left(\hat{j}\right) + 10.66 * 10^{-4}\ (-\hat{j})$, vector sum

$F_L = 10.66 * 10^{-4} - 9 * 10^{-4}$ in $(-\hat{j})$

$F_L = 1.66 * 10^{-4}\ N\ (-\hat{j})$

5)

q in straight line that mean $F_L = 0$

So, $F_M = F_E$

$qVB = qE$

$V = \frac{E}{B}$

$V = \frac{2.66 * 10^{-4}}{15}$

$V = 17.733\ m/s$

applications of motion of Charged particles:

1) Velocity selector (منتقي السرعة):

إذا كانت قوة لورنتز المؤثرة في جسيم مشحون تساوي صفرا؛ فإن الجسيم يكمل حركته بسرعة ثابتة وفي خط مستقيم وبالاعتماد على ذلك تم تصميم جهاز منتقي السرعة للحصول على حزمة من الجسيمات المشحونة المتحركة بسرعة ثابتة وفي خط مستقيم

$F_M = F_E \ \rightarrow\ qVB = qE \rightarrow V = \frac{E}{B}$

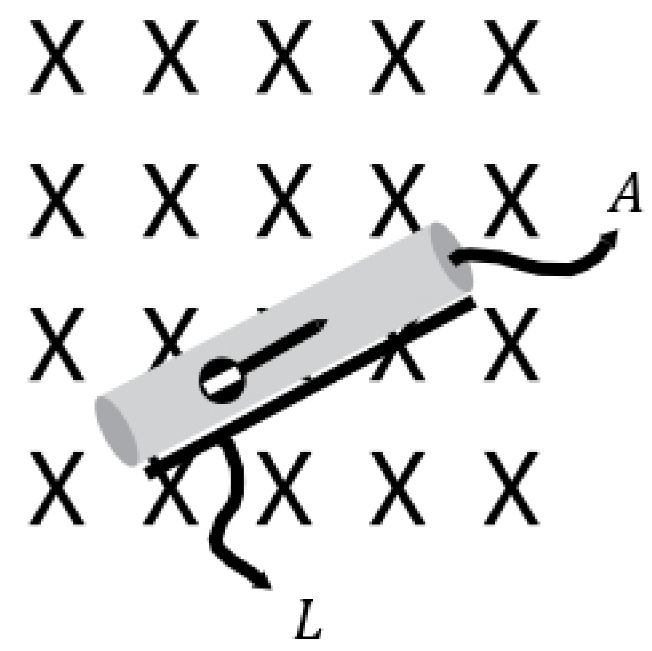
فإن الجسيمات التي تكون سرعتها مساوية النسبة $(\frac{E}{B})$ تكمل مسارها بلا انحراف أما التي تكون سرعتها أكبر او أقل فسوف تنحرف.

2) Mass spectrometers (مطياف الكتلة):

يستخدم هذا الجهاز لفصل الأيونات المشحونة بعضها عن بعض وفق نسبة شحنة كل منها الى الكتلة حيث يستخدم فيه منتقي السرعة (Velocity selector) في البداية لانتقاء الجسيمات ذات السرعة نفسها وبعد أن تخرج هذه الجسيمات من منطقة المجالين الكهربائي والمغناطيسي تدخل منطقة أخرى فيها مجال مغناطيسي اخر $(\vec{B_\circ})$ باتجاه المجال المغناطيسي $(\vec{B})$ يجبر الجسيمات على الحركة بمسار يشكل نصف دائرة تحدد نسبة الشحنة الى الكتلة اعتمادا على نصف القطر.

magnetic force on current currying conducting:

حركة الشحنات الكهربائية باتجاه واحد تشكل تيارا كهربائيا، وحيث إن الشحنات الكهربائية المتحركة داخل مجال مغناطيسي تتأثر بقوة مغناطيسية، إذا التيار الكهربائي المار في موصل مغمور في مجال مغناطيسي منتظم يتأثر بقوة مغناطيسية أيضا، فالقوة المغناطيسية المؤثرة في وحدة الشحنات (q) تتحرك بسرعة (V) في موصل طوله $(\vec{L})$ مغمور في مجال مغناطيسي $(\vec{B})$ تساوي:



$$\vec{F_M} = I\ \vec{L} \times \vec{B} = ILB\sin\theta_{LB}$$

$\vec{L}$: displacement and its equal length of conducting.

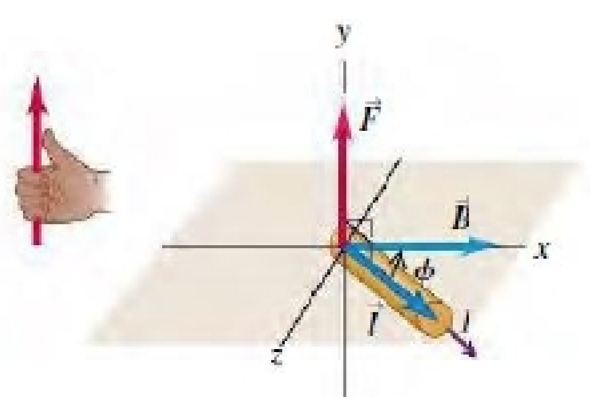
θ:angle between $L\&B$

I: Current

F_{max}: $\theta = 90^{\circ}$

تنعدم القوة المغناطيسية في حالتين $(F = 0)$:

إذا كانت السرعة موازية لخطوط المجال $(\theta = 0^{\circ} or\ \theta = 180^{\circ}\ \ (L\&B\ in\ parallel))$.



يكون اتجاه القوة المغناطيسية عاموديا على المستوى الذي يتشكل من المتجهين $(\vec{B})$ و $(\vec{L})$ مهما كانت الزاوية بين الاتجاهين.

Ex: in figure shown, find:

1) Net force on loop.

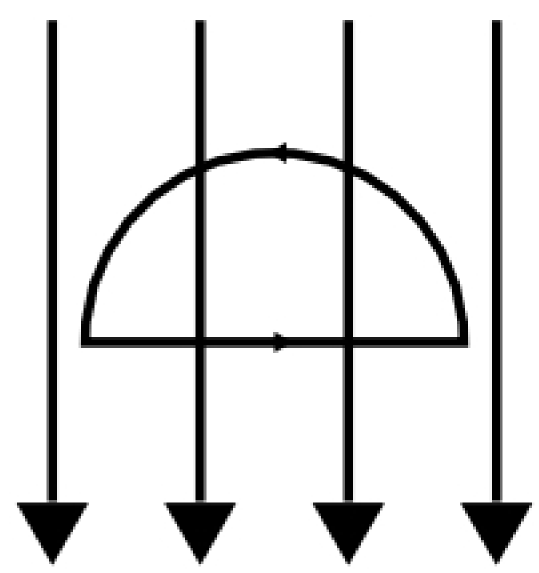
2) F_M on straight wire.

3) F_M on curved wire

$I = 3A$

$B = 4\ tesla$

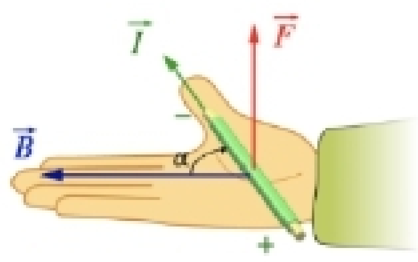
$R = 3\ cm$



Solution:

1)

Net force is zero because magnitude but opposite



F_M in straight wire and curved wire are have same direction.

2)

$F_M = ILBsin\theta, \theta = 90°$

$F_M = 3 * (2R) * 4 * 1$

$F_M = 3 * (2 * 3 * 10^{-2}) * 4 * 1$

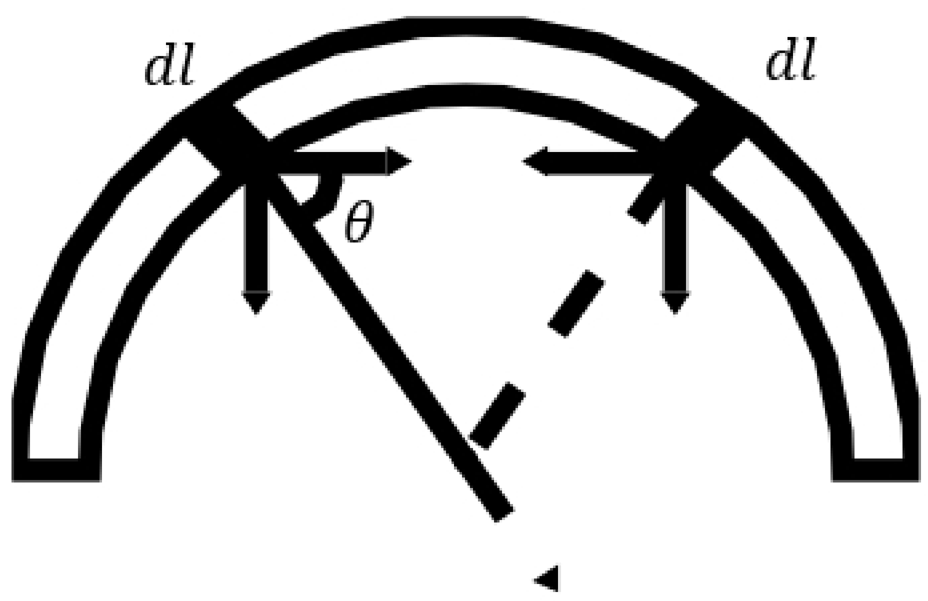
$F_M = 120 * 10^{-2}\ N\ (-\hat{k})\ RHR$

3)

$F_{M_{stright}} = F_{M_{curved}} = 120 * 10^{-2}\ N$, but opposite direction

$F_{M_{curved}} = 120 * 10^{-2}\ N\ \ (\hat{k})\ RHR$

Note: to understand why $F_{M_{stright}} = F_{M_{curved}}$



$df = idlB$

$df_y = idlBsin\theta_y$

$F_{M_{curved}} = IB \int dl\ sin\theta$

$dl = Rd\theta$,length of arc

$F_{M_{curved}} = IB \int Rd\theta\ sin\theta$

$F_{M_{curved}} = IBR \int_0^{\pi} sin\theta d\theta$

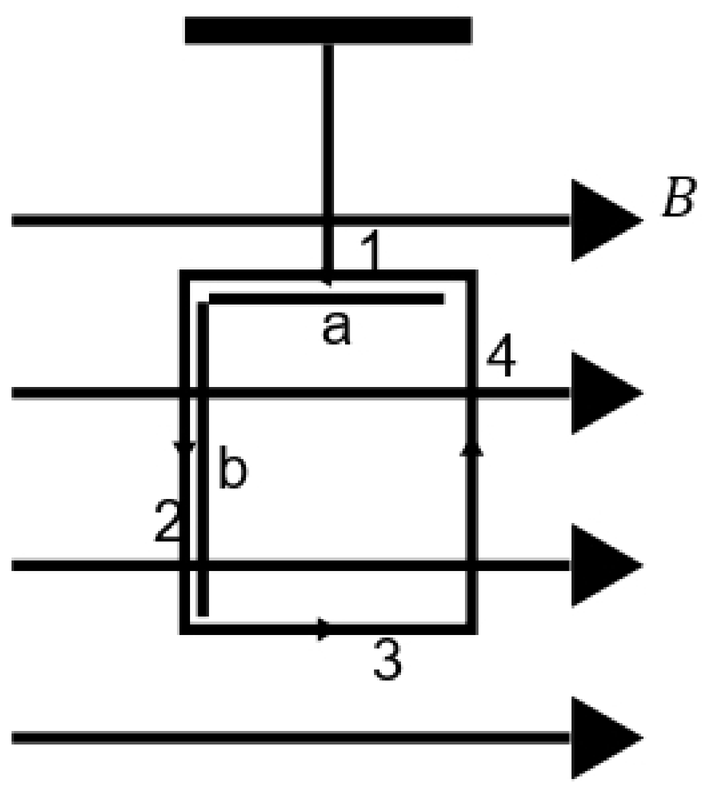
$F_{M_{curved}} = IBR * -(sin\pi - sin0)$

$F_{M_{curved}} = IBR * -(-1 - 1)$

$F_{M_{curved}} = I2RB$

force and torque on a current loop:

The net force on a current loop in a uniform magnetic field is zero. However, the net torque is not in general equal to zero.



Wire1:

$F_M = ILBsin\theta$

$F_M = 0$, because $\theta = 180°$

Wire2:

$F_M = ILBsin\theta$ in $(\hat{k})$ RHR

Wire3:

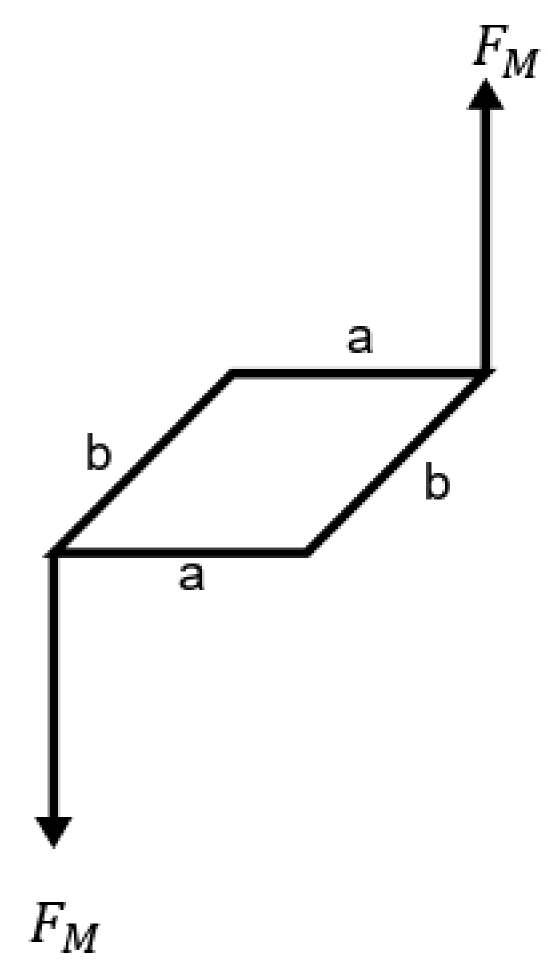
$F_M = ILBsin\theta$

$F_M = 0$, because $\theta = 0°$

Wire4:

$F_M = ILBsin\theta$ in $(-\hat{k})$ RHR

$\sum F_M = F_{\text{Wire1}} + F_{\text{Wire2}} + F_{\text{Wire3}} + F_{\text{Wire4}} = 0 + ILBsin\theta + 0 - ILBsin\theta = 0$



These two forces ($F_{\text{Wire2}}, F_{\text{Wire4}}$) make torque.

$\tau = F_M a = ILB.a\ sin\phi$

$L = b$

$\tau = IbB.a\ sin\phi, ab = A$

$\tau = IABsin\phi$

$\vec{\tau} = I\ \vec{A} \times \vec{B}$

Torque for N coils:

$\vec{\tau} = N\ I\ \vec{A} \times \vec{B} \rightarrow \tau = NIABsin\phi$

Where:

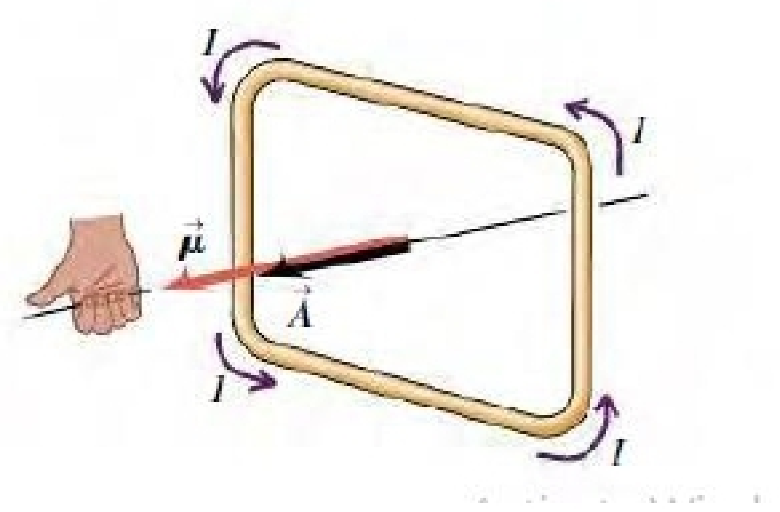
$\vec{A}$: *area vector*

ϕ: *Angle between normal to loop plane and field direction (بين العامودي على السطح والمجال المغناطيسي)*

τ: *Magnitude of magnetic torque on a current loop*

Unit of $[\tau]$: $N.m$

$\vec{\mu} = N\,I\,\vec{A}$ ((dipole magnetic moment) ممكن في السؤال يطلب)



Where:

$\vec{\mu}$: $Magnetic\ dipole\ moment$

$\vec{\tau} = \vec{\mu} \times \vec{B} \rightarrow \tau = \mu B sin\phi$

ϕ: Angle between $\vec{\mu}$ and $\vec{B}$.
Unit of magnetic moment $[\mu]$=$A.m^2$

Potential energy for a Magnetic dipole

$\boldsymbol{U} = -\vec{\mu}.\vec{B}$ $(dot\ product)$

$\boldsymbol{U} = -\mu B cos\phi$

Where:

$\boldsymbol{U}$: Potential energy for a magnetic dipole in a magnetic field
ϕ: Angle between $\vec{\mu}$ and $\vec{B}$.

U is zero when the magnetic dipole moment is perpendicular to the magnetic field 1f $\theta = 90°$.

Ex: circular loop has $I = 6A$ and its circumference=60 cm $|B| = 3\ tesla$,the angle between $\vec{B}$ and the surface 30°,find τ as magnitude?

Solution:
$\vec{\tau} = N\,I\,\vec{A} \times \vec{B}$

$\tau = N\,IAB\ sin\phi, N = 1$

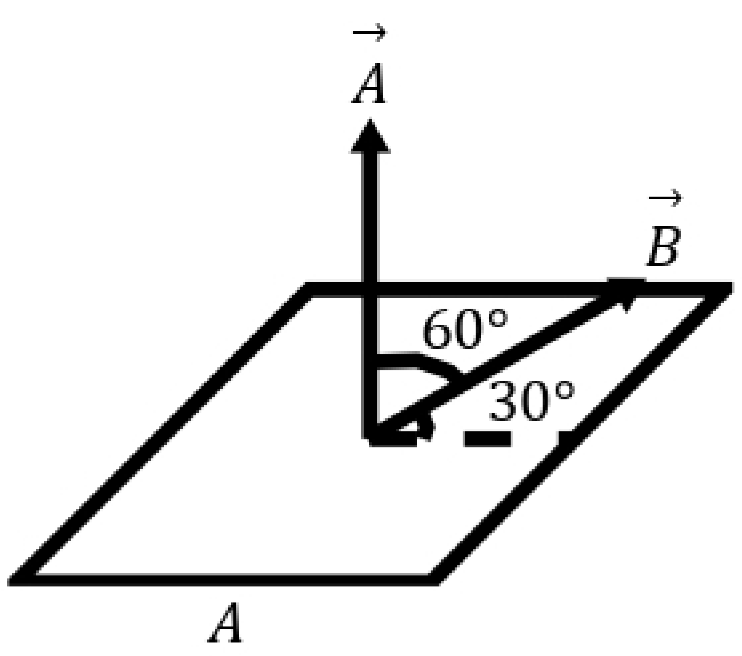
$cir = 60 * 10^{-2} = 2\pi R$

$R = \dfrac{60 * 10^{-2}}{2\pi}$

$R = 0.0954\,m$

$A = \pi R^2 = \pi(0.954)^2$

$A = 0.0286\ m^2$



$\tau = 1 * 6 * 0.0286 * 3 * sin\phi$

$\theta = 60°$, because we take area vector and B angle.

$\tau = 1 * 6 * 0.0286 * 3 * sin60°$

$\tau = 5156.62 * 10^{-4} * \dfrac{\sqrt{3}}{2} = 0.446\ N.m$

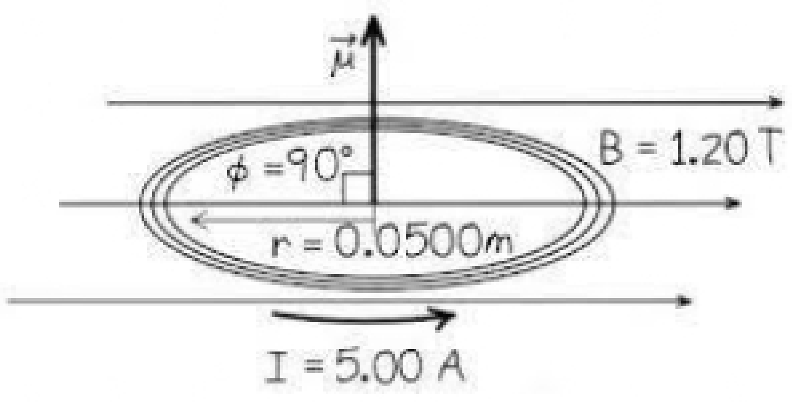
اقرأ وأنت تبحث عن شيء يدفعك لما ينفعك ويرفعك في الدارين

A circular coil 0.0500 m in radius, with 30 turns of wire, lies in a horizontal plane. It carries a counterclockwise (as viewed from above) current of 5.00 A. The coil is in a uniform 1.20-T magnetic field directed toward the right.

A) Find the magnitudes of the magnetic moment

B) The torque on the coil.

C) If the coil rotates from its initial orientation to one in which its magnetic moment $\vec{\mu}$ is parallel to $\vec{B}$ what is the change in potential energy?



solution:

A)

$A = \pi * r^2 = \pi * 0.05^2$

$\mu = N\ I\ A = 30 * 5 * \pi * 0.05^2$

$\mu = 1.18\ A.m^2$

B)

$\tau = \mu B sin\phi = 1.18 * 1.20 * sin90°$

$\tau = 1.41 N.m$

$\Delta\boldsymbol{U} = \boldsymbol{U}_2 - \boldsymbol{U}_1 = -\mu B cos\phi_2 + \mu B cos\phi_1$

Where:

$\phi_1 = 90°$

$\phi_2 = 0°$

$\Delta\boldsymbol{U} = \boldsymbol{U}_2 - \boldsymbol{U}_1 = -\mu B cos\phi_2 + \mu B cos\phi_1$

$\Delta\boldsymbol{U} = \mu B(-cos\phi_2 + cos\phi_1)$

$\Delta\boldsymbol{U} = 1.18 * 1.2 * (-cos0° + cos90°)$

$\Delta\boldsymbol{U} = -1.41 J$

أهم القوانين:

القوة المغناطيسية والمجال المغناطيسي:

$$\vec{F}_M = q\,\vec{V} \times \vec{B}$$

$$F = qVB\sin\theta_{VB}$$

$$B = \frac{F}{qV\sin\theta_{VB}}$$

حركة جسيم في مجال مغناطيسي:

$$R = \frac{v * m}{|q| * B}$$

السرعة الزاوية والزمن الدوري والتردد:

$$\omega = \frac{v}{R} = \frac{|q| * B}{m} = 2\pi f$$

$$f = \frac{1}{T_{\circ}}$$

$$T_{\circ} = \frac{2\pi}{\omega} = \frac{2\pi m}{qB}$$

$$\mathrm{W} = F\,\mathrm{d}\,cos\theta\ ,\theta\ between\ \mathrm{F\ and\ V}$$

Lorentz's law:

$$F_L = q(VB + E)$$

magnetic force on current currying conducting:

$$\vec{F}_M = I\,\vec{L} \times \vec{B} = ILB\sin\theta_{LB}$$

torque and dipole magnetic moment

$$\vec{\tau} = N\,I\,\vec{A} \times \vec{B} \rightarrow \tau = NIABsin\phi$$

$$\vec{\mu} = N\,I\,\vec{A}$$

$$\vec{\tau} = \vec{\mu} \times \vec{B} \rightarrow \tau = \mu Bsin\phi$$

Potential energy for a Magnetic dipole

$$\boldsymbol{U} = -\vec{\mu}.\vec{B} \quad (dot\,product)$$

$$\boldsymbol{U} = -\mu Bcos\phi$$

Problems

Book & more

1-A particle ($q = 5.0\ nC$, $m = 3.0\ \mu g$) moves in a region where the magnetic field has components, $B_x = 2.0\ mT$, $B_y = 3.0\ mT$, and $B_z = -4.0\ mT$. At an instant when the speed of the particle is 5.0 km/s and the direction of its velocity is 120° relative to the magnetic field, what is the magnitude of the acceleration of the particle?

a. 33 m/s^2 **b.** 17 m/s^2 **c.** 39 m/s^2 **d.** 25 m/s^2 **e.** 45 m/s^2

2- An electron moving in the positive x direction experiences a magnetic force in the positive z direction. If $Bx = 0$, what is the direction of the magnetic field?

a. negative y direction
b. positive y direction
c. negative z direction
d. positive z direction
e. negative x direction

3- A particle (mass 6.0 mg) moves with a speed of 4.0 km/s and a direction that makes an angle of 37° above the positive x axis in the x-y plane. A magnetic field of (5.0**i**) mT produced an acceleration of (8.0**k**) m/s2. What is the charge of the particle?

a. –4.8 μC **b.** 4.0 μC **c.** –5.0 μC **d.** 4.8 μC **e.** –4.0 μC

4- A particle with a charge of $-1.24 * 10^{-8}\ C$ is moving with instantaneous velocity $V = (4.19 * 10^4\ m/s\ )\hat{i} + (-3.85 * 10^4\ )\hat{j}$. What is the force exerted on this particle by a magnetic field $B = 1.4\,T\ \hat{i}$?

Answer: ....

5-A particle with mass $1.81 * 10^{-3}\ kg$ and a charge of $1.22 * 10^{-8}\ C$ has at a given instant, a velocity $V(= 4.19 * 10^4\ m/s\ )\hat{j}$. What are the magnitude and direction of the particle's acceleration produced by a uniform magnetic field $B = (1.63T)\hat{i} + (0.980T)\ \hat{j}$?

Answer: ....

6- A charged particle (mass = 4.0 μg, charge = 5.0 μC) moves in a region where the only force on it is magnetic. At a point where the speed of the particle is 5.0 km/s, the magnitude of the magnetic field is 8.0 mT, and the angle between the direction of the magnetic field and the velocity of the particle is 60°, what is the magnitude of the acceleration of the particle?

a. 39 km/s^2 **b.** 43 km/s^2 **c.** 48 km/s^2 **d.** 52 km/s^2 **e.** 25 km/s^2

7- A 2.0-m wire carries a current of 15 A directed along the positive x axis in a region where the magnetic field is uniform and given by B = (30**i** – 40**j**) mT. What is the resulting magnetic force on the wire?

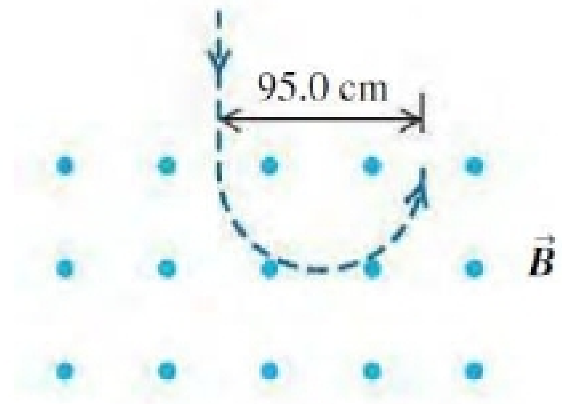
a. (-1.2 **k**) N **b.** (+1.2 **k**) N **c.** (–1.5 **k**) N **d.** (+1.5 **k**) N **e.** (+0.90 **k**) N

8- A segment of wire carries a current of 25 A along the x axis from $x = -2.0$ m to $x = 0$ and then along the z axis from $z = 0$ to $z = 3.0$m. In this region of space, the magnetic field is equal to 40 mT in the positive z direction. What is the magnitude of the force on this segment of wire?

a. 1.0 N **b.** 5.0 N **c.** 2.0 N **d.** 3.6 N **e.** 3.0 N

9- In an experiment with cosmic rays, a vertical beam of particles that have charge of magnitude $3e$ and mass 12 times the proton mass enters a uniform horizontal magnetic field of 0.250 T and is bent in a semicircle of diameter 95.0 cm, as shown in figure. Find the speed of the particles and the sign of their charge.

Answer: ……………………



10- A deuteron (the nucleus of an isotope of hydrogen) has a mass of 3.34 * 10-27 kg and a charge of $+e$. The deuteron travels in a circular path with a radius of 6.96 mm in a magnetic field with magnitude 2.50 T. Find the speed of the deuteron.

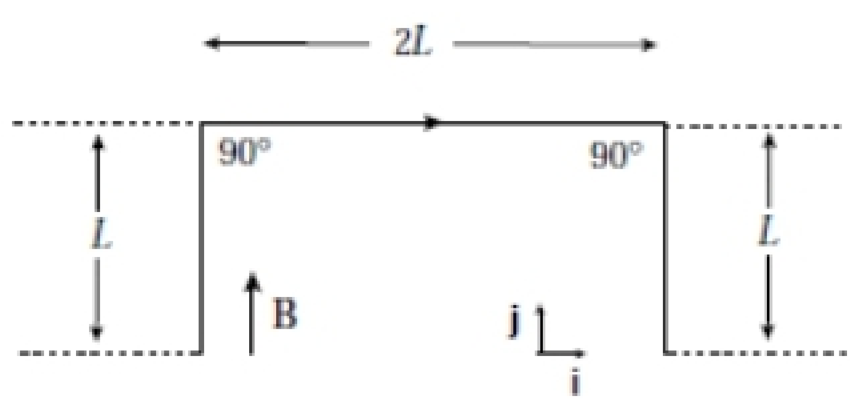
Answer: ……………………

11-What is the magnitude of the magnetic force on a charged particle ($Q = 5.0\ \mu C$) moving with a speed of 80 km/s in the positive x direction at a point where $Bx = 5.0$ T, $By = -4.0$ T, and $B_z = 3.0\ T$?

a. 2.8 N **b.** 1.6 N **c.** 1.2 N **d.** 2.0 N **e.** 0.4 N

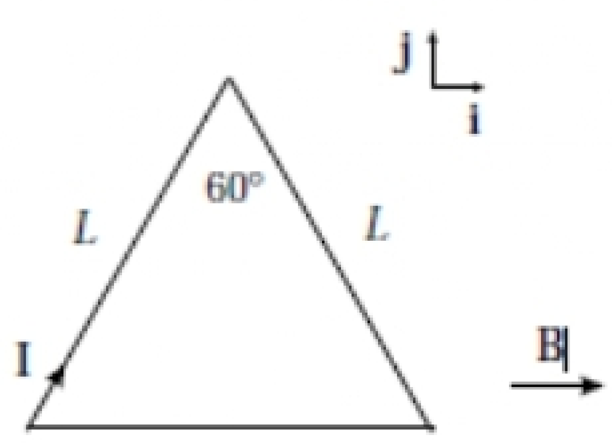
12- A straight wire is bent into the shape shown. Determine the net magnetic force on the wire.

a. 2IBL in the $-z$ direction
b. 2IBL in the $+z$ direction
c. 4IBL in the $+z$ direction
d. 4IBL in the $-z$ direction
e. zero



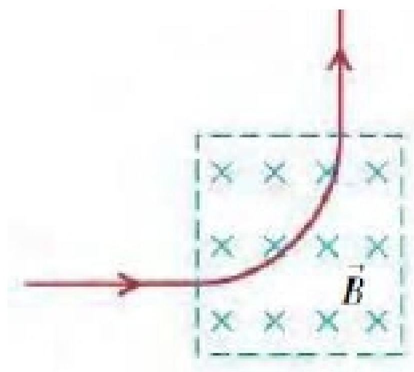
13- A straight wire is bent into the shape shown. Determine the net magnetic force on the wire.

a. Zero
b. IBL in the $+z$ direction
c. IBL in the $-z$ direction
d. 1.7 IBL in the $+z$ direction
e. 1.4 IBL in the $-z$ direction



14- A beam of protons traveling at 1.20 km/s enters a uniform magnetic field, traveling perpendicular to the field. The beam exits the magnetic field, leaving the field in a direction perpendicular to its original direction figure. The beam travels a distance of 1.18 cm *while in the field*. What is the magnitude of the magnetic field?

Answer: ....



15- A straight, 2.5-m wire carries a typical household current of 1.5 A (in one direction) at a location where the earth's magnetic field is 0.55 gauss from south to north. Find the magnitude and direction of the force that our planet's magnetic field exerts on this wire if it is oriented so that the current in it is running from west to east?

Answer: ....

16- The figure shows the orientation of a rectangular loop consisting of 80 closely wrapped turns each carrying a current *I*. The magnetic field in the region is (40 **i**) mT. The loop can turn about the *y* axis. If θ= 30°, *a* = 0.40 m, *b* = 0.30 m, and *I* = 8.0 A, what is the magnitude of the torque exerted on the loop?

a. 2.5 $N.m$ **b.** 1.5 $N.m$ **c.** 3.1 $N.m$ **d.** 2.7 $N.m$ **e.** 0.34 $N.m$

17- A current of 20 A is maintained in a triangular loop having equal length (50 cm) sides. An external magnetic field of 80 mT is directed such that the angle between the field and the plane of the loop is 35°. Determine the magnitude of the torque exerted on the loop by the magnetic forces acting upon it.

a. 0.17 $N.m$ **b.** 0.14 $N.m$ **c.** 0.10 $N.m$ **d.** 0.12 $N.m$ **e.** 0.32 $N.m$

18- A straight 10-cm wire bent at its midpoint so as to form an angle of 90° carries a current of 10 A. It lies in the *x-y* plane in a region where the magnetic field is in the positive *z* direction and has a constant magnitude of 3.0 mT. What is the magnitude of the magnetic force on this wire?

a. 3.2 mN **b.** 6.0 mN **c.** 5.3 mN **d.** 4.2 mN **e.** 2.1 mN

19- An electromagnet produces a magnetic field of 0.550 T in a cylindrical region of radius 2.50 cm between its poles. A straight wire carrying a current of 10.8 A passes through the center of this region and is perpendicular to both the axis of the cylindrical region and the magnetic field. What magnitude of force does this field exert on the wire?

Answer: ....

20- The plane of a (5.0 cm X 8.0 cm) rectangular loop of wire is parallel to a 0.19-T magnetic field. The loop carries a current of 6.2 A. What torque acts on the loop?

Answer: ....

21- A circular loop (radius = 0.50 m) carries a current of 3.0 A and has unit normal vector of (2**i** – **j** + 2**k**)/3. What is the x component of the torque on this loop when it is placed in a uniform magnetic field of (2**i** – 6**j**) T?

a. 4.7 $N.m$ **b.** 3.1 $N.m$ **c.** 19 $N.m$ **d.** 9.4 $N.m$ **e.** 12 $N.m$

22- A circular coil (radius = 0.40 m) has 160 turns and is in a uniform magnetic field. If the orientation of the coil is varied through all possible positions, the maximum torque on the coil by magnetic forces is 0.16 $N.m$ when the current in the coil is 4.0 mA. What is the magnitude of the magnetic field?

a. 0.37 T **b.** 1.6 T **c.** 0.50 T **d.** 1.2 T **e.** 2.5 T

23- An electron which moves through a velocity selector (E = 4.0 kV/m, B = 2.0 mT) subsequently follows a circular path (radius = 4.0 mm) in a uniform magnetic field. What is the magnitude of this magnetic field?

a. 1.8 mT **b.** 2.4 mT **c.** 3.2 mT **d.** 2.8 mT **e.** 4.6 mT

24-A rectangular coil of wire, 22.0 cm by 35.0 cm and carrying a current of 1.95 A, is oriented with the plane of its loop perpendicular to a uniform 1.50-T magnetic field in figure. Calculate the net force and torque that the magnetic field exerts on the coil.

Answer: ……………………

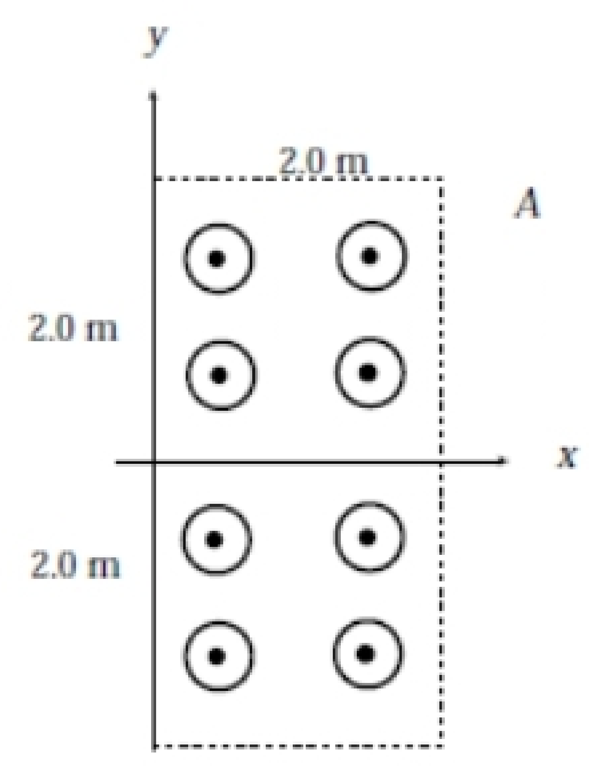
25- A coil with magnetic moment 1.45 $A.m^2$ is oriented initially with its magnetic moment antiparallel to a uniform 0.835-T magnetic field. What is the change in potential energy of the coil when it is rotated 180° so that its magnetic moment is parallel to the field?

Answer: ……………………

26- An alpha particle moves in a region where the magnetic field is uniform and has a magnitude of 0.60 T. The particle follows a helical path which has a pitch of 8.0 mm and a radius of 2.5 mm. What is the speed of this particle as it follows this path?

a. 71 km/s **b.** 80 km/s **c.** 36 km/s **d.** 58 km/s **e.** 40 km/s

27- The area shown is the boundary of a magnetic field directed in the positive z direction. An electron with a velocity along the x axis enters the magnetic field and exits 0.63 μs later at point A. What is the magnitude of the magnetic field?



a. 14 μT **b.** 18 μT **c.** 28 μT **d.** 34 μT **e.** 227 μT

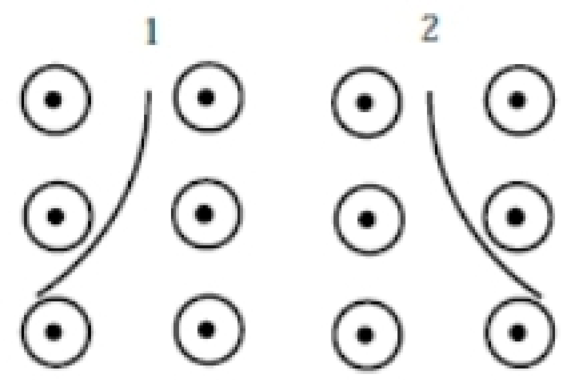
28- Two single charged ions moving perpendicularly to a uniform magnetic field (B = 0.4 T) with speeds of 5000 km/s follow circular paths that differ in diameter by 5.0 cm. What is the difference in the mass of these two ions?

a. $2.6 * 10^{-28} kg$ **b.** $6.4 * 10^{-28} kg$ **c.** $3.2 * 10^{-28} kg$ **d.** $5.1 * 10^{-28} kg$ **e.** $1.1 * 10^{-28} kg$

29-You stand near the earth's equator. A positively charged particle that starts moving parallel to the surface of the earth in a straight line directed east is initially deflected in a perpendicular direction. If you know there are no electric fields in the vicinity, a possible reason why the particle does not initially acquire a downward component of velocity is because near the equator the magnetic field lines of the earth are directed?

a. upward.
b. downward.
c. from south to north.
d. from north to south.
e. from east to west.

30- A magnetic field is directed out of the page. Two charged particles enter from the top and take the paths shown in the figure. Which statement is correct?



a. Particle 1 has a positive charge and particle 2 has a negative charge.
b. Both particles are positively. charged.
c. Both particles are negatively charged.
d. Particle one has a negative charge and particle 2 has a positive charge.
e. The direction of the paths depends on the magnitude of the velocity, not on the sign of the charge.

31- if electron enter magnetic field $(\vec{B})$ as :

$\vec{V} = 3\hat{j}$, and acceleration $\vec{a} = 1\hat{k}$, find direction of $\vec{B}$?

Solution:

Give acceleration that mean circular motion.

$\vec{F} = m\,\vec{a}$, direction of force is same direction of acceleration because m is scalar.

$\vec{F_M} = q\,\vec{V} \times \vec{B}$, direction of force is same direction of $\vec{V} \times \vec{B}$.

So, direction of acceleration same direction of $\vec{V} \times \vec{B}$.

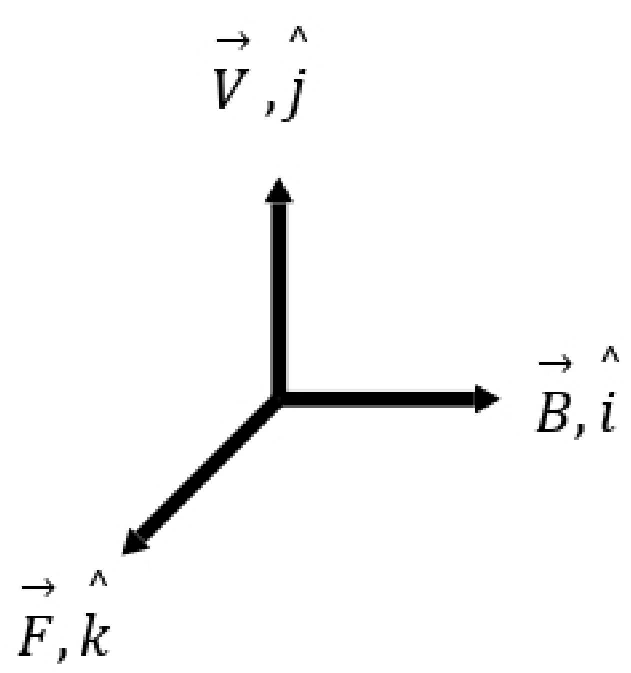
$\vec{V} \times \vec{B} = \vec{a}$

$\hat{j} \times \vec{B} = \hat{k}$

$\vec{B}$ *is in* $\vec{i}$ *direction*

But positive or negative direction?

$\vec{B}$ *is in* $+\ \vec{i}$ from LHR because it is electron



1.	**c.** 39 m/s^2	11.	**d.** 2.0 N	21.	**d.** 9.4 $N.m$
2.	**a.** negative y direction	12.	**b.** $2IBL$ in the $+z$ direction	22.	**c.** 0.50 T
3.	**e.** –4.0 μC	13.	**a.** Zero	23.	**d.** 2.8 mT
4.	$F = -6.68.6 * 10^{-4} N\, \hat{k}$	14.	$B = 1.67 * 10^{-3}\ T$	24.	$F = 0, \tau = 0$
5.	$\vec{a} = 0.33\ \mathrm{m/s^2}(-\hat{k})$	15.	$F = 2.1 * 10^{-4} N\, \hat{j}$	25.	$\Delta U = -2.42\ J$
6.	**b.** 43 km/s^2	16.	**d.** 2.7 $N.m$	26.	**b.** 80 km/s
7.	**a.** (-1.2 **k**) N	17.	**b.** 0.14 $N.m$	27.	**a.** 14 μT
8.	**c.** 2.0 N	18.	**e.** 2.1 mN	28.	**c.** $3.2 * 10^{-28} kg$
9.	$V = 2.84 * 10^6\ m/s$, negative	19.	$F = 0.297\ N$	29.	**c.** from south to north.
10.	$V = 8.35 * 10^5\ m/s$	20.	$\tau = 4.7 * 10^{-3}\ N.m$	30.	**a.**

CHAPTER 28:

SOURCES OF MAGNETIC FIELD

Chapter 28: Source of magnetic field:

إن الشحنات المتحركة هي التي تولد مجالا مغناطيسيا فقط.

**من مصادر المجال الكهربائي:

1- حركة شحنة كهربائية واحدة.
2- التيار الكهربائي.

❖ Magnetic field of A moving charge:

المجال المغناطيسي لشحنة نقطية واحدة (q)تتحرك بسرعة ثابتة (v):

$$\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{q * (\vec{V} \times \hat{r})}{r^2}$$

Where:

$\vec{B}$: magnetic field due to a point charge with constant velocity.

q: the point charge.

V: velocity

$\hat{r}$: متجه المسافة من الشحنة الى النقطة المراد القياس عندها (انتبه)

r: المسافة من الشحنة النقطية الى النقطة المراد القياس عندها

$\hat{r} = \frac{\vec{r}}{r}$ (تستخدم في حال اذا كانت المسافة بين الشحنة والنقطة في بعدين مثال اذا كانت

$$\hat{r} = ((-0.73\ )\hat{i} + (0.390\ \hat{k})m$$

$$\hat{r} = \frac{\vec{r}}{r} = \frac{(-0.73\ )\hat{i} + (0.390\ \hat{k})}{\sqrt{(-0.73\ )^2 + (0.390\ )^2}}$$

Example: A (4.80 μC) charge is moving at a constant speed of ($6.80 * 10^5$ m/s) in the (+*x*-direction) relative to a reference frame. At the instant when the point charge is at the origin, what is the magnetic-field vector it produces at the points:

A) *x* = 0, *y* = 0.500 m, *z* = 0.

B) x = 0.500 m, y = 0, z = 0;

A)

$$\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{q * (\vec{V} \times \hat{r})}{r^2}$$

$\vec{V} = (6.80 * 10^5)\hat{i}$
$\hat{r} = \hat{j}$

$\vec{V} \times \hat{r} = (6.80 * 10^5)\ \hat{i} \times \hat{j} = (6.80 * 10^5)\ \hat{k}$

$$\vec{B} = \frac{4\pi * 10^{-7}}{4\pi} * \frac{4.80 * 10^{-6} * (6.80 * 10^5)\ \hat{k}}{(0.5)^2}$$

$$\boxed{\vec{B} = (1.31 * 10^{-6} T)\ \hat{k}}$$

B)

$\vec{V} = (6.80 * 10^5)\hat{i}$
$\hat{r} = \hat{i}$
$\vec{V} \times \hat{r} = (6.80 * 10^5)\ \hat{i} \times \hat{i} = 0$

$$\boxed{\vec{B} = 0}$$

❖ Magnetic field of A current element:

**التيار الكهربائي هو احد اهم مصادر المجال المغناطيسي اذ ان المجال المغناطيسي $(d\vec{B})$ عند نقطة تبعد مسافة(r)عن $(\vec{dl})$من طول موصل يمر فيه تيار كهربائي (I) والناشئ عنه يتناسب طرديا مع مقدار التيار الكهربائي وطول الموصل:

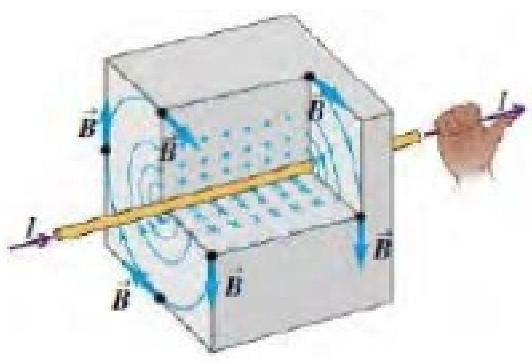
$$d\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{I * (\vec{dl} \times \hat{r})}{r^2}$$

$d\vec{B}$: Magnetic field due to an infinitesimal current element$(\vec{dl})$.
$\vec{dl}$: Vector length of element

I: current

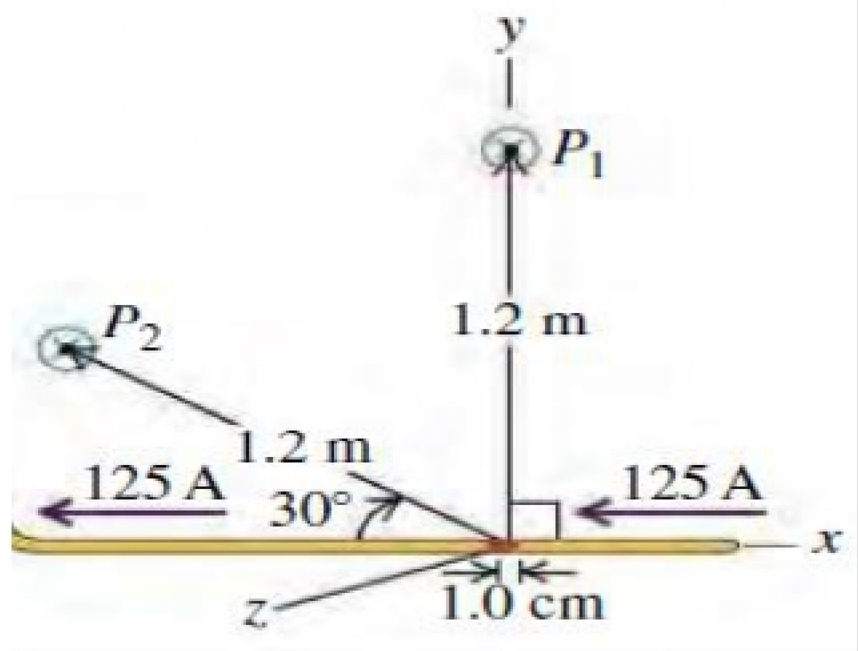
$\hat{r}$: متجه المسافة من القطعة المار فيها تيار الى النقطة المراد القياس عندها (انتبه)

ويتم تحديد اتجاه المجال المغناطيسي عند طريق قاعدة اليد اليمنى:



الابهام يشير الى الاتجاه مرور التيار الكهربائي وبقية الاصابع تشير الى اتجاه المجال المغناطيسي.

Example (2): A copper wire carries a steady 125-A current to an electroplating tank. Find the magnetic field due to a 1.0-cm segment of this wire at a point 1.2 m away from it, if the point is (a) point $P1$, straight out to the side of the segment, and (b) point $P2$, in the xy-plane and on a line at 30_ to the segment.



Solution: $\vec{dl} = -(1.0\text{-cm})\ \hat{i}$ $\quad I = 125A$

(a) $\vec{dB} = \frac{\mu_\circ}{4\pi} * \frac{I*(\vec{dl} \times \hat{r})}{r^2}$

$\hat{r} = \hat{j}$

$\vec{dl} \times \hat{r} = -(1.0\text{-cm})\ \hat{i} \times \hat{j} = -(10^{-2})\ \hat{k}$

$$\boxed{\vec{dB} = \frac{4\pi*10^{-7}}{4\pi} * \frac{125*-(10^{-2})\ \hat{k}}{(1.2)^2} = -(8.7*10^{-8}T)\ \hat{k}}$$

b)

$\hat{r} = -(1.2 * \cos(30°))\ \hat{i} + (1.2 * \sin(30°))\hat{j}$

$\vec{r} = -(1.2 * \cos(30°))\ \hat{i} + (1.2 * \sin(30°))\hat{j}$

r=$\sqrt{(1.2 * \cos(30°))^2 + (1.2 * \sin(30°))^2} = 1.2\ m$

$$\vec{dB} = \frac{4\pi * 10^{-7}}{4\pi} * \frac{125 * (-(1.0 - \text{cm})\ \hat{i} \times -(1.2 * \cos(30°))\ \hat{i} + (1.2 * \sin(30°))\hat{j})}{(1.2)^3}$$

$$\boxed{\vec{dB} = -(4.3 * 10^{-8}T)\ \hat{k}}$$

❖ **Magnetic field of a straight (infinite) current carrying conductor:**

ان مرور تيار كهربائي في موصل مستقيم طويل يولد حوله مجال مغناطيسي على شكل دوائر متحدة في المركز ويقع مركزها عند نقطة على محور الموصل ويكون مستواها عاموديا على الموصل ولحساب المجال المغناطيسي:

$$\vec{B} = \frac{\mu_\circ * I}{2\pi r}$$

عندما يطلب المجال المغناطيسي من (long, straight conductor) يحمل تيار نعوض بالقانون مباشرة.

*ويحدد الاتجاه من خلال قاعدة اليد اليمنى:

يشير الابهام الى اتجاه مرور التيار الكهربائي وباقي الاصابع الى اتجاه المجال المغناطيسي.

Example (3): A long, straight conductor carries a 1.0-A current. At what distance from the axis of the conductor does the resulting magnetic field have magnitude B = 0.5 * 10-4 T.

Solution:

$\vec{B} = \frac{\mu_\circ * I}{2\pi r} \quad \Rightarrow r = \frac{\mu_\circ * I}{2\pi B}$

$r = \frac{4\pi * 10^{-7} * 1}{2\pi * 0.5 * 10^{-4}}$

$\boxed{r = 4 \text{ mm}}$

❖ **Force Between parallel conductors:**

$\vec{B} = \frac{\mu_\circ * I}{2\pi r}$

F= $I' * \vec{L} \times \vec{B}$

the magnitude of this force is:

F= $I' * L * B = \frac{\mu_\circ * I * I' * L}{2\pi r}$

Where:

I = Current in first conductor

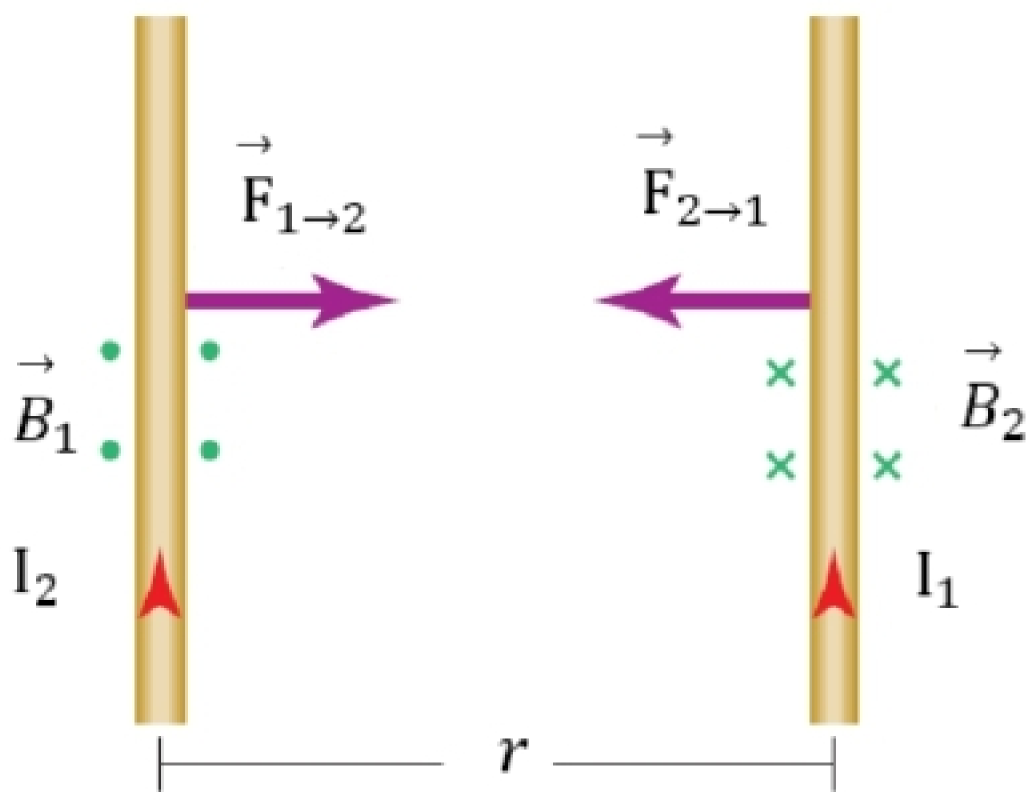
I' = Current in second conductor

$F_{2\rightarrow 1} == \frac{\mu_\circ * I_1 * I_2 * L_1}{2\pi r}$ (يؤثر الموصل الثاني في الاول)

$F_{1\rightarrow 2} == \frac{\mu_\circ * I_2 * I_1 * L_2}{2\pi r}$ (يؤثر الموصل الأول في الثاني)

$\vec{B}_1 = \frac{\mu_\circ * I_1}{2\pi r} \quad , \quad \vec{B}_2 = \frac{\mu_\circ * I_2}{2\pi r}$

$F_{1\rightarrow 2} = -F_{2\rightarrow 1}$



لحساب القوة المتبادلة لكل وحدة طول:

$\frac{F}{l} = \frac{\mu_\circ * I_1 * I_2}{2\pi r} \quad (\frac{N}{m})$

Example: Two straight, parallel, superconducting wires 4.5 mm apart carry equal currents of 15,000 A in opposite directions. What force, per unit length, does each wire exert on the other?
Solution:

The conductors repel each other because the currents are in opposite directions.

$$\frac{F}{l} = \frac{\mu_\circ * I_1 * I_2}{2\pi r} = \frac{4\pi * 10^{-7} * 15{,}000 * 15{,}000}{2\pi * 4.5 * 10^{-3}}$$

$$\boxed{1 * 10^4 (\frac{N}{m})}$$

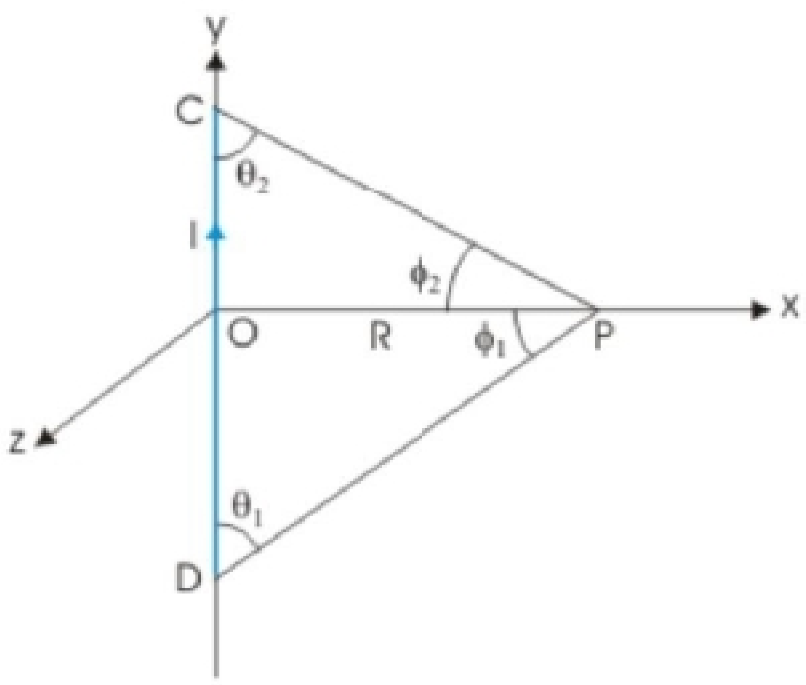
- **Magnetic field of a finite current carrying conductor:**

المجال المغناطيسي الناشئ عن تيار كهربائي يمر في موصل مستقيم محدود الطول (الموصل له طول محدد).

$$\vec{B} = \frac{\mu_\circ * I}{2\pi r} * (\cos(\theta_1) - \cos(\theta_2))$$

Where:

r:المسافة من الموصل الى النقطة المراد القياس عندها



- **Magnetic field of circular current loop and coil:**

*تولد كل لفة من لفات الموصل النحاسي مجالا مغناطيسيا عندما يمر في تيار كهربائي ويمكن حساب المجال المغناطيسي عند نقطة تبعد عن المركز مسافة (x):

$$\vec{B} = \frac{\mu_\circ * I * a^2 * N}{2(a^2 + x^2)^{(3/2)}}$$

Where:

a: Radius of loop

x: Distance along axis from center of loop to field point

N: عدد اللفات $N = \frac{\theta}{2\pi}$ (تستخدم عندما يوجد اقل من لفة مثال ربع لفة او نص لفة)

اللفة الواحدة $(\theta = 360^\circ = 2\pi)$ ، ربع لفة $(\theta = 90^\circ = \frac{\pi}{2})$ ، نص لفة $(\theta = 180^\circ = \pi)$ و هكذا.

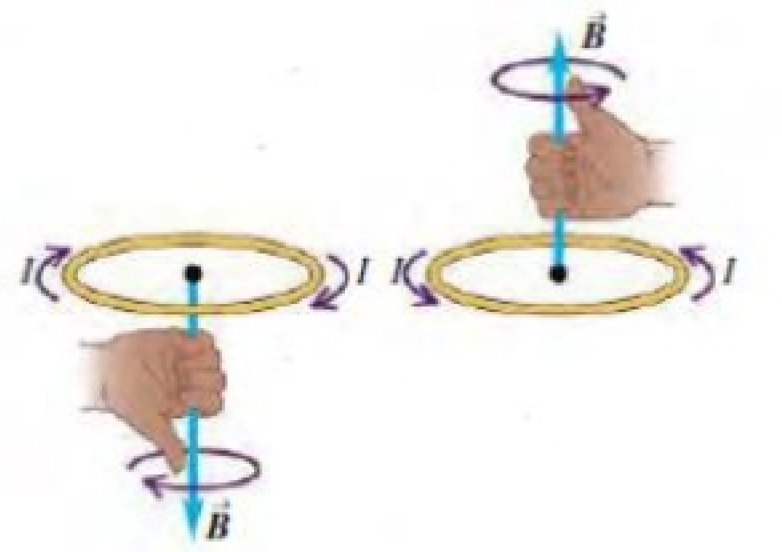
ملاحظة: إذا حكى في السؤال(circular) فهذا يعني (N=1).

حالة خاصة: لحساب المجال المغناطيسي في مركز الملف الدائري: (x=0)

$$\vec{B} = \frac{\mu_\circ * I * N}{2a}$$

ويحدد الاتجاه من خلال قاعدة اليد اليمنى:

الاصابع باتجاه مرور التيار الكهربائي في الملف ويشير الابهام الى اتجاه المجال المغناطيسي.



Example (4): A coil consisting of 100 circular loops with radius 0.60 m carries a 5.0A current. (a) Find the magnetic field at a point along the axis of the coil (0.80m) from the center. (b) Along the axis, at what distance from the center of the coil is the field magnitude $\frac{1}{8}$ as great as it is at the center:

Solution: N=100 turns a=0.6 m I=5A

(a) x=0.80m

$$\vec{B} = \frac{\mu_\circ * I * a^2 * N}{2(a^2 * x^2)^{(3/2)}} = \frac{4\pi * 10^{-7} * 5 * (0.6)^2 * 100}{2((0.6)^2 + (0.8)^2)^{(3/2)}}$$

$$\boxed{\vec{B} = 1.1 * 10^{-4} T}$$

(b)

إيجاد المسافة (x) التي تجعل المجال المغناطيسي عندها يساوي ثمن المجال المغناطيسي في المركز

$$\vec{B}_c = \frac{\mu_\circ * I * N}{2a} = \frac{4\pi * 10^{-7} * 5 * 100}{2 * 0.6}$$

$$\vec{B}_c = 5.23 * 10^{-4} T$$

$$\frac{1}{8}\vec{B}_c = \frac{1}{8} * 5.23 * 10^{-4} = \frac{4\pi * 10^{-7} * 5 * (0.6)^2 * 100}{2((0.6)^2 + (x)^2)^{(3/2)}}$$

x =1.04m

- **The Magnetic field of a solenoid (ملف لولبي):**

يتكون الملف اللولبي من عدد الحلقات الدائرية المتماثلة في نصف القطر وتقع مراكز على خط مستقيم يمثل محور الملف ولحساب المجال المغناطيسي:

$$\vec{B} = \frac{\mu_\circ * I * N}{L}$$

Where:

L: طول الملف

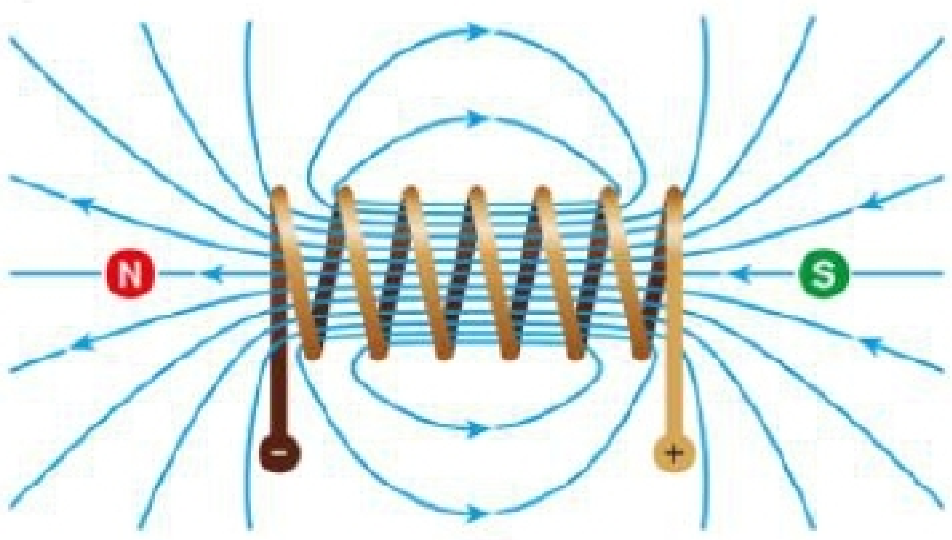
N: عدد اللفات

في بعض الأحيان يكون (N) و(L) مجهولين وبطلب (n : turns per unit length):

$$n = \frac{N}{L} \text{ (turns per unit length)}$$

$$\vec{B} = \mu_\circ * I * n$$

لتحديد اتجاه المجال المغناطيسي: تشير الاصابع الاربعة الى اتجاه التيار الكهربائي في الملف اللولبي ويشير الابهام الى اتجاه المجال المغناطيسي ((القطب الشمالي)) .



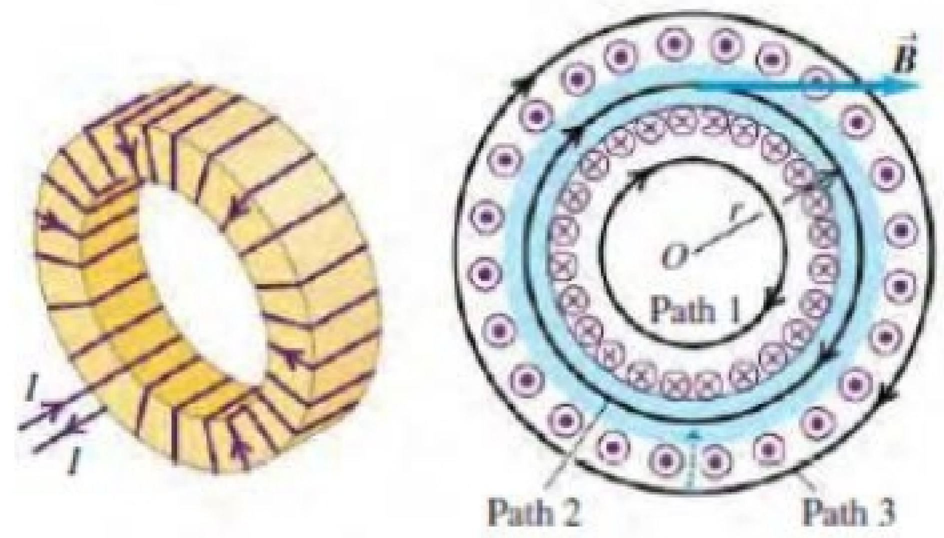
Example (5): A 15.0-cm-long solenoid with radius 0.750 cm is closely wound with 600 turns of wire. The current in the windings is 8.00 A. Compute the magnetic field at a point near the center of the solenoid.

Solution: L=0.15m I=8 N= 600

$$B = \frac{\mu_\circ * I * N}{L} = \frac{4\pi * 10^{-7} * 8 * 600}{.15}$$

$\boxed{B = 0.0402 \text{ T}}$

❖ The Magnetic field of a toroidal solenoid:



$B = \frac{\mu_\circ * I * N}{2\pi r}$ a<r<b

$B = 0$ (At center)

$B = 0$ (At outside)

❖ Field of a long cylindrical conductor:

$B = \frac{\mu_\circ * I * r}{2\pi R^2}$ (inside the conductor r<R)

$B = \frac{\mu_\circ * I}{2\pi r}$ (outside the conductor r>R)

❖ Ampere's law:

ينص قانون أمبير على أن التكامل الخطي للمجال المغناطيسي على مسار مغلق يساوي محصلة التيار الكلي المخترق للسطح المفتوح المحدود بهذا المسار المغلق مضروبا في معامل السماحية المغناطيسية.

$$\oint \vec{B} \cdot \vec{dl} = \mu_\circ * I_{enc}$$

Where:

I_{enc}: Net current enclosed by path

$\mu_\circ$: Magnetic constant

أهم القوانين:

Magnetic field of A moving charge:

$$\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{q * (\vec{V} \times \hat{r})}{r^2}$$

Magnetic field of A current element:

$$d\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{I * (\vec{dl} \times \hat{r})}{r^2}$$

Magnetic field of a straight (infinite) current carrying conductor:

$$\vec{B} = \frac{\mu_\circ * I}{2\pi r}$$

Force Between parallel conductors:

$F_{2\to1} == \frac{\mu_\circ * I_1 * I_2 * L_1}{2\pi r}$ (يؤثر الموصل الثاني في الاول)

$F_{1\to2} == \frac{\mu_\circ * I_2 * I_1 * L_2}{2\pi r}$ (يؤثر الموصل الأول في الثاني)

$F_{1\to2} = -F_{2\to1}$

Magnetic field above of a finite current carrying conductor:

$$\vec{B} = \frac{\mu_\circ * I}{2\pi r} * (\cos(\theta_1) - \cos(\theta_2))$$

Magnetic field of circular current loop and coil:

$$\vec{B} = \frac{\mu_\circ * I * a^2 * N}{2(a^2 + x^2)^{(3/2)}}$$

$\vec{B} = \frac{\mu_\circ * I * N}{2a}$ (في مركز الملف)

The Magnetic field of a solenoid (ملف لولبي):

$$\vec{B} = \frac{\mu_\circ * I * N}{L}$$

$$\vec{B} = \mu_\circ * I * n$$

The Magnetic field of a toroidal solenoid:

$B = \frac{\mu_\circ * I * N}{2\pi r}$ a<r<b

$B = 0$ (At center) , $B = 0$ (At outside)

Field of a long cylindrical conductor:

$B = \frac{\mu_\circ * I * r}{2\pi R^2}$ (Inside the conductor r<R)

$B = \frac{\mu_\circ * I}{2\pi r}$ (Outside the conductor r>R)

Problems

Book & more

تمارين مهمة:

Q1) A +6.00μC point charge is moving at a constant $8.00 * 10^6$ m/s in the +y-direction, relative to a reference frame. At the instant when the point charge is at the origin of this reference frame, what is the magnetic-field vector B it produces at the points:

a) x = 0.5 m, y = 0 m, z =0 m.

b) x = 0, y = -0.5 m, z = +0.5 m.

Answer:

$a)\ \vec{B} = -(1.92 * 10^{-5}\text{T})\ \hat{k}$

b) $\vec{B} = (6.79 * 10^{-6}\text{T})\ \hat{i}$

a)

$\hat{r} = \hat{i}\ ,\ \ \vec{V} = \hat{j}\quad \vec{V} \times \hat{r} = -\hat{k}$

$$\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{q*(\vec{V} \times \hat{r})}{r^2} = \frac{4\pi*10^{-7}}{4\pi} * \frac{+6.00*8.00*10^6}{0.5^2}(-\hat{k}) = -(1.92 * 10^{-5}\text{T})\ \hat{k}$$

b)

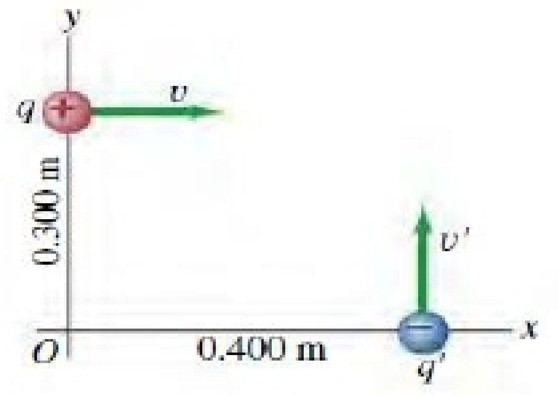
$\vec{V} = (8.00\ *\ 10^6)\hat{j}$

$\hat{r} = -(0.500\text{ m})\ \hat{j} + (0.500\text{ m})\hat{k}\ \ \rightarrow \vec{r} = (0.500\text{ m})\ \hat{j} + (0.500\text{ m})\hat{k}\ \ \rightarrow\ \ r = \sqrt{0.500^2 + 0.500^{\,2}} = 0.707$

$$\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{q*(\vec{V} \times \hat{r})}{r^2} = \frac{4\pi*10^{-7}}{4\pi} * \frac{((8.00*10^6)\hat{j} \times ((0.500\text{ m})\ \hat{j} + (0.500\text{ m})\hat{k})}{0.707^2} = (6.79 * 10^{-6}\text{T})\ \hat{i}$$

Q2) A pair of point charges, q = +8.00 μC and q' = -5.00 μC, are moving as shown with speeds v = $9.00 * 10^4$ m/s and v' = $6.50 * 10^4$ m/s. When the charges are at the locations shown in the figure, what are the magnitude and direction of the magnetic field produced at the origin.

Answer: $\text{B}_{net} = 1\mu T$

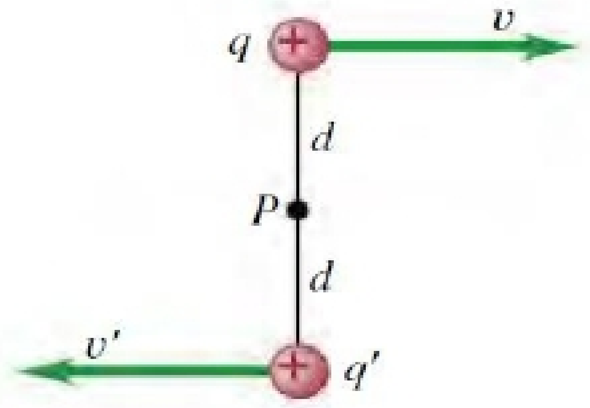


Q3) Positive point charges q = +8.00 μC and $q' = +3.00\ \mu C$ are moving relative to an observer at point P. The distance d is 0.120 m, v = $4.50 * 10^6$ m/s, and v' = $9.00 * 10^6$ m/s. When the two charges are at the locations shown in the figure, what are the magnitude and direction of the net magnetic field they produce at point P?

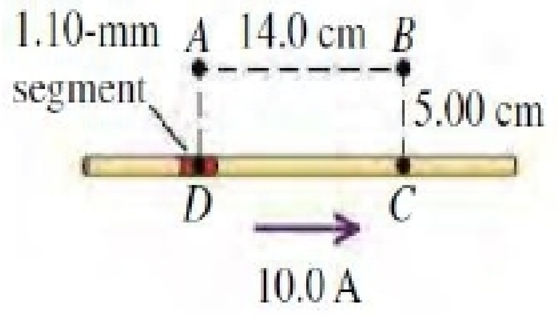
Answer: $\text{B} = 4.38 * 10^{-4}\ T$

$\vec{\text{B}}_{net} = B + B'$

$$\vec{\text{B}}_{net} = \frac{\mu_\circ}{4\pi} * \left(\frac{q*v}{d^2} + \frac{q'*v'}{d^2}\right)(-\hat{k}) = \text{B} = 4.38 * 10^{-4}(-\hat{k})$$



Q4) A straight wire carries a (10.0A) current. ABCD is a rectangle with point D in the middle of a (1.10mm) segment of the wire and point C in the wire. Find the magnitude and direction of the magnetic field due to this segment at: point A, point B and point C.



Answer:

at point A: $d\vec{B} = 4.40 * 10^{-7}$T out of the page

at point B: $d\vec{B} = 1.67 * 10^{-8}$T out of the page

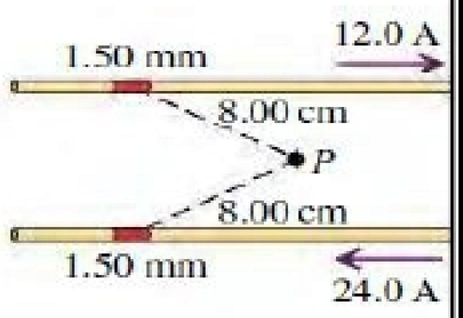
at point C: $d\vec{B} = 0\ , \theta\ = 0^{\circ}$

at point A:

$$d\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{I * (\vec{dl}\ \times \hat{r})}{r^2} = \frac{4\pi * 10^{-7}}{4\pi} * \frac{10 * (\,1.1 * 10^{-3}\,\hat{i} \times \hat{j}\,)}{(5 * 10^{-2})^2} = 4.40\ *\ 10^{-7}\text{T out of the page}$$

Q5) Two parallel wires are 5.00 cm apart and carry currents in opposite directions. Find the magnitude and direction of the magnetic field at point P due to two 1.50-mm segments of wire that are opposite each other and each 8.00 cm from P.

Answer: $\vec{dB}\ =\ (2.64 * 10^{-7}$T) into the page.



$$\hat{r} = \frac{(7.6\ \hat{i} - 2.5\hat{j})}{8}$$

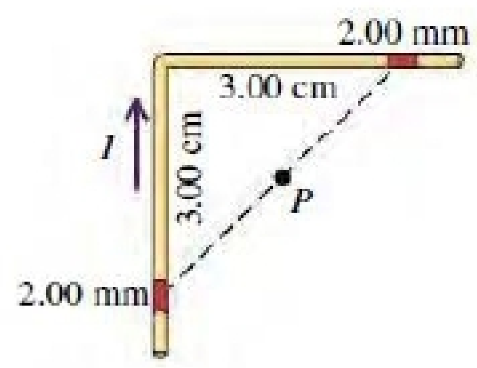
$$d\vec{B} = \frac{\mu_\circ}{4\pi} * \frac{I * (\vec{dl}\ \times \hat{r})}{r^2} = \frac{4\pi * 10^{-7}}{4\pi} * \frac{12 * (0.0015\hat{i} \times \frac{(7.6\ \hat{i} - 2.5\hat{j})}{8})}{(8 * 10^{-2})^2} = 8.79 * 10^{-8}T$$

The field from the 24.0-A segment is twice this value.

$d\vec{B}_{net} = B_1 + B_2 = (2.64 * 10^{-7}$T) into the page

Q6) A wire carrying a 28.0-A current bends through a right angle. Consider two 2.00-mm segments of wire, each 3.00 cm from the bend. Find the magnitude and direction of the magnetic field these two segments produce at point P, which is midway between them.

Answer: $\vec{dB}\ =\ (1.75* 10^{-5}$T) into the page.



Q7) The currents have the magnitudes $I_1\ = 4.0$ A, $I_2\ = 6.0$ A, and $I_2\ = 2.0$ A, and the directions shown. Four paths, labeled a through d, are shown. What is the line integral ($\oint \vec{B} \,.\, \vec{dl}$) for each path?

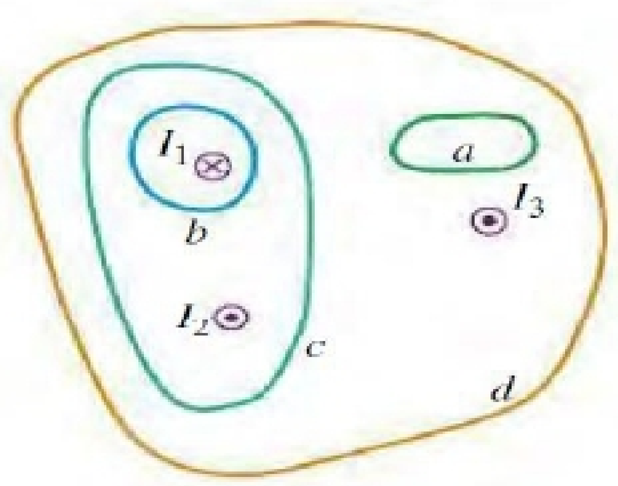
Answer:

Path a: $\oint \vec{B}\,.\,\vec{dl}$=0

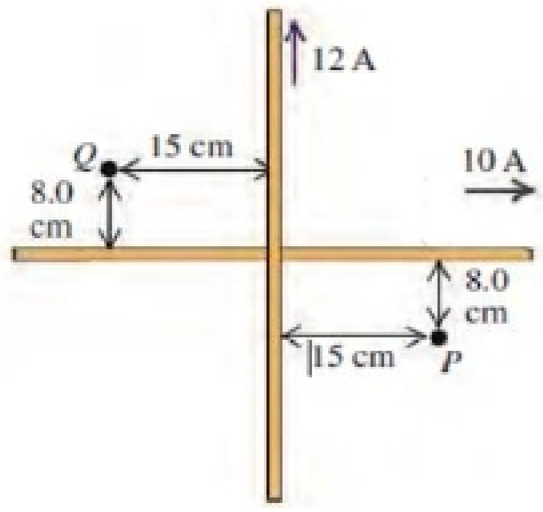
Path b: $\oint \vec{B}\,.\,\vec{dl}$= (-5.03µ T.m)

Path c: $\oint \vec{B}\,.\,\vec{dl}$= (2.51 µT.m)

Path d: $\oint \vec{B}\,.\,\vec{dl}$= (5.03 µT.m)



Q8) Two very long insulated wires perpendicular to each other in the same plane carry currents. Find the magnitude of the net magnetic field these wires produce at points P and Q.



Answer:
At point Q: B_{net}=4.1*10^{-5} T out the page
At point P: B_{net}=0.9*10^{-5} T into the page

At point Q:

$$\vec{B}_1 = \frac{\mu_\circ * I_1}{2\pi r_1} = 1.6 * 10^{-5} T$$

$$\vec{B}_2 = \frac{\mu_\circ * I_2}{2\pi r_2} = 2.5 * 10^{-5} T$$

$$B_{net} = \vec{B}_1 + \vec{B}_2 = 4.1 * 10^{-5} T$$

At point P:

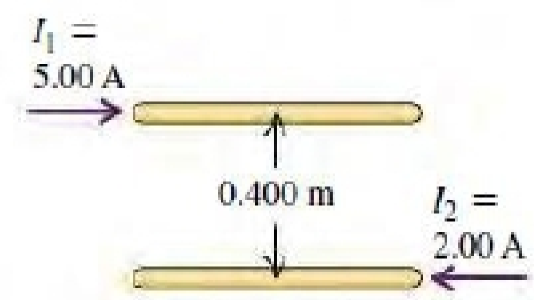
$$B_{net} = \vec{B}_2 + \vec{B}_1 = 0.9 * 10^{-5} T$$

Q9)A long wire carrier a current. If the magnetic field 19.5 cm away from the wire is 124.78 mT, what is the magnetic field 5.53 cm away?
Answer: 440.002 mT

$$\vec{B} = \frac{\mu_\circ * I}{2\pi r} \rightarrow 123.78 * 10^{-3} = \frac{4\pi * 10^{-7} * I}{2\pi\ 0.195} \rightarrow I = 121660.5$$

$$\vec{B} = \frac{\mu_\circ * I}{2\pi r} = 440.002\ mT$$

Q10) Two long, parallel wires are separated by a distance of 0.400 m. The currents I_1 and I_2 have the opposite direction. Calculate the magnitude of the force exerted by each wire on a 1.20-m length of the other. Is the force attractive or repulsive?
Answer:
F=6*$10^{-6}N$, repulsive



$$F_{2\rightarrow 1} = \frac{\mu_\circ * I_1 * I_2 * L_1}{2\pi r} = \frac{4\pi * 10^{-7} * 5 * 2 * 1.2}{2\pi * 0.4} = 6 * 10^{-6} N$$

Q11) A 2m wire is formed into a 5-turns circular loop. If the wire carries a 1.2A current, determine the magnetic field (in µT) at the center of the loop.
Answer: 59

Q12) Two long, parallel wires are separated by a distance of 2.50 cm. The force per unit length that each wire exerts on the other is 4.00 * 10^{-5} N/m, and the wires repel each other. The current in one wire is 0.600 A. What is the current in the second wire?
Answer: I=8.33A

$\frac{F}{L} = \frac{\mu_\circ * I_1 * I_2}{2\pi r} \rightarrow 4.00 * 10^{-5} = \frac{\mu_\circ * 6 * I_2}{2\pi * 0.025} \rightarrow I = 8.33A$

Q13) A closely wound, circular coil with radius 2.40 cm has 800 turns. What must the current in the coil be if the magnetic field at the center of the coil is 0.0770 T?
Answer: I=3.68A

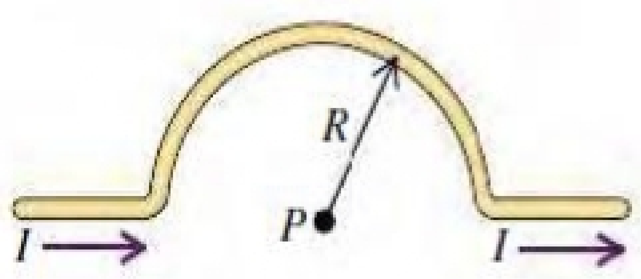
$\vec{B} = \frac{\mu_\circ * I * N}{2a} \rightarrow 0.0770 = \frac{4\pi * 10^{-7} * I * 800}{2 * 0.024} \rightarrow I = 3.68A$

Q14) A closely wound, circular coil with radius 2.40 cm has 800 turns and the current is (3.68A) if the magnetic field at the center of the coil is 0.0770 T. At what distance x from the center of the coil, on the axis of the coil, is the magnetic field half its value at the center?
Answer: X=1.84 cm

$$\vec{B} = \frac{\mu_\circ * I * a^2 * N}{2(a^2 + x^2)^{(3/2)}}$$

X=1.84 cm

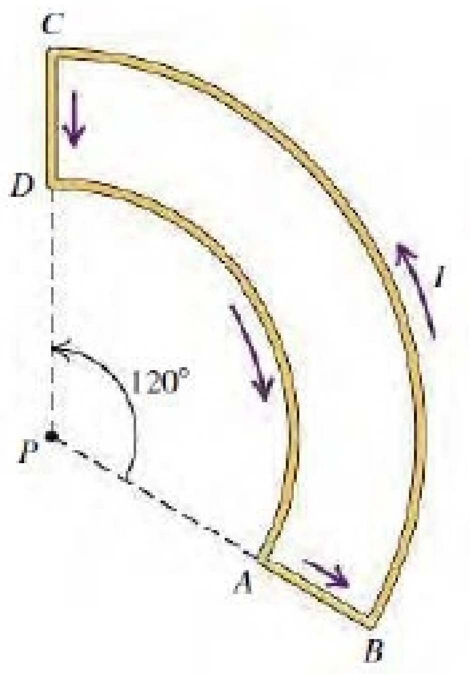
Q15) Calculate the magnitude and direction of the magnetic field at point P due to the current in the semicircular section of wire is (2A) and R = 1.4 cm.
Answer: B = 44.9µ



$$N = \frac{\theta}{2\pi} = \frac{\pi}{2\pi} = 0.5$$

$$\vec{B} = \frac{\mu_\circ * I * N}{2a} = \frac{4\pi * 10^{-7} * 2 * 0.5}{2 * 1.4} = 44.9\mu$$

Q16) Calculate the magnetic field (magnitude and direction) at a point P due to a current I = 12.0 A in the wire. Segment BC is an arc of a circle with radius 30.0 cm, and point P is at the center of curvature of the arc. Segment DA is an arc of a circle with radius 20.0 cm, and point P is at its center of curvature. Segments CD and AB are straight lines of length 10.0 cm each. Answer:



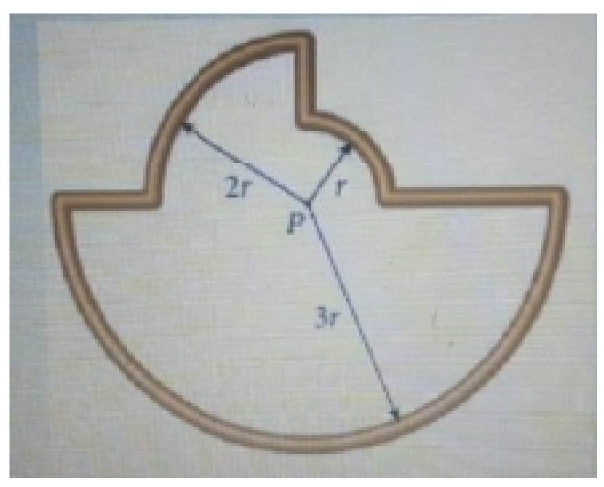
$$N = \frac{\theta}{2\pi} = \frac{\frac{2\pi}{3}}{2\pi} = \frac{1}{3}$$

$$\vec{B}_{20} = \frac{\mu_\circ * I_1 * N}{2\pi r_1}$$

$$\vec{B}_{30} = \frac{\mu_\circ * I_2 * N}{2\pi r_2}$$

$$B_{net} = \vec{B}_{20} - \vec{B}_{30} = 4.16\mu t$$

Q17)In the current-carrying loop shown in the figure, the distance r= 2.329 m. the magnitude of the magnetic field at point p inside the loop is $5.937 * 10^{-7}$ T. what is the current in the loop.
answer: 4.063 A



$$\vec{B}_1 = \frac{\mu_\circ * I * N_1}{2\pi r_1} = 1.6 * 10^{-5} T$$

$$\vec{B}_2 = \frac{\mu_\circ * I * N_2}{2\pi r_2} = 2.5 * 10^{-5} T$$

$$\vec{B}_3 = \frac{\mu_\circ * I * N_3}{2\pi r_3} =$$

$$B_{net} = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 = \frac{\mu_\circ * I}{2\pi}\left(\frac{0.25}{r} + \frac{0.25}{2r} + \frac{0.5}{3r}\right)$$
$$I = 4.963$$

Q18) A 15.0-cm-long solenoid with radius 0.750 cm is closely wound with 600 turns of wire. The current in the windings is 8.00 A. Compute the magnetic field at a point near the center of the solenoid.
Answer:
B = 0.0402 T

$$\vec{B} = \frac{\mu_\circ * I * N}{L} = \frac{4\pi * 10^{-7} * 8 * 600}{0.15} = 0.402T$$

Q19) A solenoid has magnetic field (0.0270 T) at the center. It has radius 1.40 cm and length 40.0 cm, and the wire can carry a maximum current of 12.0 A. find the minimum number of turns per unit length must the solenoid have and the total length of wire is required?
Answer:

$$\frac{n}{l} = 1790$$

L= 63m

{Done by: Omar Mohammad}

تمارين:

1-A wire carries a current of 20 A along the x-axis from $x = -3.0$ cm to $x = +3.0$ cm. Determine the magnitude of the resulting magnetic field at the point $y = 4.0$ cm on the y axis.

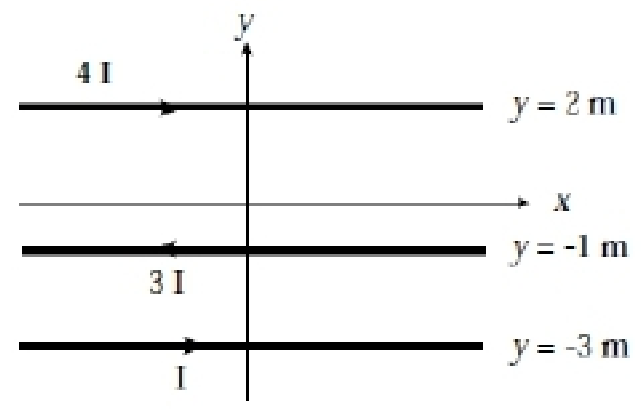
a. 96 μT **b.** 72 μT **c.** 84 μT **d.** 60 μT **e.** 100 μT

2-Two long parallel wires each carry a current of 5.0 A directed to the east. The two wires are separated by 8.0 cm. What is the magnitude of the magnetic field at a point that is 5.0 cm from each of the wires?

a. 72 μT **b.** 48 μT **c.** 24 μT **d.** 96 μT **e.** 32 μT

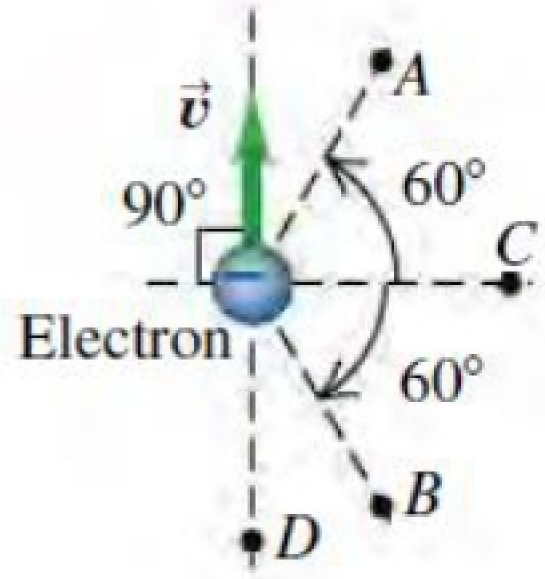
3-Three long wires parallel to the x axis carry currents as shown. If $I = 20$ A, what is the magnitude of the magnetic field at the origin?

a. 37 μT **b.** 28 μT **c.** 58 μT **d.** 47 μT **e.** 19 μT



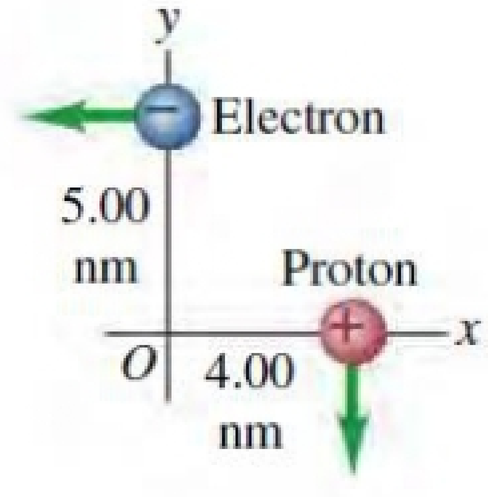
4-An electron moves at $0.100c$ as shown in **figure**. Find the magnitude and direction of the magnetic field this electron produces at the following points, each 2.00 mm from the electron points A and B?

Answer: ……………………



5-An electron and a proton are each moving at 735 km>s in perpendicular paths as shown in Fig. E28.8. At the instant when they are at the positions shown, find the magnitude and direction of the total magnetic field they produce at the origin?

Answer: ……………………



6-Two long straight wires carry currents perpendicular to the xy plane. One carries a current of 50 A and passes through the point $x = 5.0$ cm on the x axis. The second wire has a current of 80 A and passes through the point $y = 4.0$ cm on the y axis. What is the magnitude of the resulting magnetic field at the origin?

a. 200 μT **b.** 600 μT **c.** 300 μT **d.** 450 μT **e.** 400 μT

7-Two long parallel wires separated by 5.0 mm each carry a current of 60 A. These two currents are oppositely directed. What is the magnitude of the magnetic field at a point that is between the two wires and 2.0 mm from one of the two wires?

a. 2.0 mT **b.** 10 mT **c.** 8.0 mT **d.** 1.6 mT **e.** 7.2 mT

8-Two long parallel wires carry unequal currents in the same direction. The ratio of the currents is 3 to 1. The magnitude of the magnetic field at a point in the plane of the wires and 10 cm from each wire is 4.0 μT. What is the larger of the two currents?

a. 4.5 A **b.** 0.75 A **c.** 3.0 A **d.** 2.3 A **e.** 0.5 A

9-A short current element $\vec{dl} = (500\ mm)\hat{j}$ carries a current of 5.40 A in the same direction as $\vec{dl}$. Point P is located at $\vec{r} = (-0.730\ m)\hat{i} + (0.390\ m)\hat{k}$. Use unit vectors to express the magnetic field at P produced by this current element.

Answer: ……………………

10-A square wire loop 10.0 cm on each side carries a clockwise current of 8.00 A. Find the magnitude and direction of the magnetic field at its center due to the four 1.20-mm wire segments at the midpoint of each side.

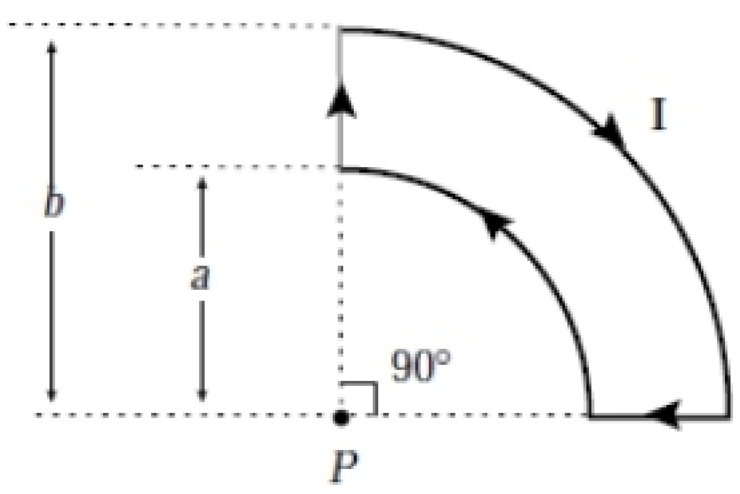
Answer: ……………………

11-A segment of wire of total length 2.0 m is formed into a circular loop having 5.0 turns. If the wire carries a 1.2–A current, determine the magnitude of the magnetic field at the center of the loop.

a. 59 μT **b.** 69 μT **c.** 79 μT **d.** 89 μT **e.** 9.4 μT

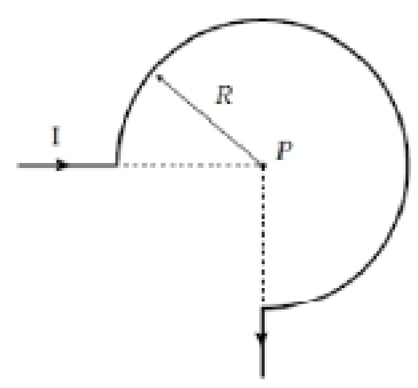
12-In the figure shown, if a = 1.0 cm, b = 3.0 cm, and I = 30 A, what is the magnitude of the magnetic field at point P?

a. 0.62 mT **b.** 0.59 mT **c.** 0.35 mT **d.** 0.31 mT **e.** 0.10 mT



13-The segment of wire (total length = 6R) is formed into the shape shown and carries a current I. What is the magnitude of the resulting magnetic field at the point P?

a. $\frac{3\mu_0 I}{8R}$ **b.** $\frac{3\mu_0 I}{2R}$ **c.** $\frac{3\mu_0 I}{4R}$ **d.** $\frac{3\mu_0 I}{R}$ **e.** $\frac{3\mu_0 \pi I}{8R}$

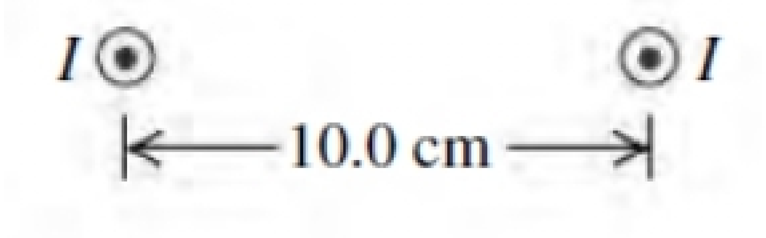


14-Two long, straight wires, one above the other, are separated by a distance $2a$ and are parallel to the x-axis. Let the $+y$-axis be in the plane of the wires in the direction from the lower wire to the upper wire. Each wire carries current I in the $+x$-direction. What are the magnitude and direction of the net magnetic field of the two wires at a point in the plane of the wires midway between them?

Answer: ....

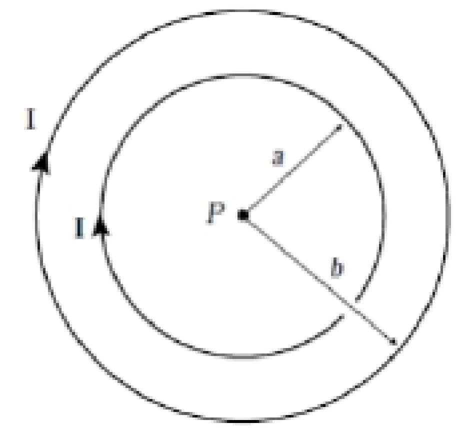
15-Two long, straight, parallel wires, 10.0 cm apart, carry equal 4.00-A currents in the same direction, as shown in **figure**. Find the magnitude and direction of the magnetic field at point $P1$, point $P3$, 20.0 cm directly above $P1$?

Answer: ....



16-What is the magnitude of the magnetic field at point P if $a = R$ and $b = 2R$?

a. $\frac{\mu_0 I}{3R}$ **b.** $\frac{\mu_0 I}{4R}$ **c.** $\frac{3\mu_0 I}{4R}$ **d.** $\frac{2\mu_0 I}{3R}$ **e.** $\frac{3\mu_0 \pi I}{4R}$

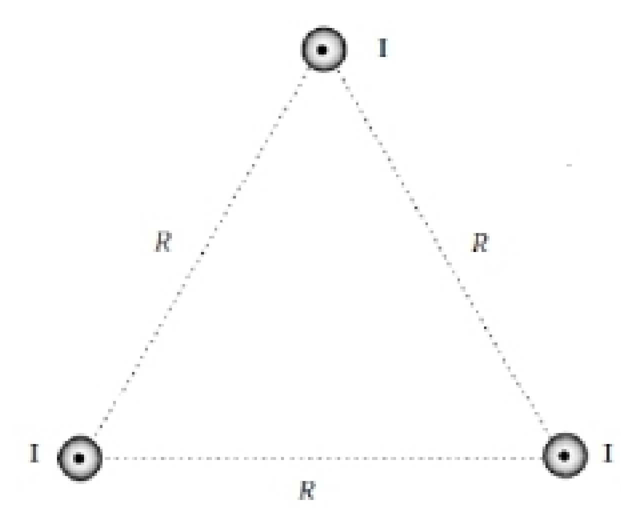


17-Two long parallel wires are separated by 6.0 mm. The current in one of the wires is twice the other current. If the magnitude of the force on a 3.0-m length of one of the wires is equal to 8.0 μN, what is the greater of the two currents?

a. 0.20 A **b.** 0.40 A **c.** 40 mA **d.** 20 mA **e.** 0.63 A

18-The figure shows a cross section of three parallel wires each carrying a current of 5.0 A out of the paper. If the distance $R = 6.0$ mm, what is the magnitude of the magnetic force on a 2.0-m length of any one of the wires?

a. 2.5 mN **b.** 3.3 mN **c.** 2.2 mN **d.** 2.9 mN **e.** 1.7 mN

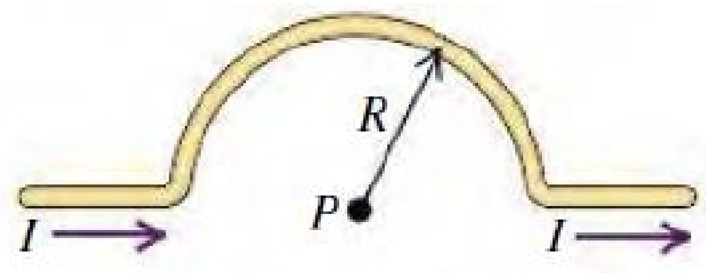


19-Two long, parallel wires are separated by a distance of 2.50 cm. The force per unit length that each wire exerts on the other is $4 * 10^{-5} N/m$, and the wires repel each other. The current in one wire is 0.600 A. What is the current in the second wire? Are the two currents in the same direction or in opposite directions?

Answer: .... / ....

20-Calculate the magnitude and direction of the magnetic field at point P due to the current in the semicircular section of wire shown in **figure?**

Answer: ....



21-The figure shows a cross section of three 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 force on a 4.0-m length of wire A?

a. 15 mN **b.** 77 mN **c.** 59 mN **d.** 12 mN **e.** 32 mN

22-A long straight wire (diameter = 2.0 mm) carries a current of 25 A. What is the magnitude of the magnetic field 0.50 mm from axis of the wire?

a. 5.0 mT **b.** 10 mT **c.** 0.63 mT **d.** 2.5 mT **e.** 0.01 mT

23-A hollow cylindrical (inner radius = 2.0 mm, outer radius = 4.0 mm) conductor carries a current of 24 A parallel to its axis. This current is uniformly distributed over a cross section of the conductor. Determine the magnitude of the magnetic field at a point that is 5.0 mm from the axis of the conductor.

a. 0.96 mT **b.** 1.7 mT **c.** 0.55 mT **d.** 1.2 mT **e.** 0.40 mT

24-A closely wound, circular coil with radius 2.40 cm has 800 turns. What must the current in the coil be if the magnetic field at the center of the coil is 0.0770 T?

Answer: ....

25-A closely wound coil has a radius of 6.00 cm and carries a current of 2.50 A. How many turns must it have if, at a point on the coil axis 6.00 cm from the center of the coil, the magnetic field is $6.36 * 10^{-4} T$?

Answer: ....

26-A wire carries a current of 10 A along the y axis from $y = -9.0$ cm to $y = 16$ cm. What is the magnitude of the resulting magnetic field at a point, $x = 12$ cm, on the x axis?

a. 6.7 μT **b.** 12 μT **c.** 5.0 μT **d.** 1.7 μT **e.** 3.3 μT

27-A conducting hollow cylinder (inner radius = a, outer radius = b) carries a current of 40 A that is uniformly distributed over the cross section of the conductor. If a = 3.0 mm and b = 60 mm, what is the magnitude of the (line) integral $\oint \boldsymbol{B} \cdot \boldsymbol{dl}$ around a circular path (radius = 5.0 mm) centered on the axis of the cylinder and in a plane perpendicular to that axis?

a. $50\ \mu T \cdot m$ **b.** $47\ \mu T \cdot m$ **c.** $22\ \mu T \cdot m$ **d.** $37\ \mu T \cdot m$ **e.** $30\ \mu T \cdot m$

28-A conducting rod with a square cross section (3.0 cm . 3.0 cm) carries a current of 60 A that is uniformly distributed across the cross section. What is the magnitude of the (line) integral $\oint \boldsymbol{B} \cdot d\boldsymbol{l}$ around a square path (1.5 cm . 1.5 cm) if the path is centered on the center of the rod and lies in a plane perpendicular to the axis of the rod?

a. $14\ \mu T \cdot m$ **b.** $75\ \mu T \cdot m$ **c.** $19\ \mu T \cdot m$ **d.** $57\ \mu T \cdot m$ **e.** $38\ \mu T \cdot m$

29-A closed curve encircles several conductors. The line integral $\oint \boldsymbol{B} \cdot d\boldsymbol{l}$ around this curve is $3.83 * 10^{-4} T.m$ .What is the net current in the conductors?

Answer: ……………………

30-By using a compass to measure the magnetic field direction at various points adjacent to a long straight wire, you can show that the wire's magnetic field lines are

a. straight lines in space that go from one magnetic charge to another.
b. straight lines in space that are parallel to the wire.
c. straight lines in space that are perpendicular to the wire.
d. circles in planes perpendicular to the wire that have their centers on the wire.
e. circles that have the wire lying along a diameter of the circle.

1.	**d.** 60 μT	11.	**a.** 59 μT	21.	**b.** 77 mN
2.	**c.** 24 μT	12.	**d.** 0.31 mT	22.	**d.** 2.5 mT
3.	**e.** 19 μT	13.	**a.** $\frac{3\mu_\circ I}{8R}$	23.	**a.** 0.96 mT
4.	$B_A = 6 * 10^{-8}\ T, B_B = 6 * 10^{-8}\ T$	14.	$B = 0$	24.	$I = 3.68A$
5.	$B = 1.21 * 10^{-3}\ T, into\ the\ page$	15.	$7.54\ \mu T\ , to\ the\ left$	25.	$N = 69$
6.	**d.** 450 μT	16.	**c.** $\frac{3\mu_\circ I}{4R}$	26.	**b.** 12 μT
7.	**b.** 10 mT	17.	**b.** 0.40 A	27.	**e.** $30\ \mu T \cdot m$
8.	**c.** 3.0 A	18.	**d.** 2.9 mN	28.	**a.** $14\ \mu T \cdot m$
9.	$(1.85 * 10^{-10}, 0, 3.47 * 10^{-10})\ T$	19.	$I = 8.33A, Opposite$	29.	$I_{enc} = 305\ A$
10.	$dB_{tot} = 1.54 * 10^{-6}\ T, into\ the\ page$	20.	$B_p = \frac{\mu_\circ I}{4R}, into\ the\ page$	30.	**d.**