Electromagnetism #2 Name: SOLUTIONS

FORCE ON A CURRENT CARRYING CONDUCTOR

A current carrying conductor has a magnetic field associated with it. This magnetic field will interact with other magnetic fields resulting in a force being applied.

This means a current carrying conductor in an external magnetic field will experience a force.

Magnetic Flux Density - a measure of the magnetic field in terms of a force acting on an element of current.

$$B = \frac{F}{I\ell}$$

B - magnetic Flux Density
Tesla (T)

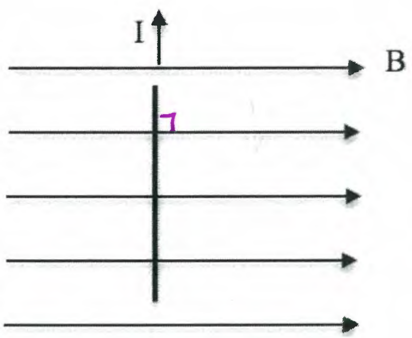
F - Force (N)

I - current (A)

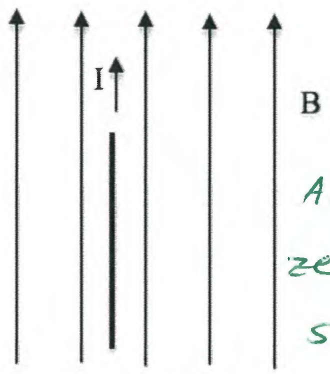
ℓ = length of current carrying conductor (m)

$F = I\ell B$

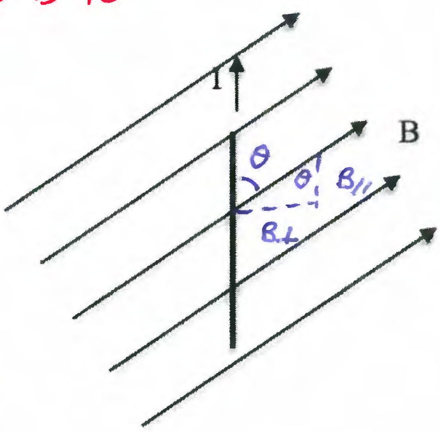
Note:
1. The force is always mutually perpendicular to B and I.
2. Only the component of B which is perpendicular to the current carrying conductor will contribute to the force.



Angle between ℓ & B is 90°
Maximum Force
$\sin 90° = 1$



Angle = 0°
zero force
$\sin 0 = 0$



$$\boxed{F = I\ell B\sin\theta}$$

where $\sin\theta$ is the angle between ℓ & B

$B_{\perp} = B\sin\theta$

DETERMINATION OF DIRECTION OF FORCE

Right-Hand Slap Rule:

- Fingers point in direction of magnetic field
- Thumb points in direction of the current (conventional)
- Palm 'slaps' in the direction of the force on the current carrying conductor.

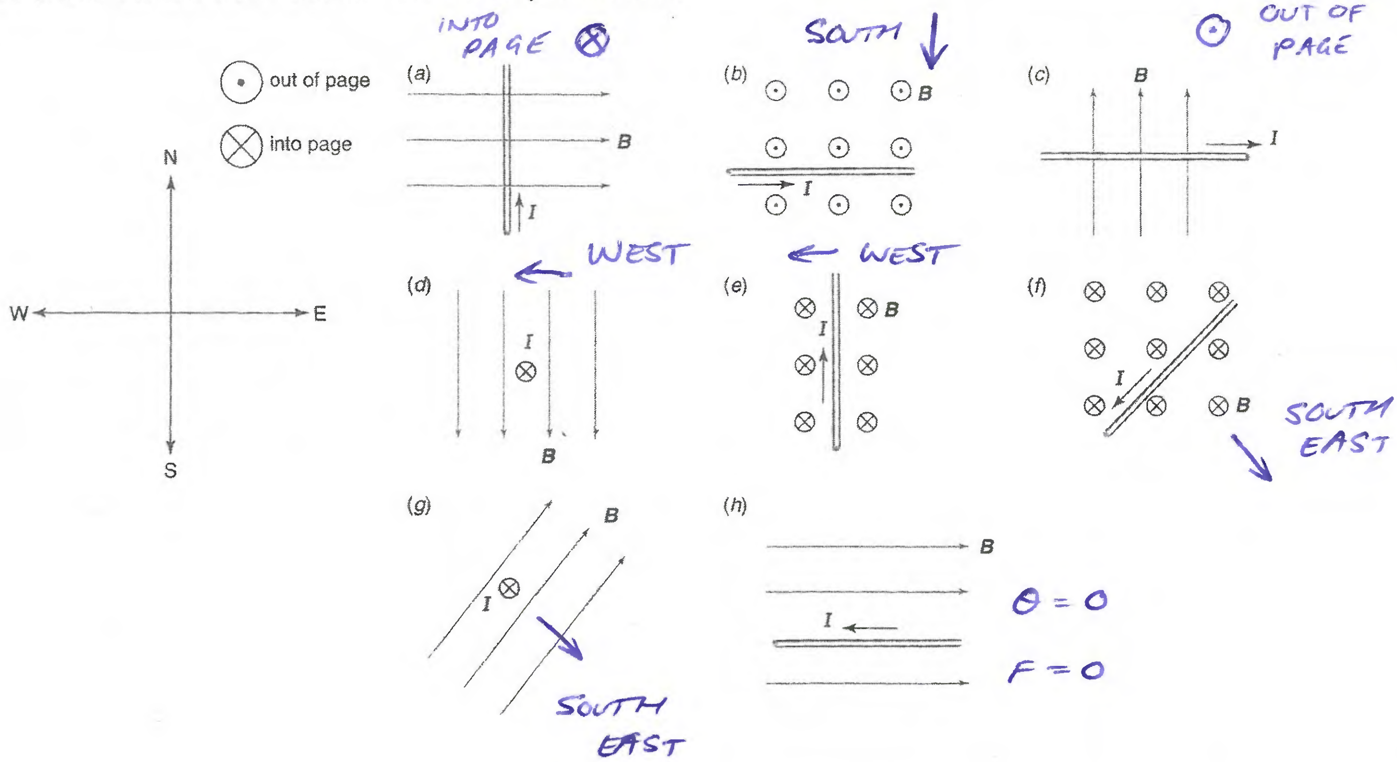
Left-Hand FBI Rule:

- Thumb points in the direction of the force on the current carrying conductor.
- First finger points in the direction of the magnetic field
- Second finger points in direction of the current (conventional)

Beware! – These rules are for: POSITIVE charges (conventional current)

If you have a negative charge or are dealing with electron current the force will be in the **opposite direction** to what the RH slap and LH FBI rules indicate (you could use a 'back-slap' with the RH slap rule instead).

Using the right-hand-slap rule or left-hand-FBI rule to find the direction of the magnetic force on the wire in each of the cases below. Use the answer key on the left.



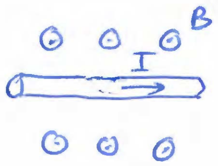
FORCE ON A CURRENT CARRYING CONDUCTOR – EXAMPLES

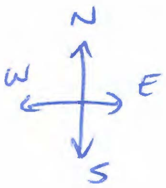
1. A wire carries a steady current of 2.40 A. A straight section of the wire is 0.750 m long and lies along the East-West axis within a uniform magnetic field of magnitude 1.60 T pointing upwards direction. If the current is in an Easterly direction, calculate the force exerted on the section of wire.

$I = 2.40\,A$

$\ell = 0.750\,m$

$B = 1.60\,T$





$$B = \frac{F}{I\ell}$$

$$F = BI\ell$$
$$= 1.60\,(2.40)(0.750)$$
$$= 2.88\,N$$

SOUTH

2. A wire of 2.80 m in length carries a current of 5.00 A in a region where the magnetic field has a magnitude of 0.390 T. Calculate the magnitude of the magnetic force on the wire if the angle between the magnetic field and the current is 60.0°.

$\ell = 2.80\,m$

$I = 5.00\,A$

$B = 0.390\,T$

$\theta = 60.0°$

$$F = BI\ell\sin\theta$$
$$= 0.390\,(5.00)(2.80)\sin 60°$$
$$= 4.73\,N$$

3. A wire of mass 50.0 g carries 2.00 A current horizontally to the south. Calculate the minimum magnetic field required to lift this wire vertically upwards.

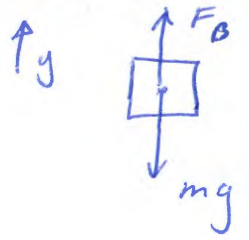
$m = 50.0\,g$

$= 50 \times 10^{-3}\,kg$

$I = 2.00\,A$

$B = ?$

TO LIFT UP



$\Sigma F_y = 0$

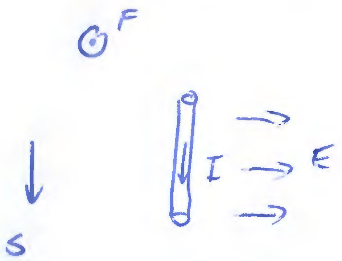
$F_B = mg$

$= 50 \times 10^{-3} \times 9.80$

$= 0.490\,N$

$F = I\ell B$

Let $\ell = 1m$



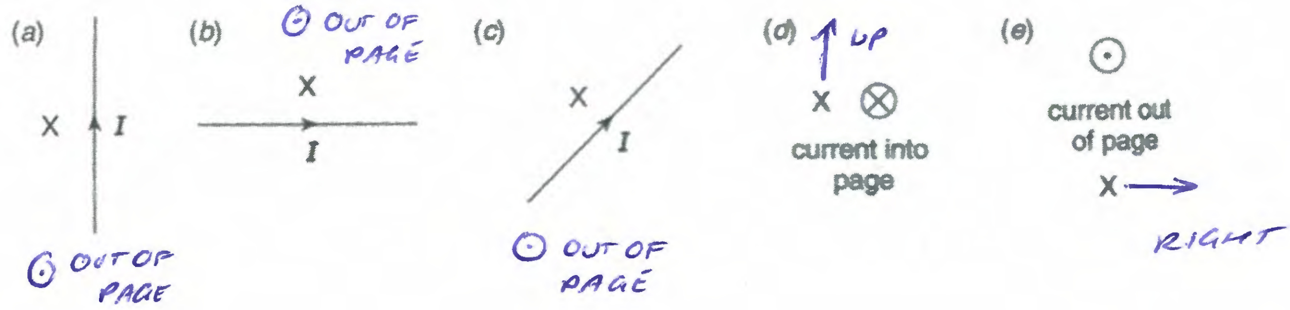
$B = \frac{F}{I\ell} = \frac{0.490}{(2.00)(1)}$

$= 0.245\,T$ EAST

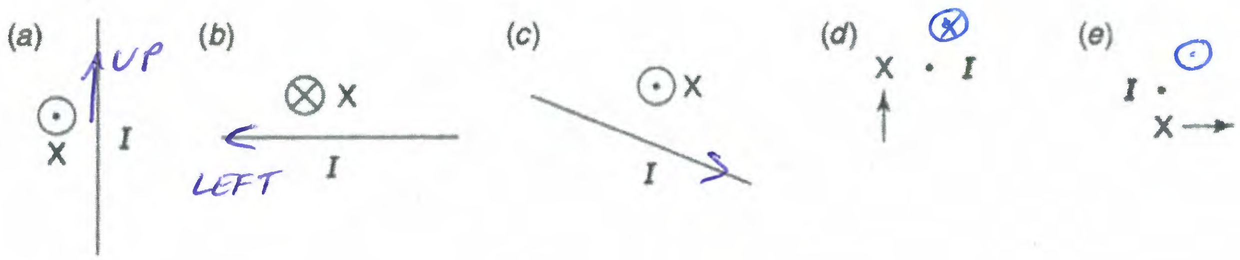
per unit length

CURRENT CARRYING CONDUCTORS - QUESTIONS

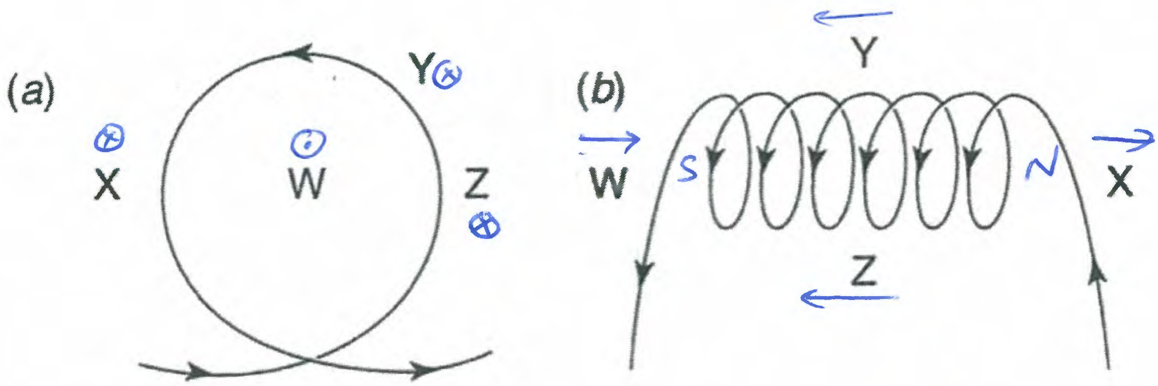
1. Determine the direction of the magnetic field at point X in the following diagrams.



2. Determine the direction of the current in the wire in the following diagrams.

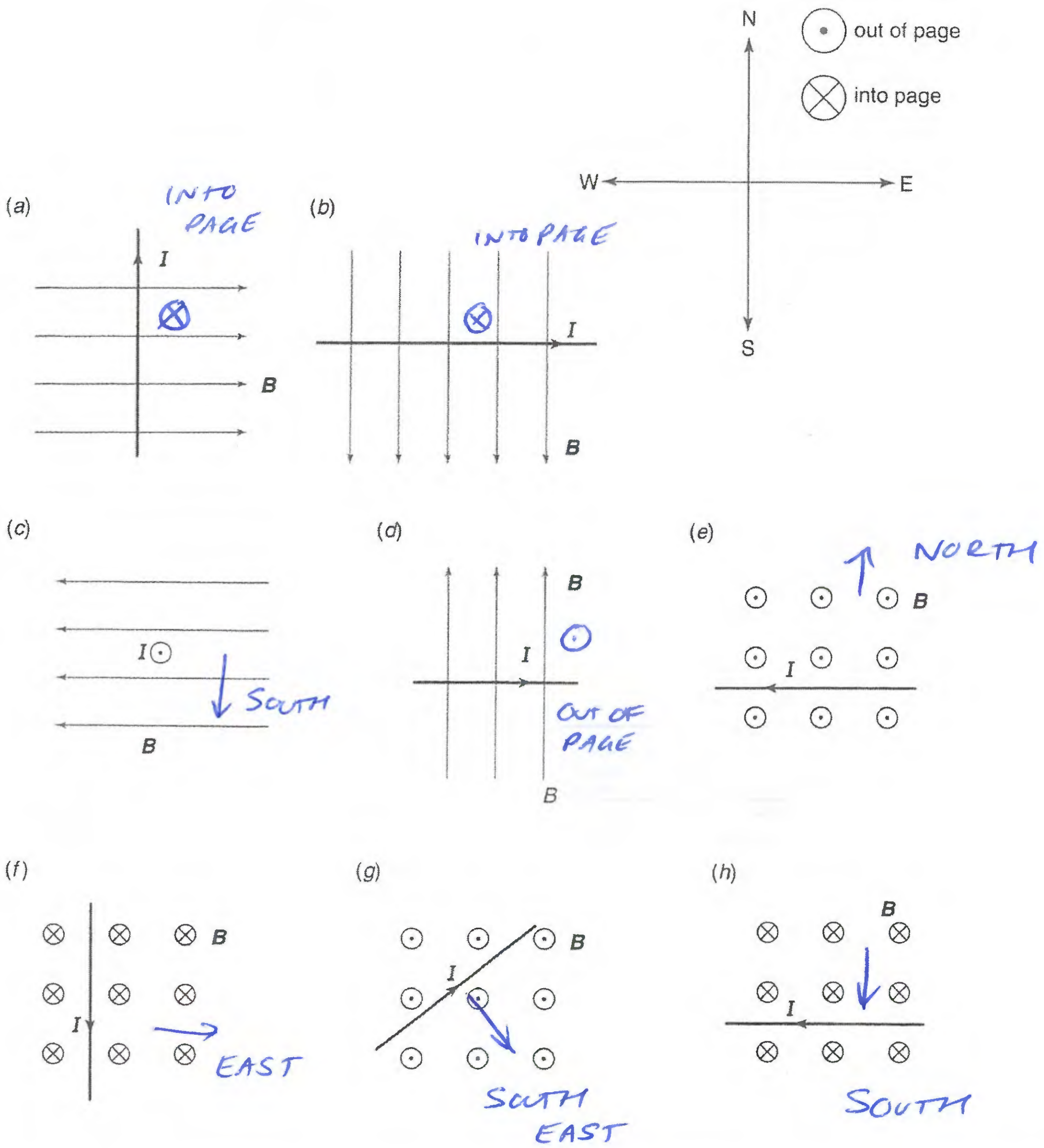


3. Determine the direction of the magnetic field at W, X, Y and Z in the diagrams below.



Electromagnetism #2

4. Use the answer key on the right to determine the direction of the force on the current carrying conductor in the diagram below.



5. A small piece of wire 0.0400 m long, carrying 50.0 A is placed at right angles to a magnetic field and it experiences a force of 4.00×10^{-4} N. Calculate the magnitude of the magnetic flux density.

[2.00×10^{-4} T]

$$B = \frac{F}{Il} = \frac{4.00 \times 10^{-4}}{50(0.04)}$$

$$= 2.00 \times 10^{-4} \text{ T}$$

6. 0.0500 m of wire at right angles to a magnetic field experiences a force of 1.20 x 10^{-4} N. If the magnitude of the magnetic flux density is 8.00 x 10^{-6} T, calculate the current the wire is carrying.

[3.00 x 10^2 A]

$$B = \frac{F}{Il} \qquad I = \frac{F}{lB} = \frac{(1.20 \times 10^{-4})}{(0.05)(8.00 \times 10^{-6})}$$

$$= 3.00 \times 10^{2} A$$

7. Calculate the size of the force on a wire of length 0.0500 m in a magnetic field of strength 0.300 T, if the wire is at right angles to the field and it carries a current of 4.50 A.

[0.0675 N]

$$F = IlB$$
$$= (4.50)(0.05)(0.3)$$
$$= 0.0675 N$$

8. Calculate the size of the force on a wire carrying a current of 1.80 A at right angles to a magnetic field of strength 40.0 mT, if the length of the wire is 8.00 cm.

[5.76 x 10^{-3} N]

$$F = IlB$$
$$= 1.80(8.00 \times 10^{-2})(40 \times 10^{-3})$$
$$= 5.76 \times 10^{-3} N$$

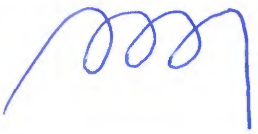
9. Calculate the size of the force exerted on a loudspeaker coil of radius 1.50 cm and 500 turns which carries a current of 15.0 mA in a radial magnetic field of 2.00 T. [Hint – consider the circumference of the loudspeaker coil]

[1.41 N]

$B = 2.00\,T$

$n = 500$

$I = 15 \times 10^{-3}\,A$



$r = 1.50 \times 10^{-2}\,m$

$\ell = 2\pi r n$
$= 2\pi (1.50\times10^{-2})(500)$
$= 47.124\,m$

$F = I\ell B$
$= 15\times10^{-3}(47.124)(2.00)$
$= 1.41\,N$

10. Calculate the angle at which 0.100 m of wire carrying a current of 150.0 mA must be placed to a magnetic field of strength 1.00 x 10^{-4} T if it is to experience a force of 1.41 μN.

[70.1°]

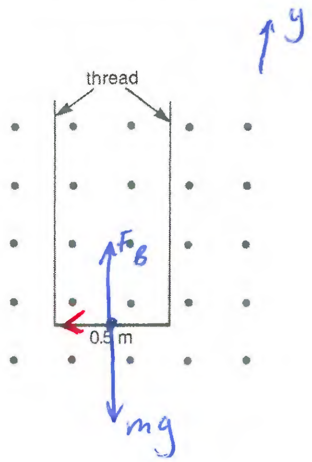
$F = I\ell B\sin\theta$

$$\sin\theta = \frac{F}{I\ell B} = \frac{1.41\times10^{-6}}{(150\times10^{-3})(0.1)(1\times10^{-4})} = 0.94$$

$\theta = 70.1°$

11. A wire of length 0.500 m and mass 3.00 g is suspended by two threads in a magnetic field of flux density 0.100 T (as shown below). Calculate the magnitude and direction of the current needed so that there is no tension in the threads.

[0.588 A to the left]



NO TENSION

$\Rightarrow F_y = 0$

$F_B = mg$
$= (3\times10^{-3})(9.80)$
$= 0.0294\,N$

$F = I\ell B$

$$I = \frac{F}{\ell B} = \frac{0.0294}{(0.5)(0.1)}$$

$= 0.588\,A$ LEFT

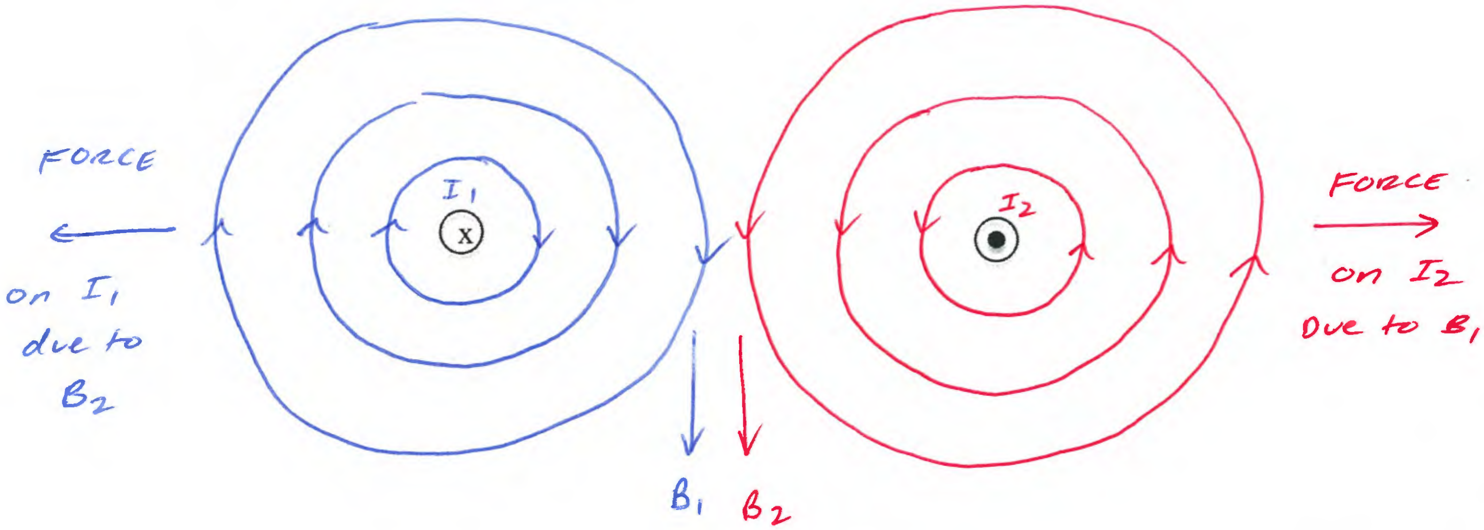
Electromagnetism #2

FORCE BETWEEN PARALLEL CURRENT CARRYING CONDUCTORS

Beware! - A current carrying conductor does not feel its own magnetic field.

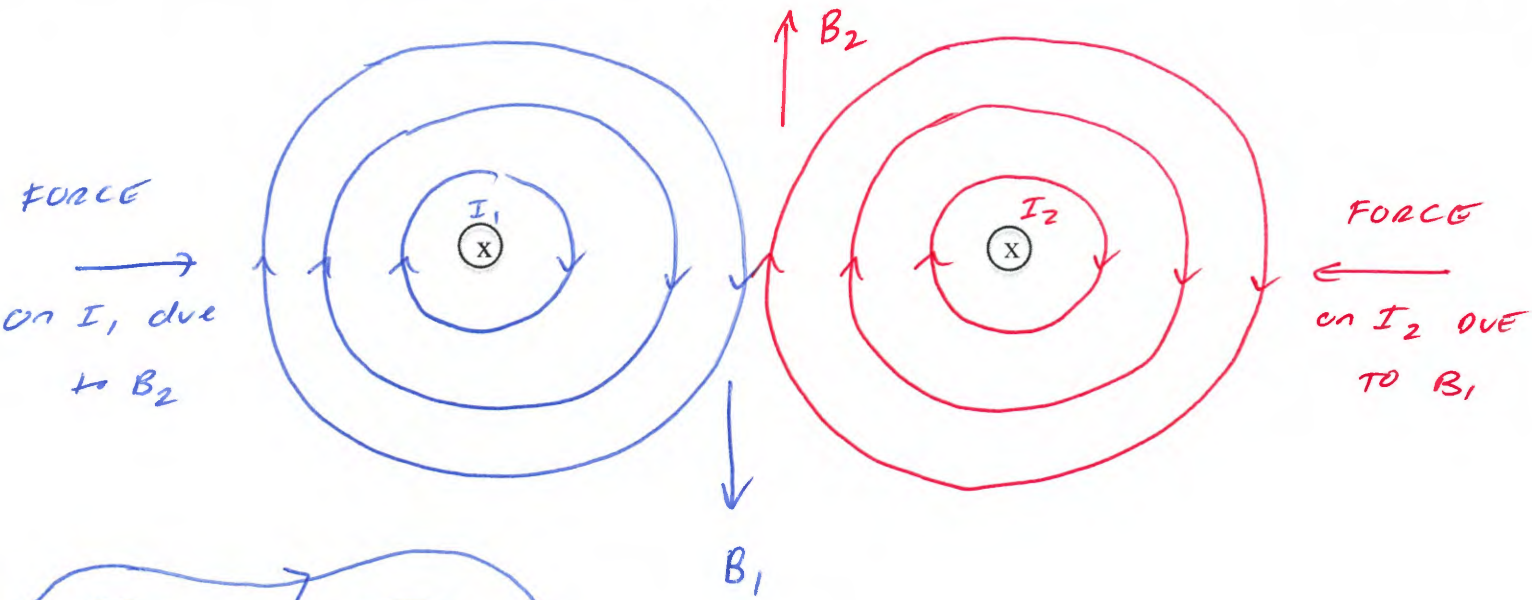
No force is exerted on it due to its own magnetic field.

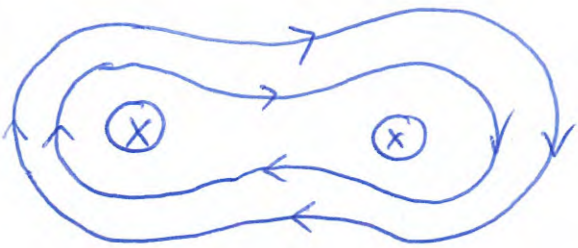
Currents in opposite direction:



$\Rightarrow$ REPULSION

Currents in same direction:





Electromagnetism #2

Magnetic Field due to a Long Straight Wire:

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

μ_0 - permeability of free space

r → Distance between the wire & where B is measured.

Force Between two Parallel Wires:

magnetic field of first wire

$$B_1 = \frac{\mu_0 I_1}{2\pi r}$$

Force on second wire due to B_1

$$F = I_2 \ell_2 B_1$$

$$= I_2 \ell_2 \frac{\mu_0 I_1}{2\pi r}$$

$$\frac{F}{\ell} = \mu_0 \frac{I_1 I_2}{2\pi r}$$

$$F_e = \frac{k q_1 q_2}{r^2}$$

COMPARE

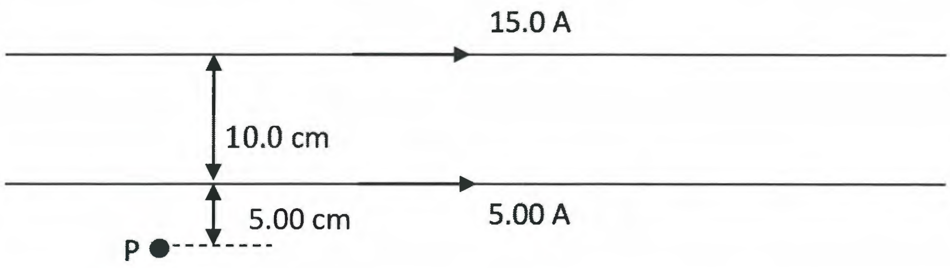
$$F_G = \frac{G m_1 m_2}{r^2}$$

Electromagnetism #2

Definition of the Ampere:

1.00 Ampere is a constant current that when maintained in two straight parallel conductors of infinite length, placed 1.00 m apart in a vacuum, produce a force of 2.00×10^{-7} N per unit of length.

1. Two very long straight parallel wires carry currents of 15.0 A and 5.00 A as shown below.



(a) Calculate at P, the magnitude and direction of the magnetic flux density due to;

(i) the 5.00 A current

[2.01×10^{-5} T, into the page]

$$B_1 = \frac{\mu_0 I}{2\pi r} = \frac{1.26\times10^{-6}(5.00)}{2\pi(5.00\times10^{-2})}$$

$$= 2.01\times10^{-5}\ T \quad \text{INTO PAGE}$$

(ii) the 15.0 A current

[2.01×10^{-5} T, into the page]

$$B_2 = \frac{\mu_0 I}{2\pi r} = \frac{1.26\times10^{-6}(15.0)}{2\pi(15\times10^{-2})}$$

$$= 2.01\times10^{-5}\ T \quad \text{INTO PAGE}$$

(b) Calculate the net magnetic flux density at P.

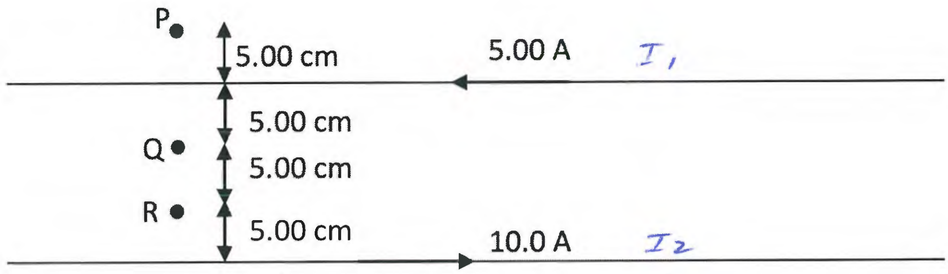
[4.02×10^{-5} T, into the page]

$$B_{TOTAL} = B_1 + B_2$$

$$= 2(2.01\times10^{-5})$$

$$= 4.02\times10^{-5}\ T \quad \text{INTO PAGE}$$

2. Two parallel, horizontal wires carrying currents of 5.00 A and 10.0 A in opposite direction are 15.0 cm apart, as shown below.



Calculate the magnitude and direction of the magnetic flux density at P, Q and R.

[P = 1.01 x 10^{-5} T into the page, Q = 4.02 x 10^{-5} T out of the page, R = 5.01 x 10^{-5} T out of the page]

P DUE TO I_1

$B_1 = \dfrac{\mu_0 I_1}{2\pi r}$

$= \dfrac{1.26 \times 10^{-6}(5)}{2\pi(5 \times 10^{-2})}$

$= 2.01 \times 10^{-5}$ T

INTO PAGE

P DUE TO I_2

$B_2 = \dfrac{\mu_0 I_2}{2\pi r}$

$= \dfrac{1.26 \times 10^{-6}(10)}{2\pi(20 \times 10^{-2})}$

$= 1.00 \times 10^{-5}$ T

OUT OF PAGE

$B_P = B_1 - B_2$

$= (2.01 - 1.00) \times 10^{-5}$

$= 1.01 \times 10^{-5}$ T INTO PAGE

Q DUE TO I_1

$B_1 = \dfrac{\mu_0 I_1}{2\pi r}$

$= \dfrac{1.26 \times 10^{-6}(5)}{2\pi(5 \times 10^{-2})}$

$= 2.01 \times 10^{-5}$ T

OUT OF PAGE

Q DUE TO I_2

$B_2 = \dfrac{\mu_0 I_2}{2\pi r}$

$= \dfrac{1.26 \times 10^{-6}(10)}{2\pi(10 \times 10^{-2})}$

$= 2.01 \times 10^{-5}$ T

OUT OF PAGE

$B_Q = B_1 + B_2$

$= 4.02 \times 10^{-5}$ T

OUT OF PAGE

R DUE TO I_1

$B_1 = \dfrac{\mu_0 I_1}{2\pi r}$

$= \dfrac{1.26 \times 10^{-6}(5)}{2\pi(10 \times 10^{-2})}$

$= 1.00 \times 10^{-5}$ T OUT OF PAGE

R DUE TO I_2

$B_2 = \dfrac{\mu_0 I_2}{2\pi r}$

$= \dfrac{1.26 \times 10^{-6}(10)}{2\pi(5 \times 10^{-2})}$

$= 4.01 \times 10^{-5}$ T OUT OF PAGE

$B_R = B_1 + B_2$

$= (1.00 + 4.01) \times 10^{-5}$

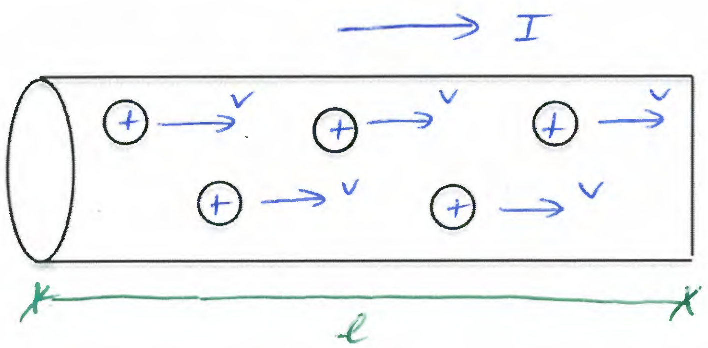
$= 5.01 \times 10^{-5}$ T

OUT OF PAGE

FORCE ON A CHARGED PARTICLE IN A MAGNETIC FIELD

We have looked at the force on a charged carrying conductor in a magnetic field – but what if there is only one charged particle?

Imagine individual charges moving through a conductor (these individual charges make up the current).



n PARTICLES OF CHARGE q PASS A POINT IN TIME t

$$I = \frac{nq}{t} \qquad s = tv \qquad v = \frac{s}{t}$$

$$l = tv$$

FOR THE CURRENT CARRYING CONDUCTOR

$$F = IlB$$
$$= \frac{nq}{t} \cdot tv \cdot B$$
$$= nqvB$$

$\therefore$ FOR ONE PARTICLE $\boxed{F = qvB}$

RH slap
LH FBI } CURRENT THUMB/FINGER POINTS IN THE DIRECTION OF VELOCITY OF THE CHARGED PARTICLE (+ve CHARGE)

$F = qvB\sin\theta$

v & B are // $\Rightarrow$ NO FORCE

MOVING CHARGES IN A MAGNETIC FIELD

We have previously derived the formula for the force exerted on a charged particle moving in a magnetic field:

$$F_B = qvB$$

We have also derived a formula for the force required for an object to maintain a circular path:

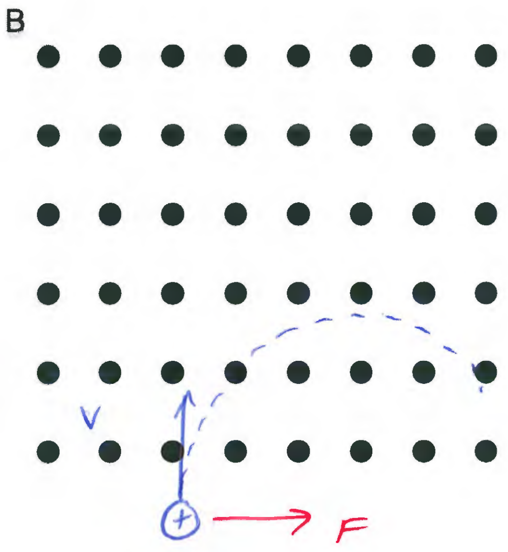
$$F_c = \frac{mv^2}{r}$$

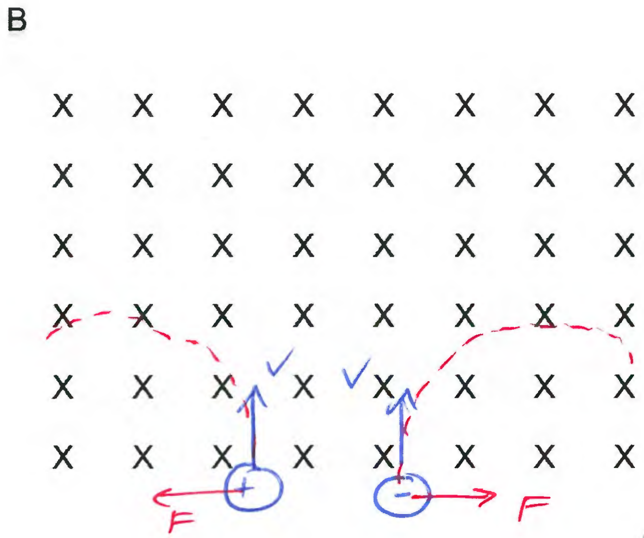
Because the force experienced by a charged particle moving in a magnetic field will be perpendicular to the direction of velocity – it is possible to have circular motion.

$$F_B = F_c$$

$$qvB = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB}$$



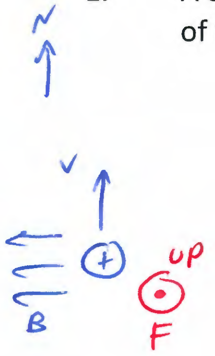


Electromagnetism #2

FORCE ON CHARGED PARTICLE IN A MAGNETIC FIELD

1. A charge of +2.00 C is moving due North at 3.00×10^{2} ms^{-1} in a magnetic field pointing to the West of flux density 5.00 μT. Calculate the force the charge will experience.

[3.00×10^{-3} N, Up]

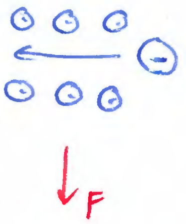


$$F = qvB$$
$$= (2.00)(3.00\times10^{2})(5\times10^{-6})$$
$$= 3.00\times10^{3}\,N \quad UP$$

2. A charge of 1.80 C is moving horizontally West at 1.00 kms^{-1} between the horizontal poles of an electromagnet which produces an upwards flux density of 15.0×10^{-6} T. Calculate the force the charge will experience.

[2.70×10^{-2} N, South]

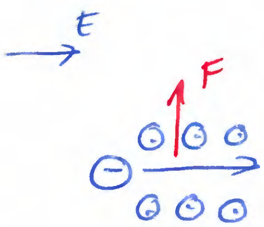
W



$$F = qvB$$
$$= (1.80)(1000)(15\times10^{-6})$$
$$= 2.70\times10^{-2}\,N \quad SOUTH$$

3. An electron is moving East at 5.00×10^{3} ms^{-1} inside a T.V tube and it passes through a magnetic field of 8.00×10^{-5} T vertically upwards. Calculate the force it will experience.

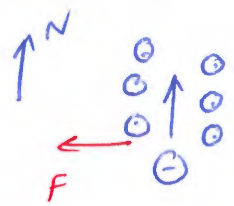
[6.40×10^{-20} N, North]



$$F = qvB$$
$$= (1.6\times10^{-19})(5.00\times10^{3})(8.00\times10^{-5})$$
$$= 6.40\times10^{-20}\,N \quad NORTH$$

4. An electron moves due north at 1.00×10^6 ms^{-1} into a uniform magnetic field of 5.00×10^{-2} T directed vertically upwards. Calculate the magnitude of the force on the electron and determine the direction in which will it be deflected.

[8.00×10^{-15} N, ~~left~~] WEST



$$F = qvB$$
$$= (1.6\times10^{-19})(1.00\times10^{6})(5.00\times10^{-2})$$
$$= 8.00\times10^{-15}\text{ N WEST}$$

5. A positively charged carbon ion (m = 2.00×10^{-26} kg and a charge of 1.60×10^{-19} C) moves in a circular path of radius 0.200 m. A magnetic field of 0.500 T is perpendicular to the plane of the circular path. Calculate the speed of the carbon ion.

[8.00×10^5 ms^{-1}]

$$F_c = F_B$$
$$\frac{mv^2}{r} = qvB$$
$$v = \frac{qBr}{m} = \frac{(1.60\times10^{-19})(0.5)(0.2)}{(2.00\times10^{-26})}$$
$$= 8.00\times10^{5}\text{ m/s}$$

6. A charge moving north at 3.00×10^2 ms^{-1} enters a region in which there is a 5.00 μT field acting vertically downwards. The charge undergoes circular motion in a clockwise direction with a centripetal force of 3.00×10^{-3} N acting. Calculate the size of the charge and state its nature.

[-2.00 C]

$$F_c = F_B$$
$$= qvB$$
$$q = \frac{F_c}{vB} = \frac{3.00\times10^{-3}}{(300)(5\times10^{-6})}$$
$$= 2.00\text{ C NEGATIVE}$$
$$\Rightarrow -2.00\text{ C}$$

7. An electron travelling at 1.60×10^4 ms^{-1} enters a region in which there is a uniform magnetic field of 3.00×10^{-2} T. Calculate the radius of curvature of the resulting path.

[3.04×10^{-6} m]

$$F_c = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB}$$

$$= \frac{(9.11\times10^{-31})(1.60\times10^4)}{(1.6\times10^{-19})(3.00\times10^{-2})}$$

$$= 3.04\times10^{-6}\ m$$

8. A beam of electrons moves at 4.00×10^6 ms^{-1} perpendicular to a magnetic field of 5.00×10^{-4} T. Calculate:

(a) The magnitude of the force on each electron in the beam
(b) The radius of the circular path of the electrons.
(c) The radius of a beam of alpha particles that moves into this same field with a velocity of 8.00×10^2 ms^{-1}. The mass of an alpha particle is 6.68×10^{-27} kg.

[3.20×10^{-16} N; 4.56×10^{-2} m; 3.34×10^{-2} m]

a) $F = qvB$

$$= 1.60\times10^{-19}(4.00\times10^6)(5\times10^{-4})$$

$$= 3.20\times10^{-16}\ N$$

b) $F_c = F_B$

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

$$r = \frac{mv^2}{F_B} = \frac{9.11\times10^{-31}\times(4.00\times10^6)^2}{3.20\times10^{-16}}$$

$$= 4.56\times10^{-2}\ m$$

c) $F_c = F_B$

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB}$$

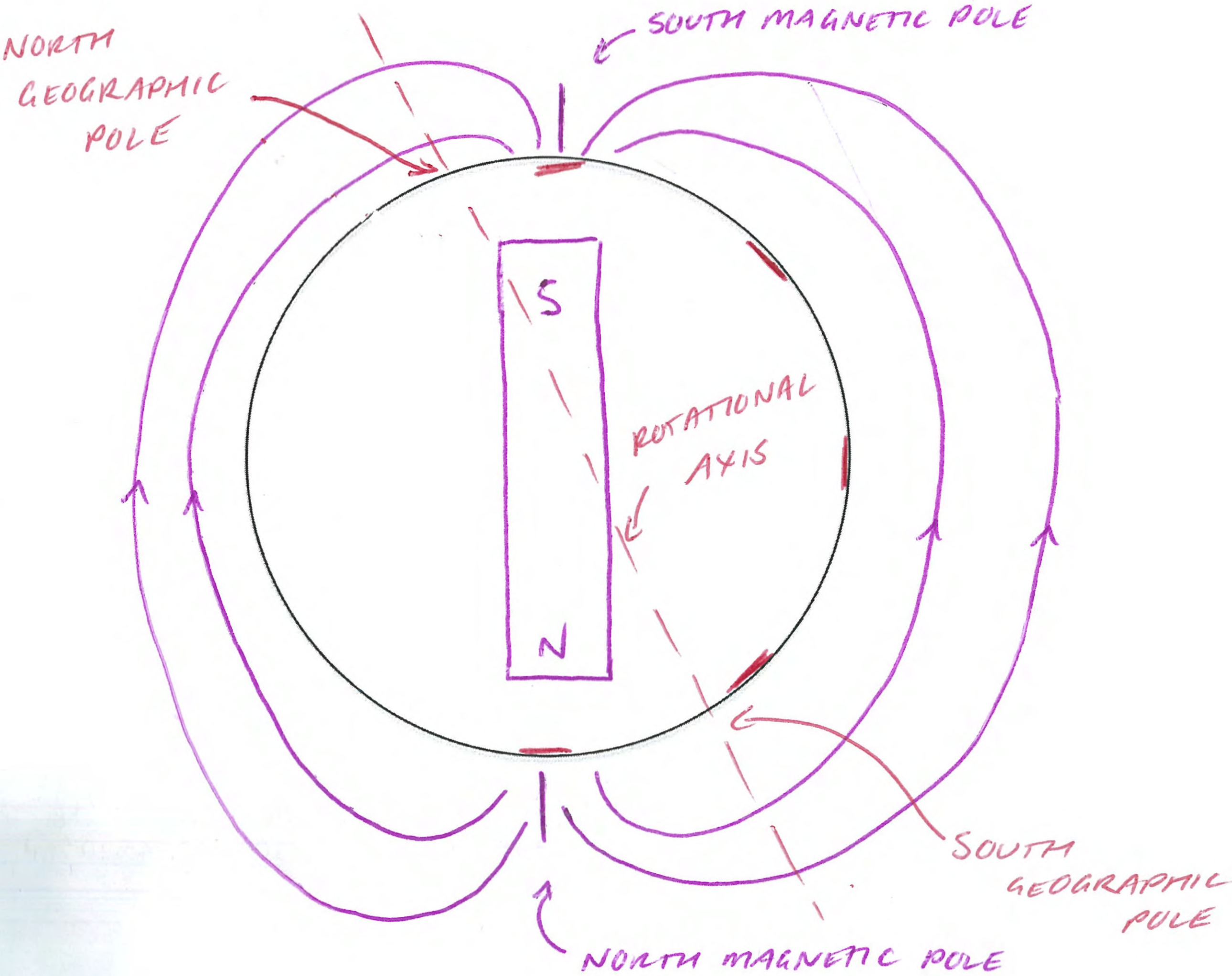
$q = +2e$

$$r = \frac{(6.68\times10^{-27})(8.00\times10^2)}{(2\times1.60\times10^{-19})(5.00\times10^{-4})}$$

$$= 3.34\times10^{-2}\ m$$

Electromagnetism #2

THE EARTH'S MAGNETIC FIELD

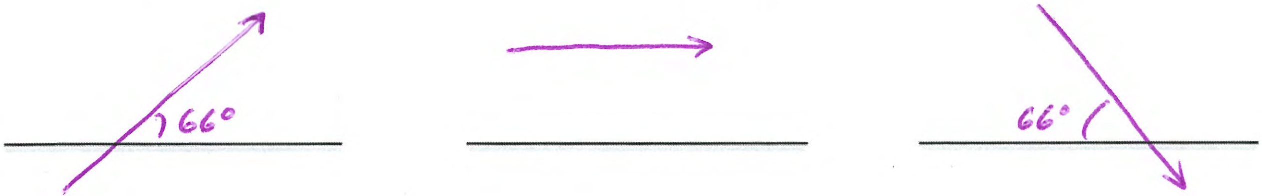


Magnetic Declination –

ANGULAR DIFFERENCE BETWEEN THE GEOGRAPHIC & MAGNETIC POLES

Magnetic Inclination or Dip –

THE ANGLE THE EARTH'S MAGNETIC FIELD MAKES WITH THE HORIZONTAL AT ANY POINT ON EARTH.



Perth (southern hemisphere) | Equator | USA (northern hemisphere)

S POLE (GEOG)

N POLE (GEOG)

ALL POINT TO GEOGRAPHIC NORTH (MAGNETIC SOUTH)

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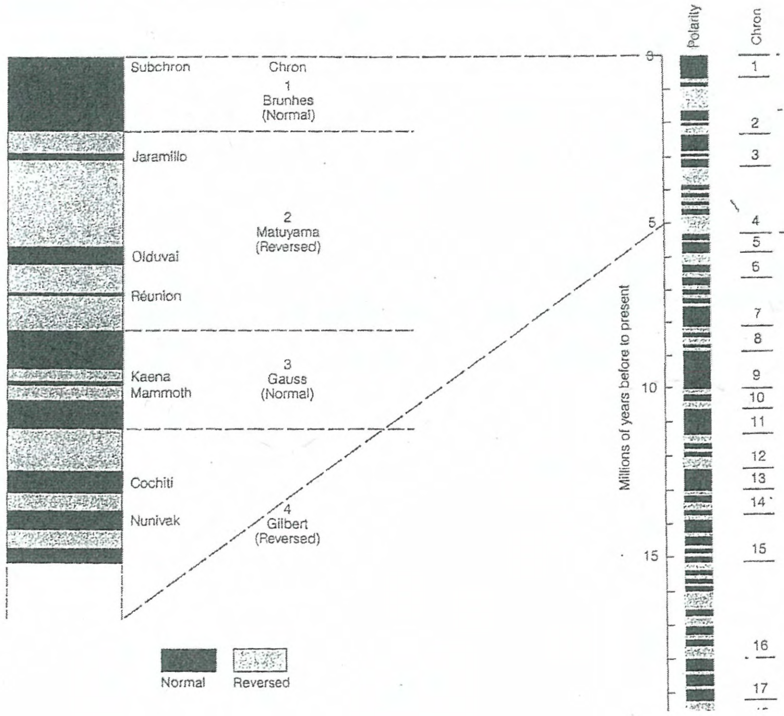
EARTH'S MAGNETIC FIELD – ORIGINS, POLE REVERSAL AND AURORAS

ORIGINS

- The magnetic field pattern of the Earth is similar to one that would be set up by a bar magnet deep within the Earth.
- But – although the Earth does have large deposits of iron ore deep beneath the surface, the high temperatures of the core (above T_{curie} of iron) prevent the iron from retaining permanent magnetism.
- Instead, the origin of the Earth's magnetic field is believed to be due to charge carrying convection currents in the Earth's outer core.
- Particles in the molten rock become charged due to fiction. friction.
- Moving charges constitute a current and there is a magnetic field associated with a current.
- There is also some evidence to suggest that the faster a planet rotates the stronger its magnetic field is.

POLARITY REVERSAL

- The direction of the Earth's magnetic field has reversed direction several times during the last million years.

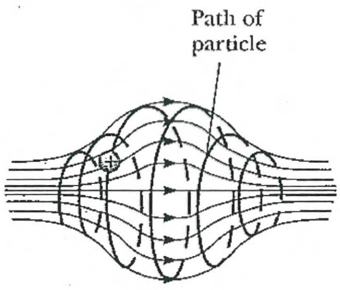


Time interval between a polarity reversal

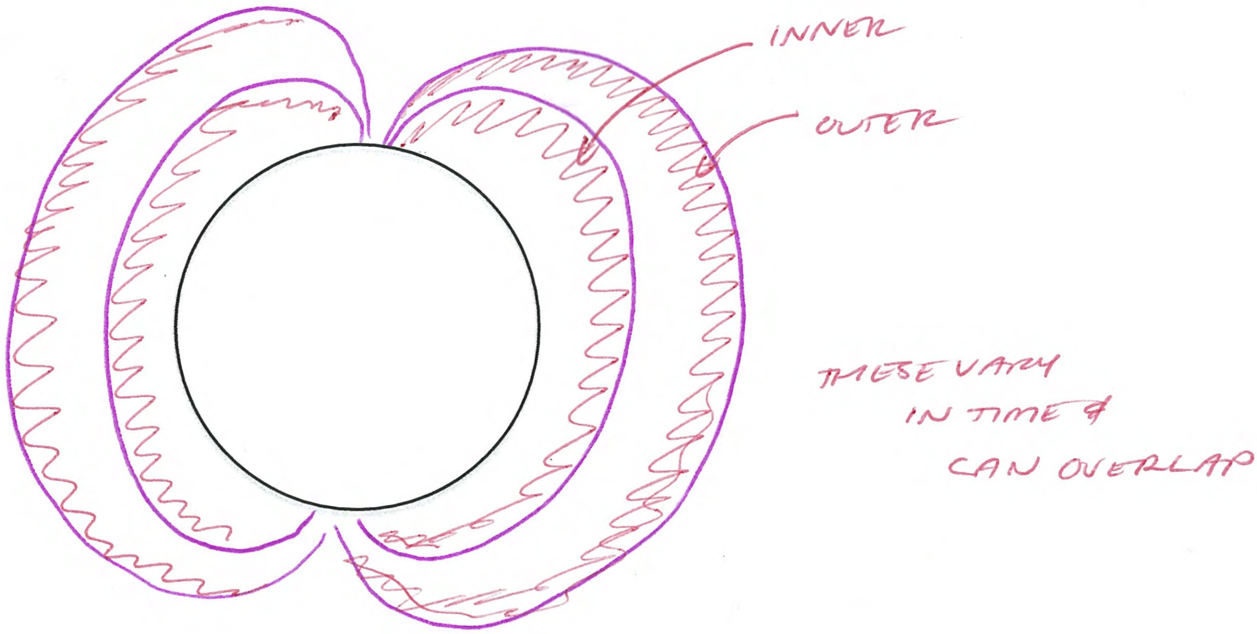
- Over a 1000 – 5000 year period the Earth's magnetic field slowly dies to low intensity and the magnetic poles move erratically and fluctuate, before building up again in the opposite direction.
- This is evidenced by geological records of basalt (a rock that contains iron).
- As lava (from the outer core) erupts onto the ocean floor and cools down, it passes through its Curie Point (500°C) leaving a permanent record of the Earth's magnetisation when it cooled.
- The rocks can be dated by alternative means to determine a timeline for these reversals.

AURORAS

- When charged particles move in a non-uniform magnetic field – the motion is quite complex.
- For a field that is strong at the ends and weak in the middle (similar to the Earth's magnetic field), particles spiral around the field lines and oscillate back and forth between the end points. This is sometimes termed a 'magnetic bottle'.



- Cosmic rays (also known as solar winds) carry charged particles towards the Earth. Most of these charged particles are deflected back into space by the Earth's magnetic field, some, however, become trapped in regions called the Van Allen radiation belts.
- These particles – mostly electrons and protons – spiral around the Earth's magnetic field lines from pole to pole within these belts.
- When these particles reach the poles they can collide with atoms in the atmosphere causing the atoms to emit visible light, producing the Aurora Australis and Aurora Borealis.
- The auroras tend to occur in the polar regions because it is here that the Van Allen Belts are closest to the atmosphere.
- The trapping of the particles is due to the non-uniformity of the Earth's magnetic field.



EARTH'S MAGNETIC FIELD – DIP QUESTIONS EXAMPLES

Assume the Earth's magnetic field in Perth is 5.50×10^{-5} T at 66.0° to the horizontal.
Assume that the magnetic field at the equator is 5.50×10^{-5} T and is horizontal.
Assume that the magnetic field at the poles is 6.00×10^{-5} T and is vertical.

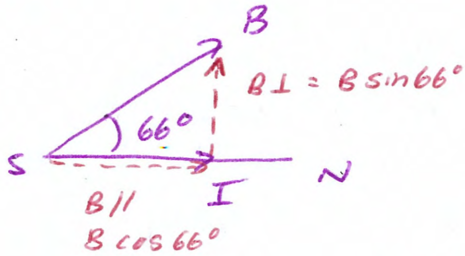
1. Calculate the force on a 15.0 m length of overhead cable, carrying a current of 2.50×10^2 A in a South → North direction, due to the earth's magnetic field in Perth.

$\ell = 15.0\,m$

$I = 250\,A$

$B = 5.50 \times 10^{-5}\,T$ @ $66°$

$$B_\perp = B\sin\theta = 5.50 \times 10^{-5} \sin 66° = 5.025 \times 10^{-5}\,T$$



creates no force

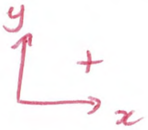
$$F = BI\ell = (5.025 \times 10^{-5})(250)(15) = 1.88 \times 10^{-1}\,N \quad \text{EAST}$$

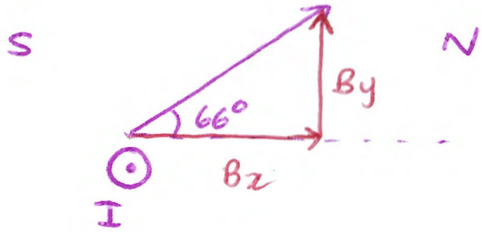
F ⊙

OUT OF PAGE

2. Calculate the force on a 20.0 m length of overhead cable, carrying a current of 2.50 x 10^2 A in West → East direction, due to the earth's magnetic field in Perth?

E ⊙ W ⊗





BOTH x AND y WILL CREATE A FORCE.

$l = 20 m$

$I = 250 A$

$B = 5.50 \times 10^{-5} T$ @ 66°

IN Y DIRECTION OF B

$F = B_y I l$

$= 5.50\times10^{-5} \sin 66° \times (250)(20)$

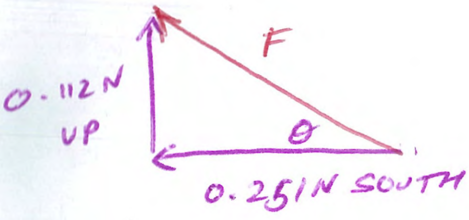
$= 0.251 N$ SOUTH

IN x DIRECTION OF B

$F = B_x I l$

$= 5.50\times10^{-5} \cos 66° (250)(20)$

$= 0.112 N$ UP



$F = \sqrt{0.251^2 + 0.112^2}$

$= 0.275 N$

$\tan\theta = \dfrac{0.112}{0.251}$

$\theta = 24.0°$ → S 24° UP

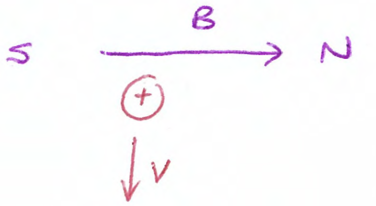
$F = 0.275 N$ SOUTH, 24.0° ABOVE HORIZONTAL

NOTE: DO NOT HAVE TO USE COMPONENTS FOR THIS HOWEVER IF YOU DON'T YOU WILL LIKELY GET CONFUSED WITH DIRECTIONS

EARTH'S MAGNETIC FIELD – DIP QUESTIONS

1. Calculate the force on a proton travelling at 2.00 x 10^7 ms^{-1} directly downwards at the equator.

[1.76 x 10^{-16} N East]

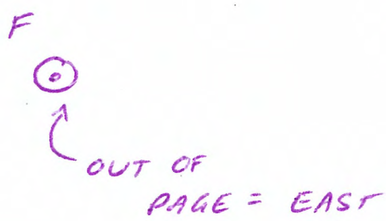


$v = 2.00 \times 10^7$

$F = ?$

$B = 5.50 \times 10^{-5}\ T$

$q = 1.60 \times 10^{-19}\ C$ (POSITIVE)



$F = qvB$

$= (1.60 \times 10^{-19})(2.00 \times 10^7)(5.50 \times 10^{-5})$

$= 1.76 \times 10^{-16}\ N$ EAST

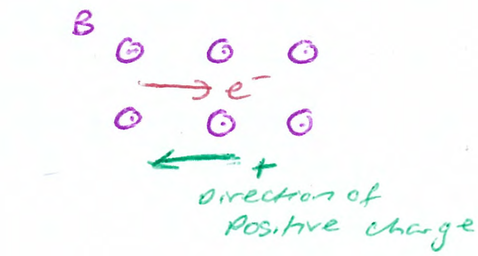
2. Calculate the force on an electron travelling horizontally at 2.00 x 10^7 ms^{-1} over the South Geographic Pole.

NEGATIVE CHARGE.

[1.92 x 10^{-16} N ~~towards N geographic pole~~]

$B = 6 \times 10^{-5}\ T$

AT SOUTH POLE



$F = qvB$

$= (1.6 \times 10^{-19})(2.00 \times 10^7)(6 \times 10^{-5})$

$= 1.92 \times 10^{-16}\ N$

HORIZONTALLY

270° FROM PLANE OF

ELECTRON TRAVEL.

Electromagnetism #2

↗ NORTHERN HEMISPHERE

3. In the central United States the magnetic flux density is measured to be 4.00 x 10^{-5} T at an angle of 70.0° to the ground. If a proton travels East to West in this field at a speed of 6.00 x 10^{7} ms^{-1}, calculate the force it would experience.

[3.84 x 10^{-16} N ~~19.9~~° down in a Southerly direction]

20.0

$B = 4.00 \times 10^{-5}\,T$ @ 70°

y B + x

⊗ velocity

BOTH COMPONENTS OF B HAVE PERPENDICULAR COMPONENT

W ⟵ (+) E

B_y.

$F = B_y I \ell$

$= q v B_y$

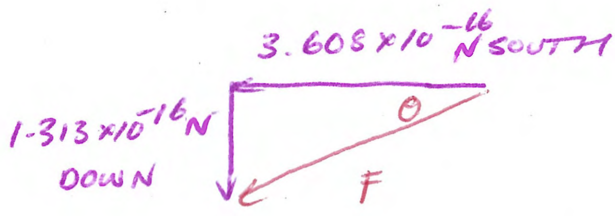
$= (1.6\times10^{-19})(6\times10^{7})(4\times10^{-5})\sin 70^\circ$

$= 3.608\times10^{-16}$ N SOUTH

B_x: $F = q v B_x$

$= (1.6\times10^{-19})(6.00\times10^{7})(4\times10^{-5}\cos 70^\circ)$

$= 1.313\times10^{-16}$ N DOWN



$F = \sqrt{(3.608\times10^{-16})^2 + (1.313\times10^{-16})^2}$

$= 3.84\times10^{-16}$ N

$\tan\theta = \dfrac{1.313\times10^{-16}}{3.608\times10^{-16}}$

$= 20.0^\circ$

$F = 3.84\times10^{-16}$ N SOUTH, 20° BELOW HORIZONTAL