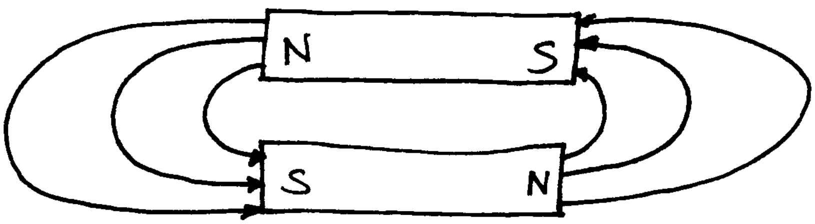
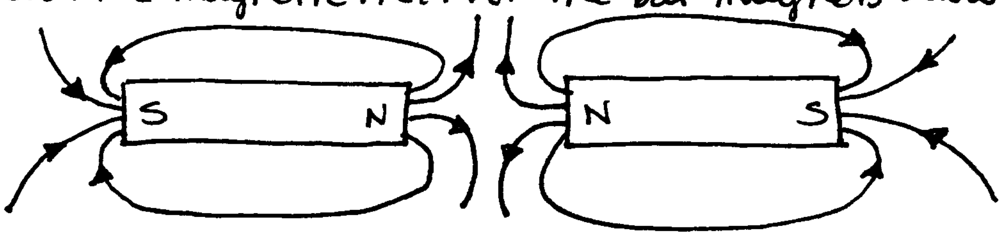
④ Sketch the magnetic field for the bar magnets below




⑤ Sketch the magnetic field for the bar magnets below




⑨ On the planet XARON 9 I notice a 1.5T B field pointing NORTH. A proton with $K_E = 8.0 \times 10^{-13}$ J falls vertically downward. What is the magnetic force on the proton?

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- The $K_E$ is related to velocity: $K_E = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2K_E/m}$

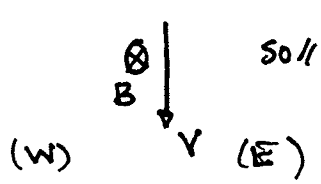
- The magnitude of the magnetic force is given by: $F = qvB$
  So using my expression for v:

$$F = qvB = qB\sqrt{\frac{2K_E}{m}} = (1.60\times10^{-19}\text{C})(1.5\text{T})\left[\frac{2\cdot 8\times10^{-13}\text{J}}{1.673\times10^{-27}\text{kg}}\right]^{1/2}$$

$$\boxed{F = 7.42\times10^{-12}\text{ N}}$$

(ANS)

DIRECTION FROM RHR: Facing North:




So // RHR gives $\vec{F}$ to EAST

(20) I build a Cyclotron 9000 in my basement, with a field of 0.50T. What is the chamber radius if the max proton velocity is $1.0 \times 10^7$ m/s?

The gyroradius is: $r = mv/qB$

Sol/

$$r = \frac{(1.673 \times 10^{-27}\,\text{kg})(1.0 \times 10^{7}\,\text{m/s})}{(1.60 \times 10^{-19}\,\text{C})(0.50\,\text{T})} = \boxed{0.21\,\text{m} = r}$$ (ANS)

(21) A singly charged ion of unknown mass moves in a circle of radius 12.5cm in a B = 1.2T field. The ion was accelerated thru a potential of 7.0kV before entering the B field. What was the mass of the ion?

Before accelerating thru the potential all the energy is $U_E$, and at the end of acceleration it is all $K_E$. I can find v from this:

$$\left.\begin{array}{l} U_E = \frac{1}{2}QV \\ K_E = \frac{1}{2}mv^2 \end{array}\right\} U_E = K_E \rightarrow \frac{1}{2}QV = \frac{1}{2}mv^2 \rightarrow v^2 = \frac{QV}{m}$$

The gyroradius is: $r = \frac{mv}{QB}$

If I square this: $r^2 = \frac{m^2v^2}{Q^2B^2} = \frac{m^2}{Q^2B^2}\left(\frac{QV}{m}\right) = \frac{mV}{QB^2}$

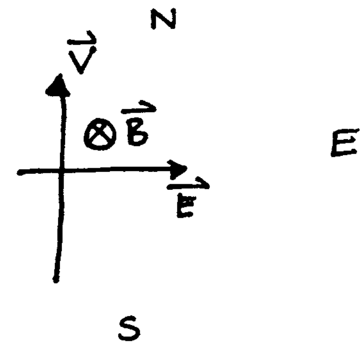
So the mass can be found to be: $m = \frac{QB^2r^2}{V}$

Sol/

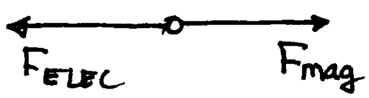
$$m = \frac{(1.60 \times 10^{-19}\,\text{C})(1.2\,\text{T})(0.125\,\text{m})^2}{7000\,\text{V}} = \boxed{4.286 \times 10^{-25}\,\text{kg}}$$ (ANS)

(27) I build a VELOCITY SELECTOR from crossed E and B fields. The B field is 0.635T vertically down. The E field is $2.68 \times 10^6$ V/m horizontally to the east. An electron travels horizontally to the North, and experiences ZERO NET FORCE. What is the speed?

Viewed from above the situation is shown to the right. From this, I can draw the FREE BODY DIAGRAM.




- Electric force on electron points to the WEST (electrons accelerate against $\vec{E}$)
- Magnetic force on electron points to the EAST (RHR).




Since they point in opposite directions, if there is no net force, the two magnitudes must be equal: $F_{mag} = F_{elec}$

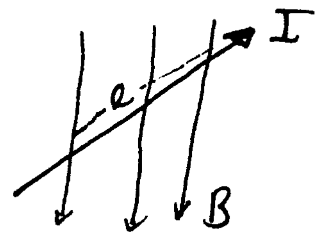
$$F_{elec} = qE = (1.60 \times 10^{-19} C)(2.68 \times 10^6 \, V/m) = 4.29 \times 10^{-13} N$$

$$F_{mag} = qVB = F_{elec} \Rightarrow V = F_{elec}/qB$$

SO// $$V = \frac{4.29 \times 10^{-13} N}{(1.60 \times 10^{-19} C)(0.635T)} = \boxed{4.22 \times 10^6 \, m/s = V}$$ (ANS)

(38) A 25cm segment of straight wire carries a 33.0A current, and is immersed in a uniform external B field. The magnetic force on the wire is 4.12N. (a) What is the minimum magnitude of B field? (b) Why can we only compute the minimum field?

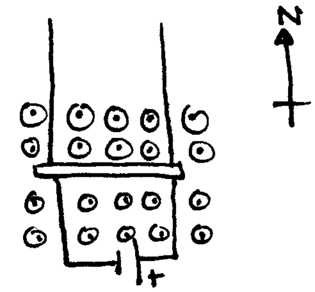
For a current immersed in a B field the force is: $F = I \ell B \sin\theta$




We are not given $\theta$, so assume $\theta = \pi/2$, which will give the minimum possible B to give the observed force. So:

$$F = I\ell B \Rightarrow B = \frac{F}{I\ell} = \frac{4.12\text{N}}{(33.0\text{A})(0.25\text{m})} = \boxed{0.50\text{T}}$$ (ANS)

(39) Consider a sliding bar circuit immersed in a vertical $B = 1.2T$ field as shown. The bar masses 0.040 kg and carries 3.0 A of current. If the rod is 2 cm long, what is magnetic force on rod?

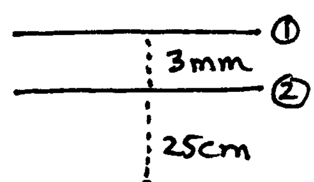



The current flows CCW given the orientation of the battery, so the RIGHT HAND RULE gives NORTH as direction.

The current and B field are at right angles, so the magnitude of the force is:

$$F = I\ell B = (3.0A)(0.02m)(1.2T) = \boxed{0.072\,N}$$ (ANS)

(55) Consider a point near 2 parallel wires, each carrying 10.0 A. The point is 25 cm from one, and 25.3 cm from the other. (a) What is B for current in opposite directions and (b) same directions?




The current magnitudes are: $B = \mu_0 I / 2\pi r$

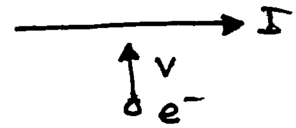
$$B_1 = (4\pi \times 10^{-7}\,Tm/A)(10.0A)/2\pi(0.253m) = 7.905 \times 10^{-6}\,T$$

$$B_2 = (4\pi \times 10^{-7}\,Tm/A)(10.0A)/2\pi(0.25m) = 8.000 \times 10^{-6}\,T$$

OPPOSITE : Fields subtract : $B_{TOT} = B_2 - B_1 = 9.5 \times 10^{-8}\,T$

SAME : Fields add : $B_{TOT} = B_2 + B_1 = 1.6 \times 10^{-5}\,T$

(ANS)




(57) A long wire carries 50.0A as shown. An electron travelling at $1.0 \times 10^7$ m/s is 5.0cm from the wire. What force is action on the electron?

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The B field seen by the electron points down thru the page with magnitude:

$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7}\ \text{Tm/A})(50.0\text{A})}{2\pi\,(0.05\text{m})} = 2.0 \times 10^{-4}\ \text{T}$$

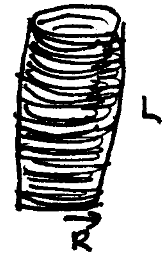
The RHR says the force felt by the electron for B into the page points TO THE RIGHT (same direction as current)

The magnitude of the force is:

$$F = qvB = (1.60 \times 10^{-19}\text{C})(1.0 \times 10^{7}\ \text{m/s})(2.0 \times 10^{-4}\text{T})$$

$$= \boxed{3.2 \times 10^{-16}\ \text{N}}$$ (ANS)

(60) A 4.5 A current runs thru a 244 turn solenoid that is 0.256m long and 2.0cm in radius. What is B at the center?

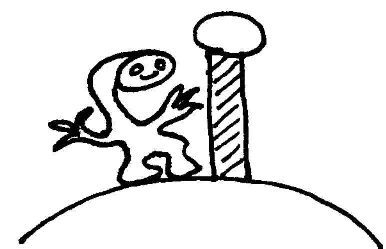



For solenoids: $B = \mu_0 N I / L$

sol/

$$B = \frac{(4\pi \times 10^{-7} \frac{Tm}{A})(244)(4.5A)}{0.256m} \approx 5.39 \times 10^{-3} T$$ (ANS)

(95) An alien at the N pole of Earth has a 20.0cm diameter loop of wire. The Earth's B field is $6.0 \times 10^{-5}$T. (a) What magnitude and direction of current (as viewed from above) is needed to cancel the Earth's field in the center of the loop?



Earths N pole is a S MAGNETIC so field points IN. For an induced current to counter this (up in center of loop) the current must flow CCW seen from above.

Field at center of a loop is: $B = \mu_0 I / 2R$

sol/

$$I = \frac{2BR}{\mu_0} = \frac{2(6.0 \times 10^{-5} T)(0.10m)}{4\pi \times 10^{-7} Tm/A} \approx 9.55A = I_{LOOP}$$

(ANS)