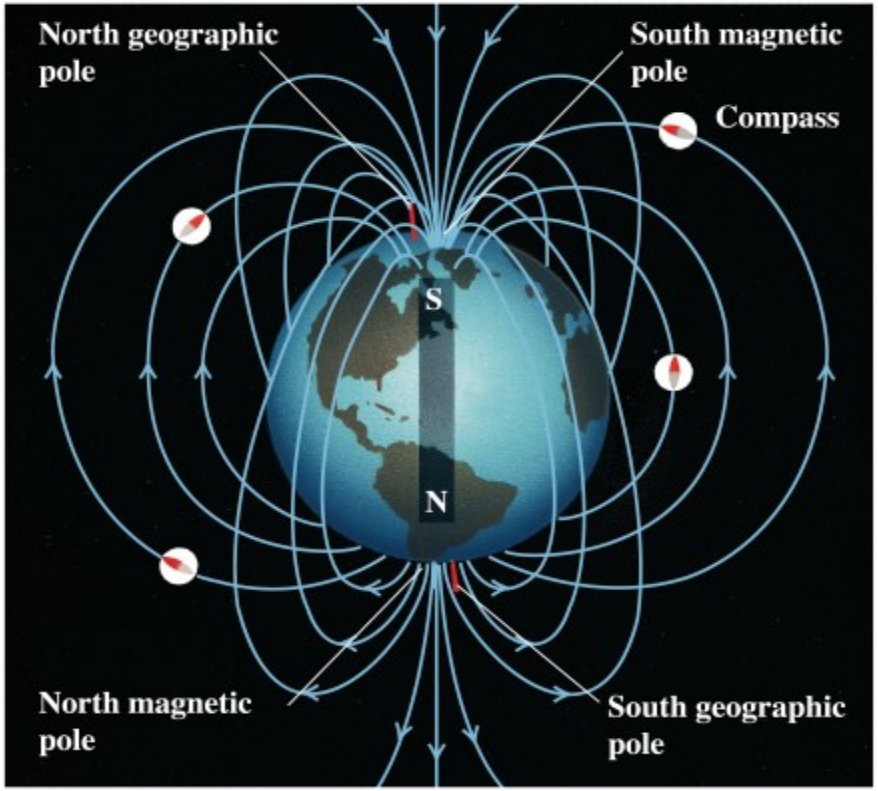
# Magnetism



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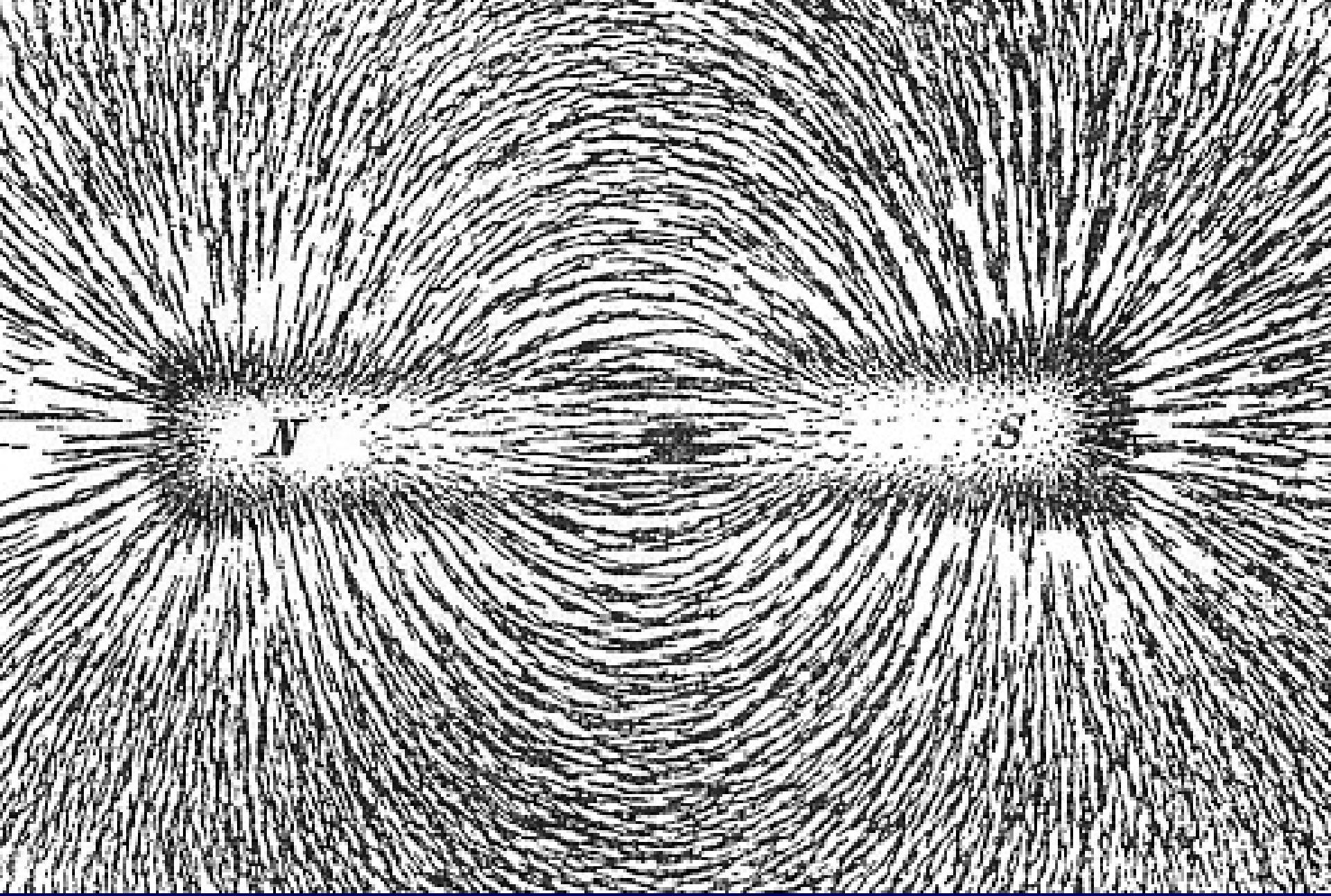
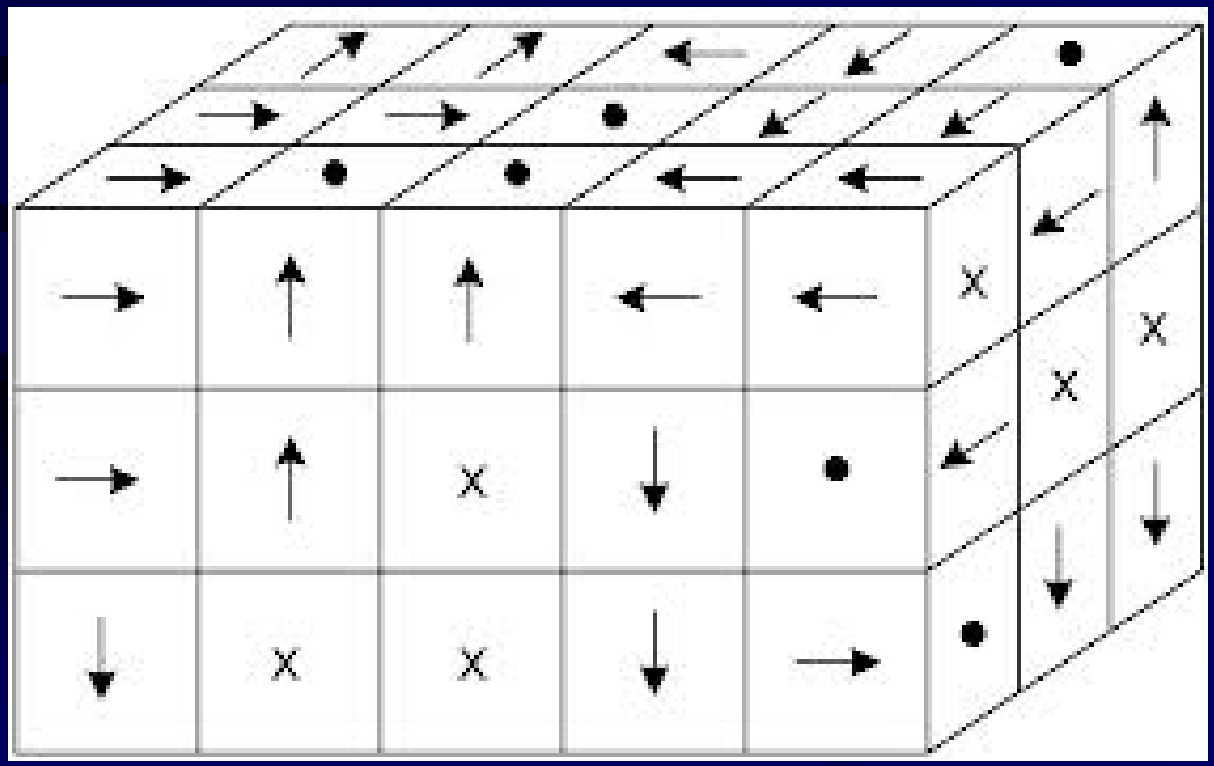
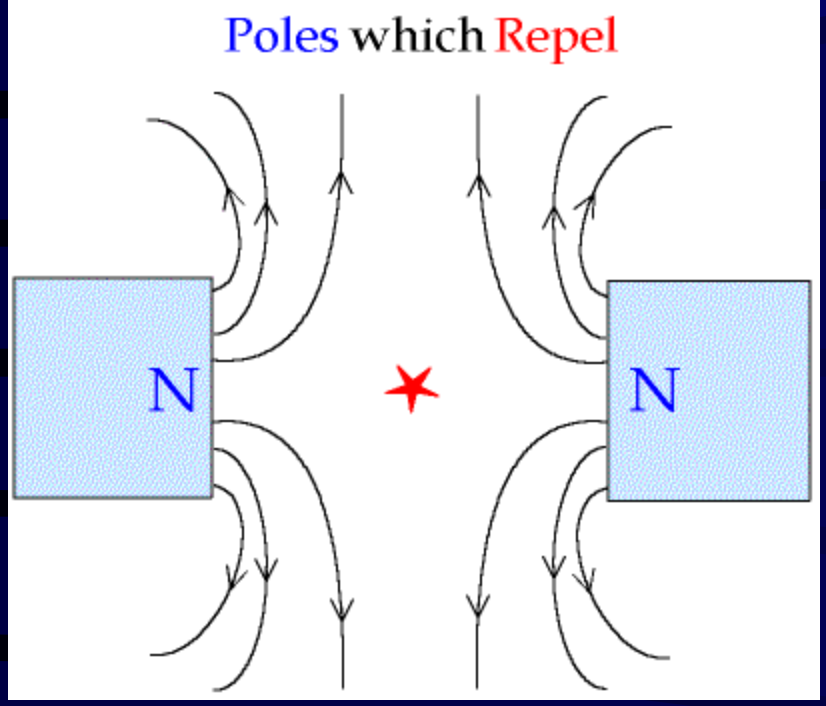
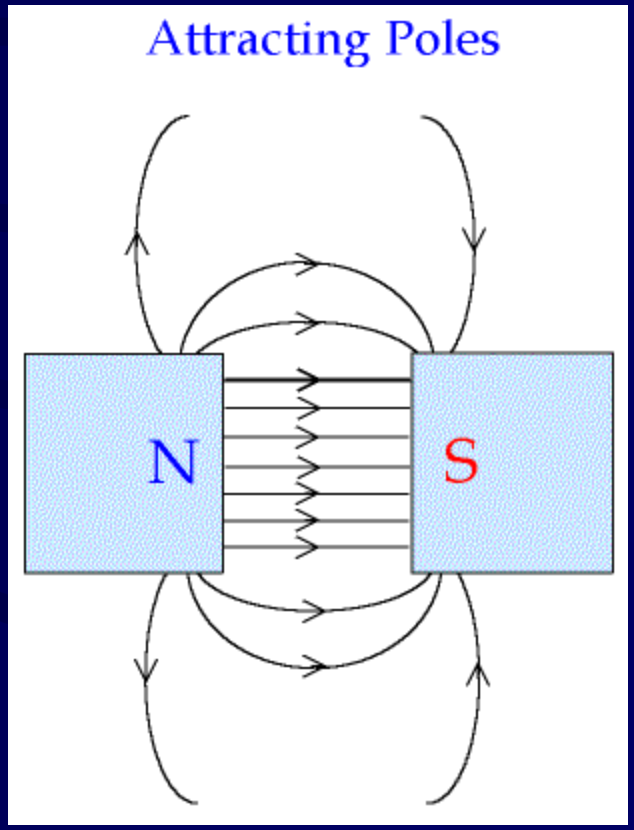
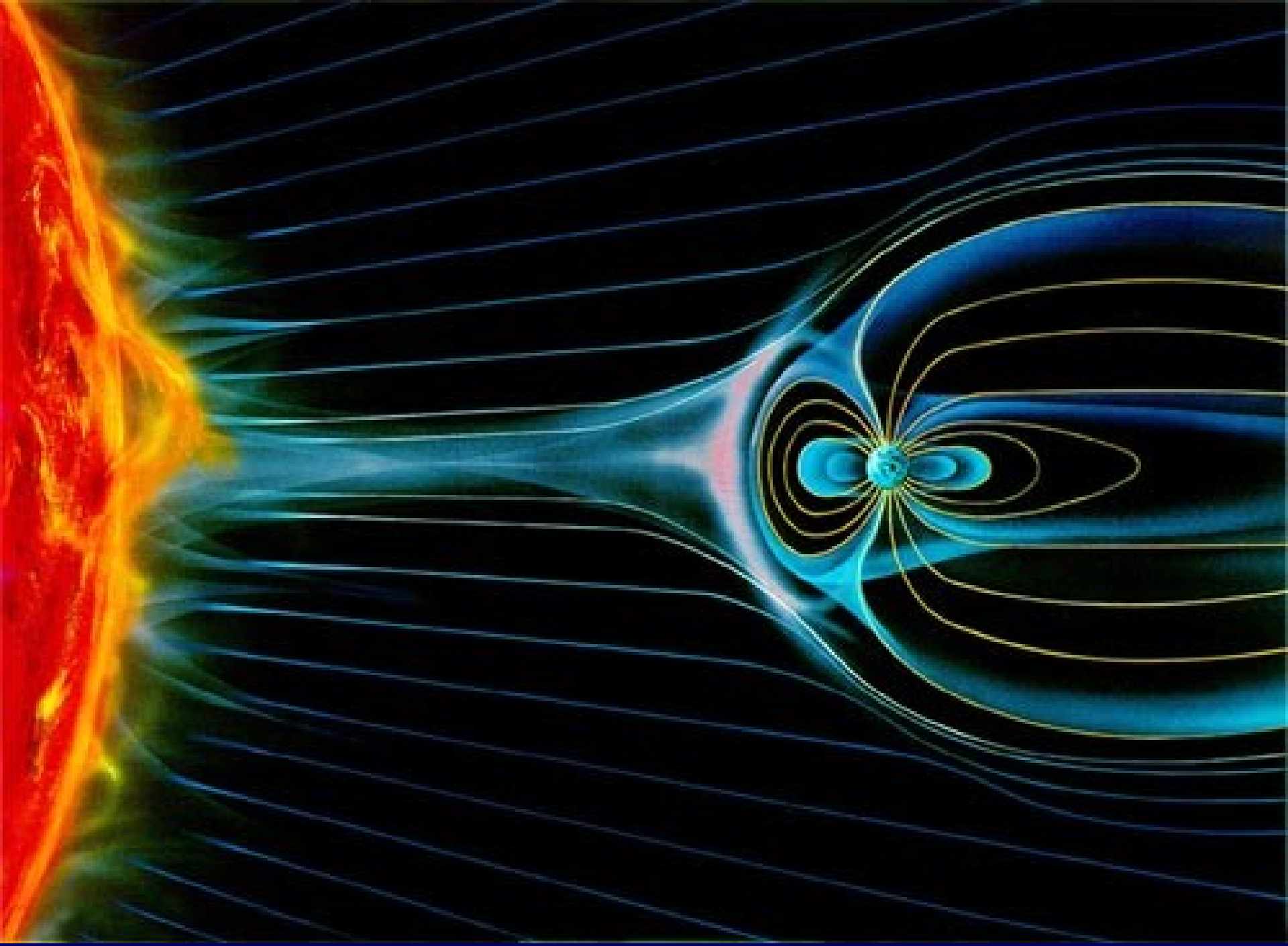

N
S

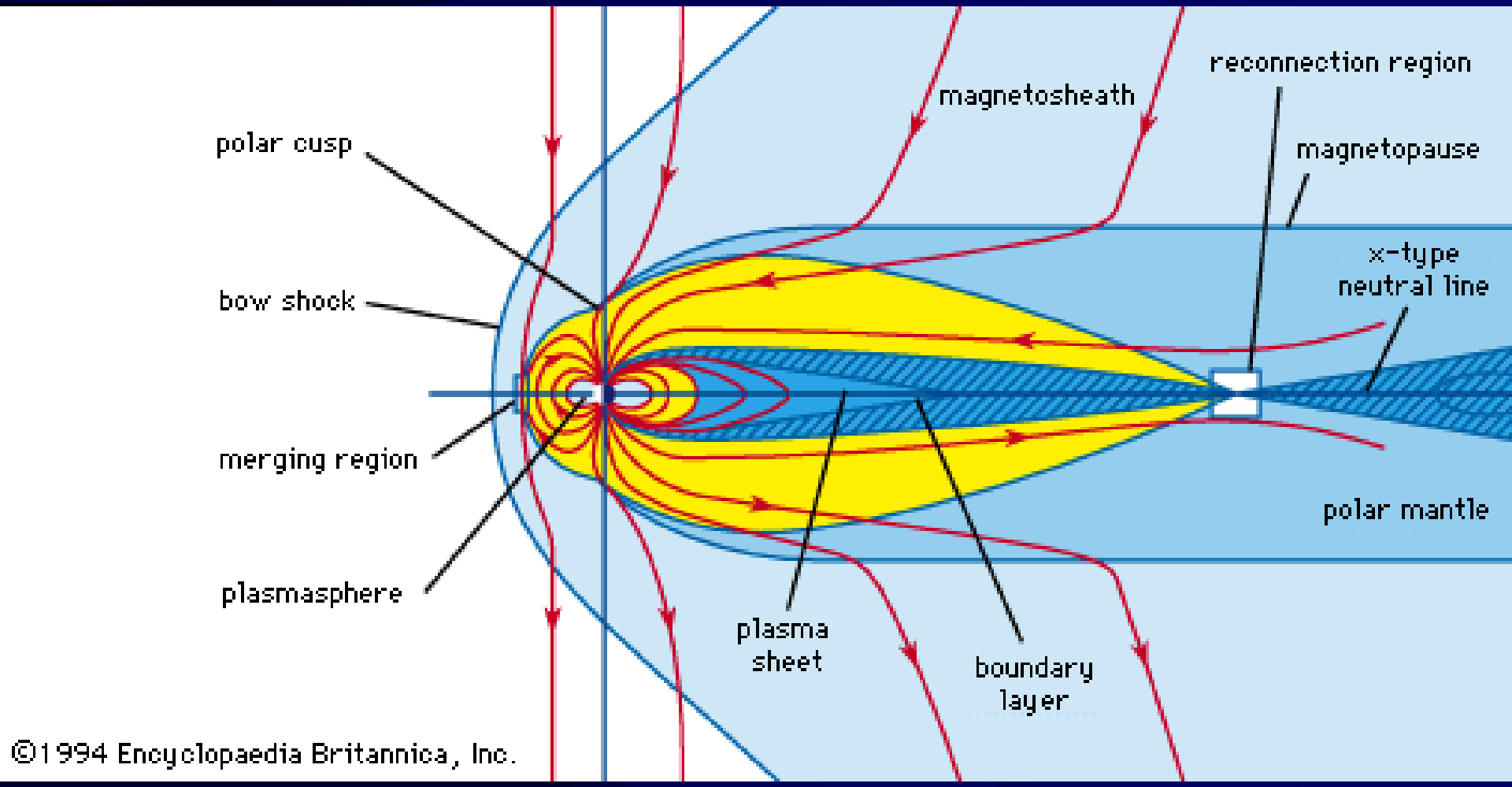
# Domains




Poles which Repel
N
N


Attracting Poles
N
S




reconnection region
magnetosheath
magnetopause
polar cusp
x-type
neutral line
bow shock
merging region
polar mantle
plasmasphere
plasma
sheet
boundary
layer
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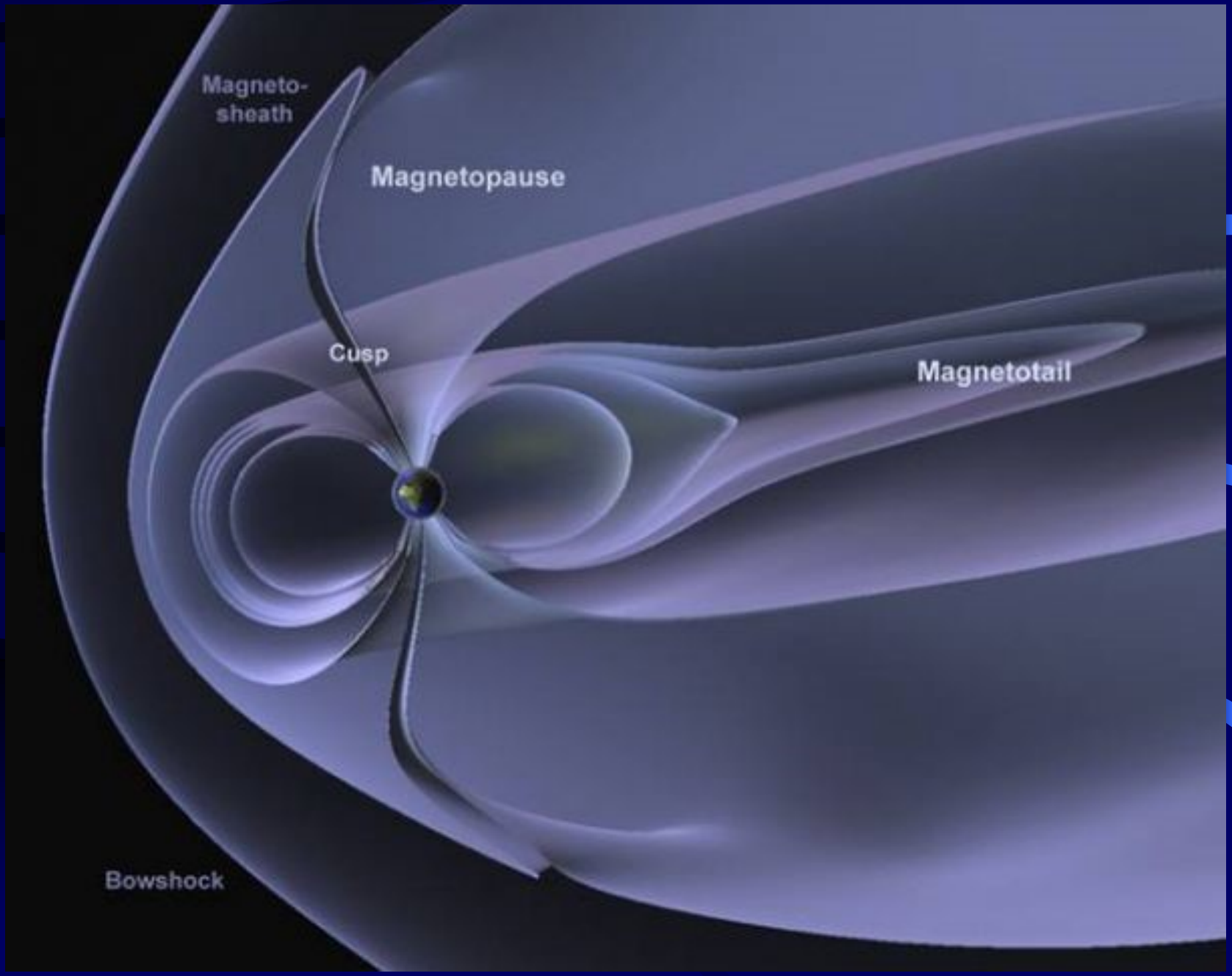
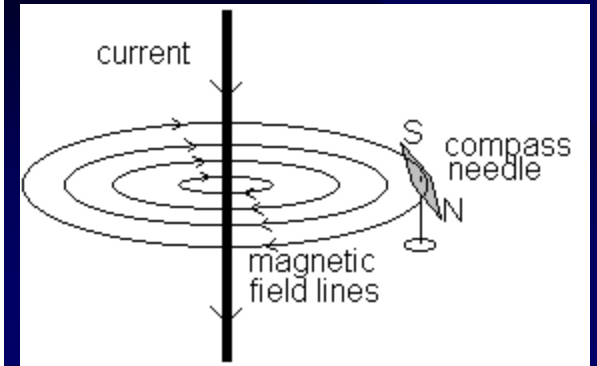
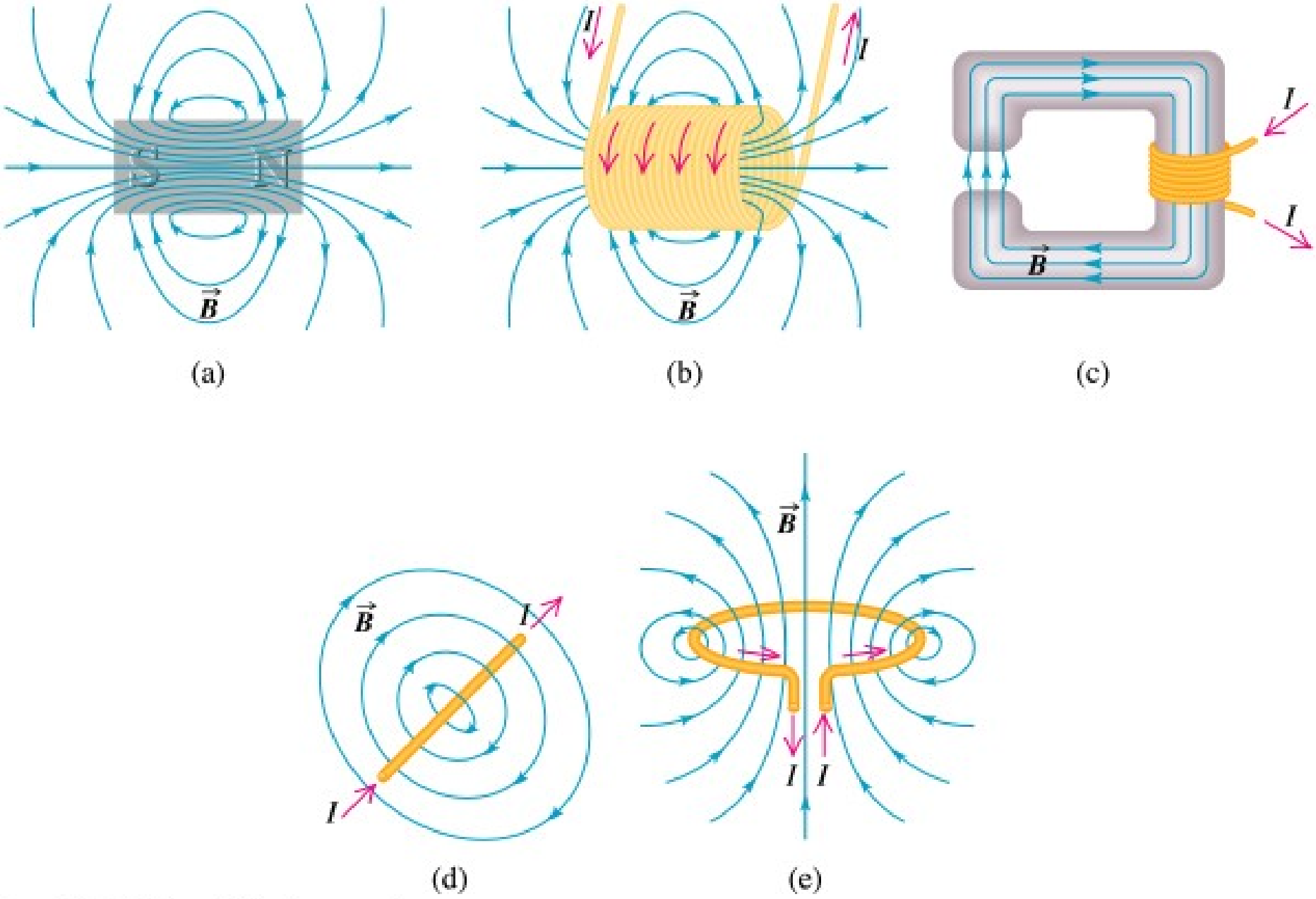

Magneto-
sheath
Magnetopause
Cusp
Magnetotail
Bowshock

# Electro-what?

- Hans Oersted first discovered the connection when he noticed a compass deflected by a current
- Any current produces a magnetic field around it according to the right hand rule



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# Exercises

- p. 212 #1-2
- p. 218 #1

# Maxwell's Equations

- These are cool…
  - Gauss' law for electricity
  - Gauss' law for magnetism
  - Faraday's law of induction
  - Ampere's law

$$\oint \vec{E} \cdot d\vec{A} = \frac{q}{\varepsilon_0}$$

$$\oint \vec{B} \cdot d\vec{A} = 0$$

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$$

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i + \frac{1}{c^2}\frac{\partial}{\partial t}\int \vec{E} \cdot d\vec{A}$$

# Magnetic Field

- We define magnetic field direction as the direction of force on the North end of a compass
- The units for magnetic field B are Tesla
- 1 T=1 N/A·m

# Force on moving charges

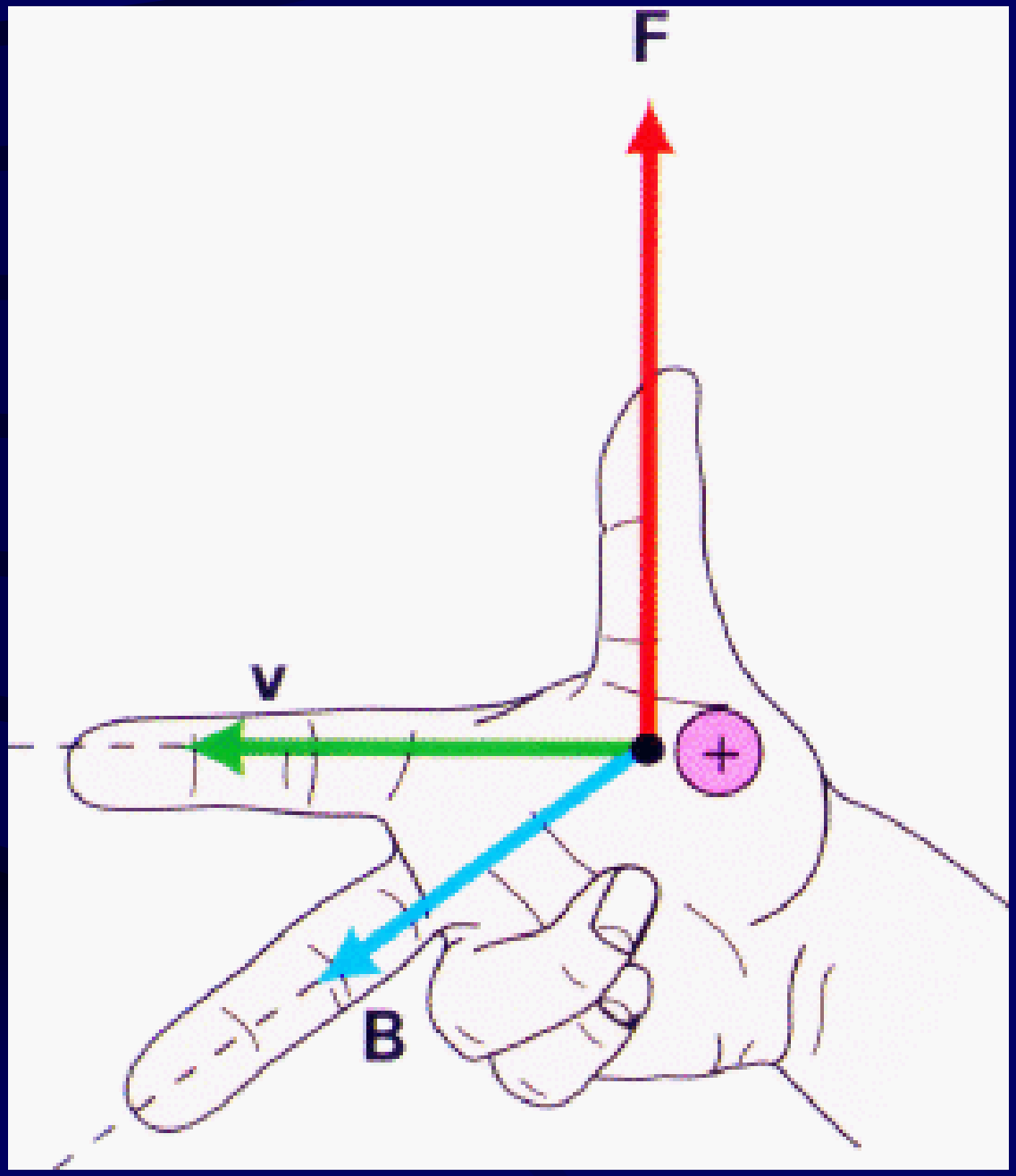
- For a moving point charge we have:

$$F = QvB$$

- This translates for a current carrying wire:

$$F = BIl$$

- Direction of Force?
- You Guessed it… another Right hand rule


F
v
+
B

# Ex 1: Find force

- Find the force on a proton travelling at 300 km/s East in a field of 0.35T North

$$F = QvB$$

$$F = 1.6\times10^{-19}C \cdot 3.0\times10^{5}\, m/s \cdot 0.35T$$

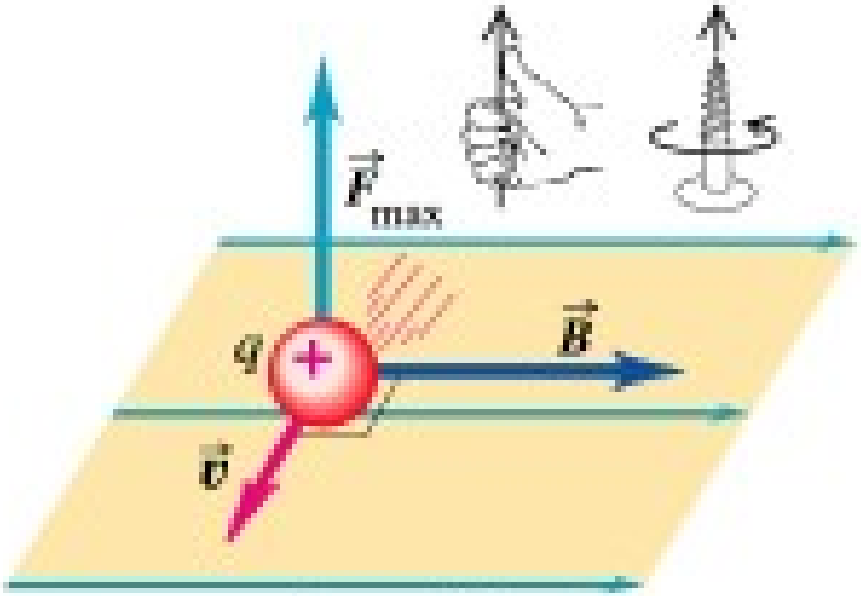
$$F = 1.68\times10^{-14}\,N$$

$$\vec{F} = 1.68\times10^{-14}\,N \uparrow up$$

$F = qvB \sin \phi$

$v_\perp = v \sin \phi$

(b)




$F = qvB$

(c)

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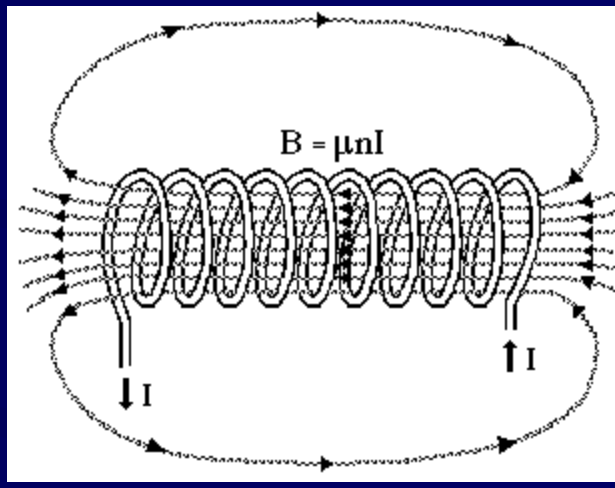
# Exercises

- p. 220 #1-3

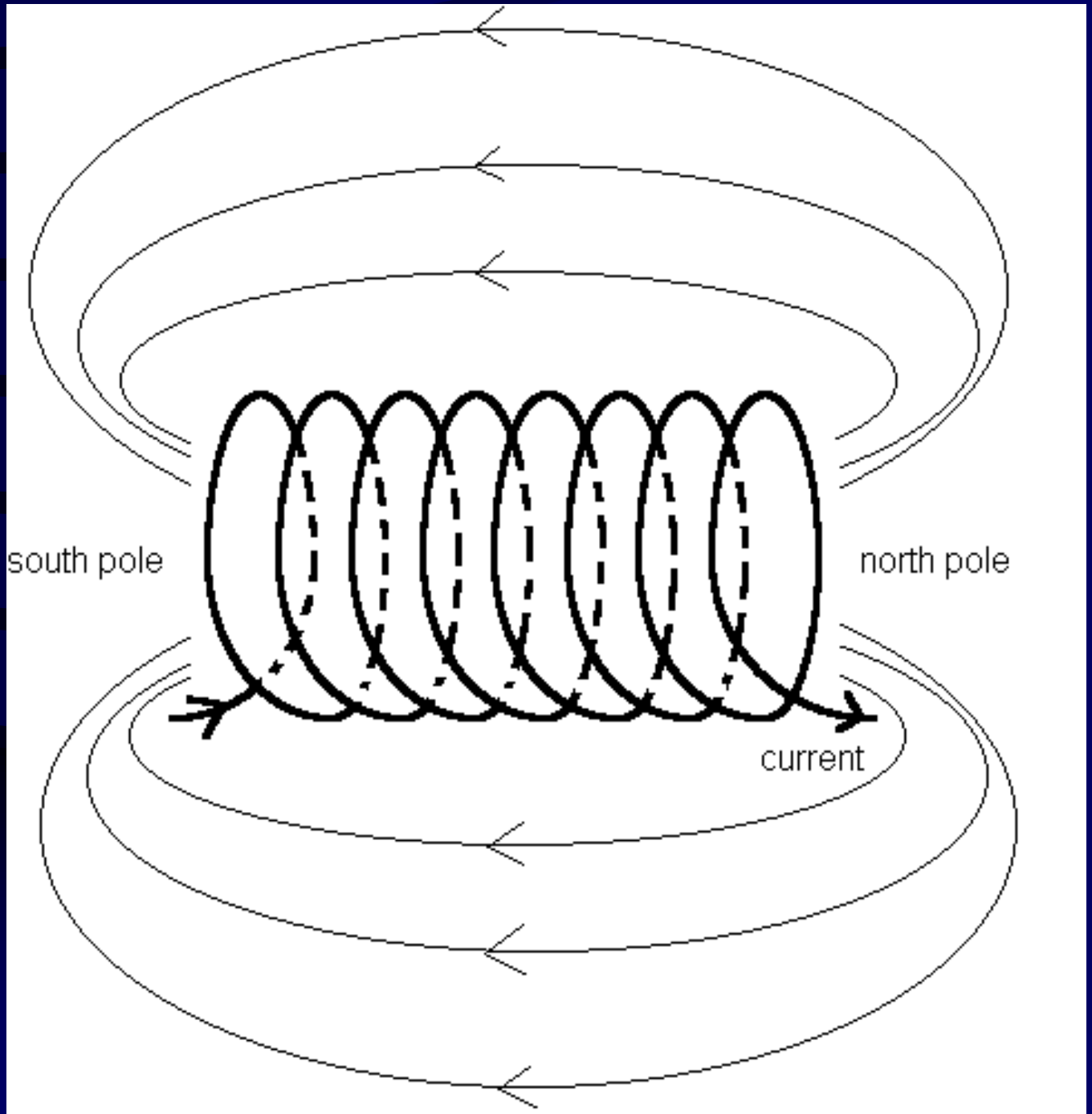
# Calculating B in a solenoid

- We would expect the magnetic field will be proportional to:
  - current
  - number of turns per unit length




$$B = \mu_0 n I$$

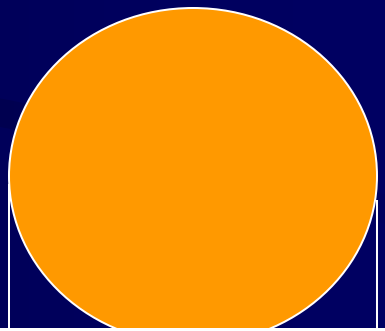
- Where n is the number of turns per unit length N/l, $\mu_0$ is the permeability of free space


south pole
north pole
current

# Ex 1: Find the field

- Find the Magnetic field inside a 520 turn 0.155m solenoid with a 5A current flowing in a clockwise direction (looking end-on)

$$B = \mu_0 \frac{N}{l} I$$



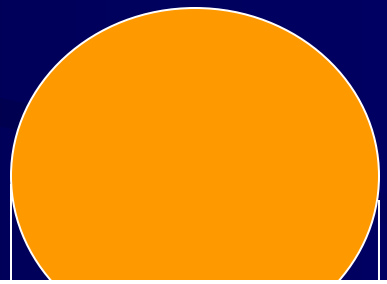
$$B = 4\pi \times 10^{-7}\, {Tm}/{A} \cdot \frac{520}{0.155m} 5.0A$$

$$B = 0.021T$$

# Ex 2: Find the field

- Find the Magnetic field inside a 350 turn/m solenoid with a 2.5A current flowing in a clockwise direction (looking end-on)

$$B = \mu_0 n I$$



$$B = 4\pi \times 10^{-7}\, {Tm}/{A} \cdot 350 m^{-1} 2.5 A$$

$$B = 1.1 mT$$

# Exercises

- p. 221 #1-4
- Prep lab 7-2 p. 224-6

# Ex 2: Find the current

- Find the current flowing in a 3.5cm length wire at right angles to a field of 0.62T if it is subject to a force of 5.5mN

$$F = BIl$$

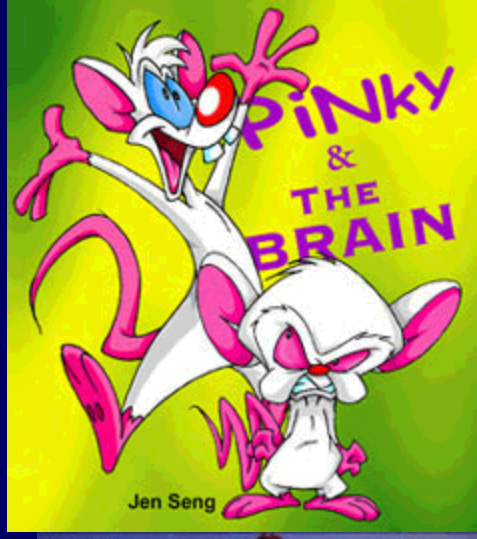
$$I = \frac{F}{Bl}$$

$$I = \frac{5.5 \times 10^{-3}\, N}{0.62T \cdot 0.035m}$$

$$I = 0.25A$$

# Define Flux

Flux is the product of the magnetic field passing through a perpendicular area



$$\Phi = BA$$

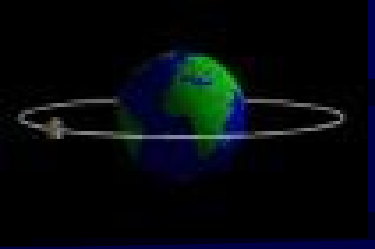
- Define the Weber (WB) =$Tm^2$

# Exercises

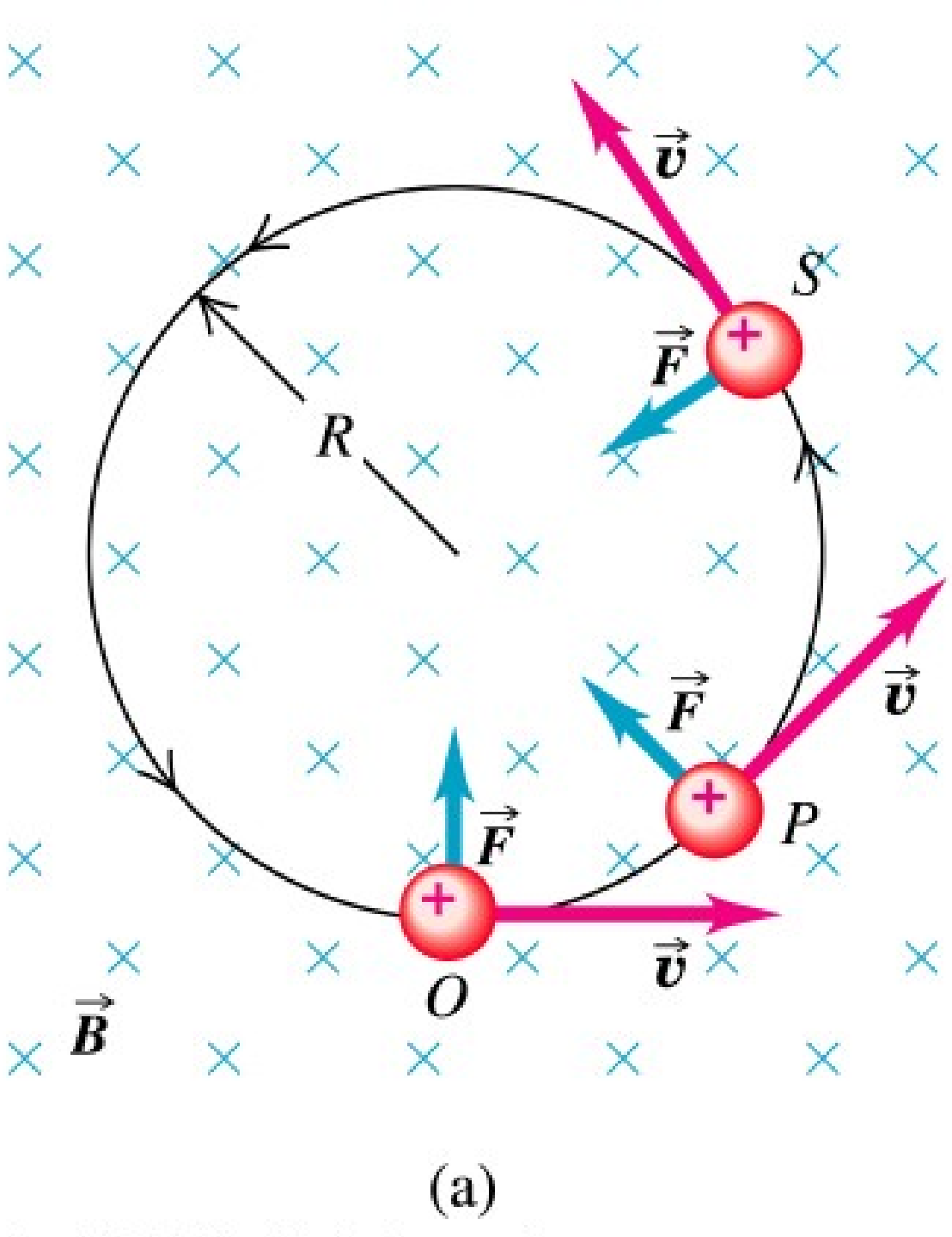
- p. 227 #1-5

# Motion in a magnetic field

- More right hand rule
- What is the shape of a charged particle's path in a magnetic field?

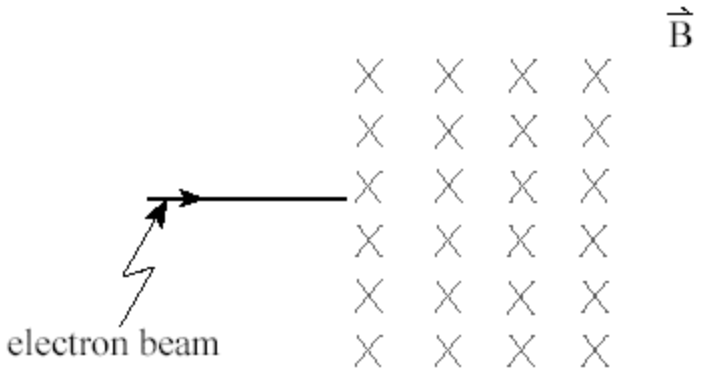


- Particles moving perpendicular to a uniform magnetic field
- F ⊥ v
- sound familiar?

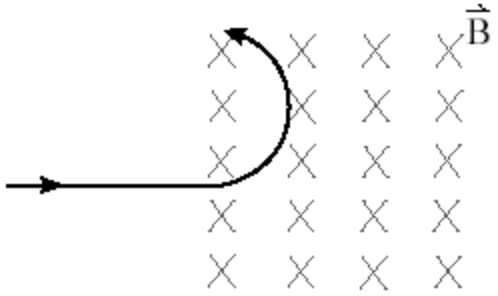


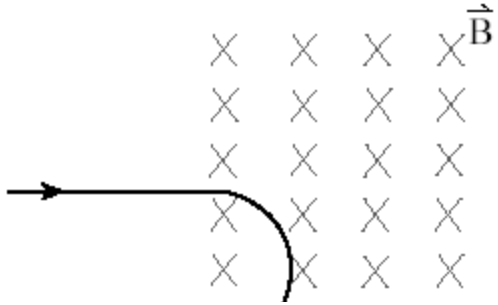
# Ex 4: Find the radius

A beam of electrons travelling at $1.8 \times 10^8$ m/s is directed towards a 0.014 T magnetic field as shown in the diagram below.




a) Which of the following diagrams illustrates the path of the electron beam once in the magnetic field? (Circle one.) **(1 mark)**




What is the radius of the path of the electron beam while in the magnetic field?

# Ex 4b: Find the radius

- What is the radius of the path of the electron beam while in the magnetic field?

$$F = ma = qvB$$

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

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

$$r = \frac{9.11\times10^{-31}\,kg \cdot 1.8\times10^{8}\,m/s}{0.014T \cdot 1.6\times10^{-19}\,C}$$

$$r = 0.073m$$

# Exercises

- p. 233 #1-4
- p. 235 #1-2
- Finish lab: use the slope of your graph to find the magnetic field strength inside the horseshoe magnet
- Start:
  - Review Project: choose a Chapter to do a PowerPoint slideshow to present to the class.
  - This will be due June 8th (in time for our year-end review)

# Review

- Start:
- Chapter Review Questions p. 237-238 1-17 (Bonus 18-19)
- Bonus: Test Yourself p. 239-242 1-14 if turned in b4 test