PHY 1120 - Dr. Rowley

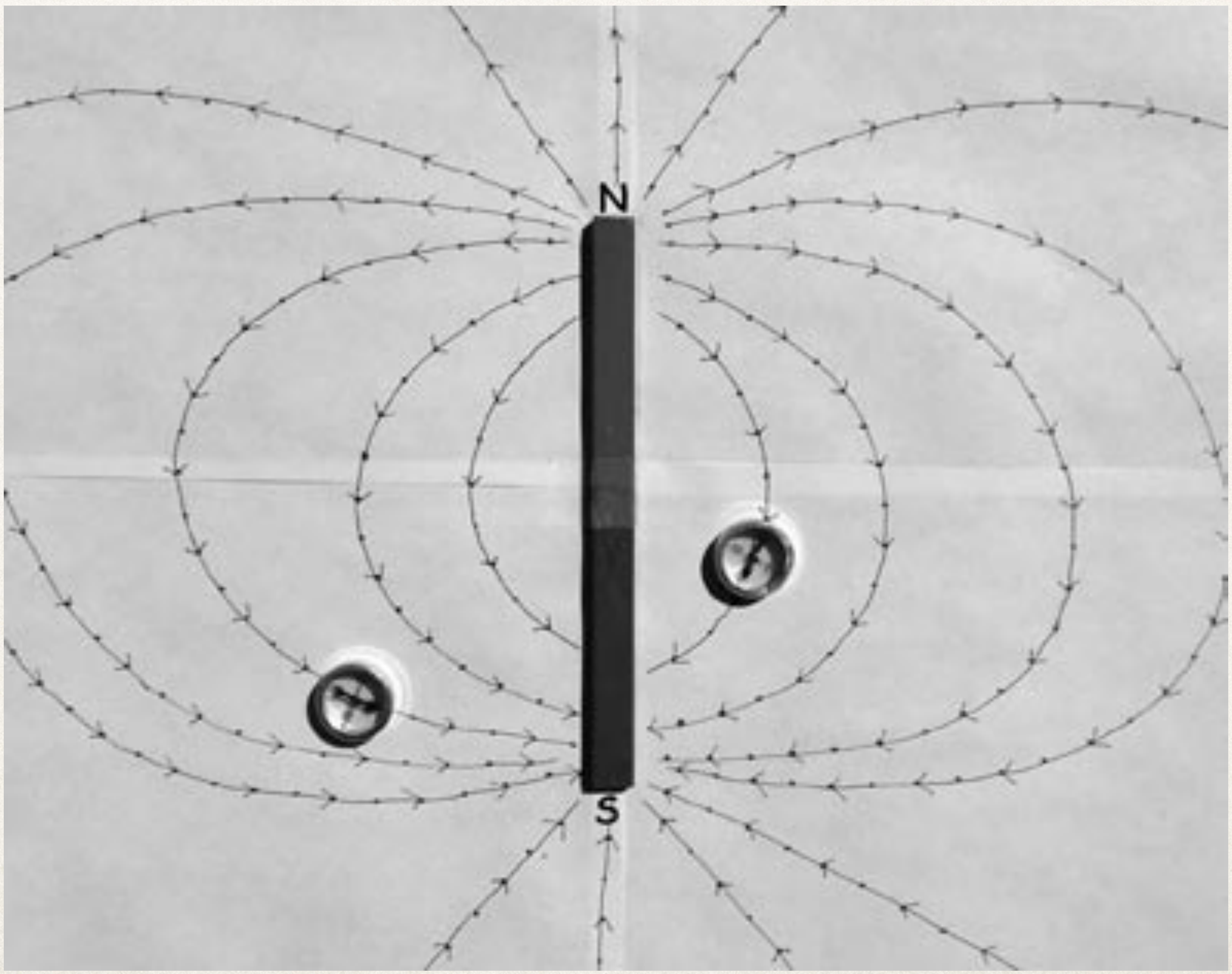
Chapter 22 - Magnets

Summer 2020

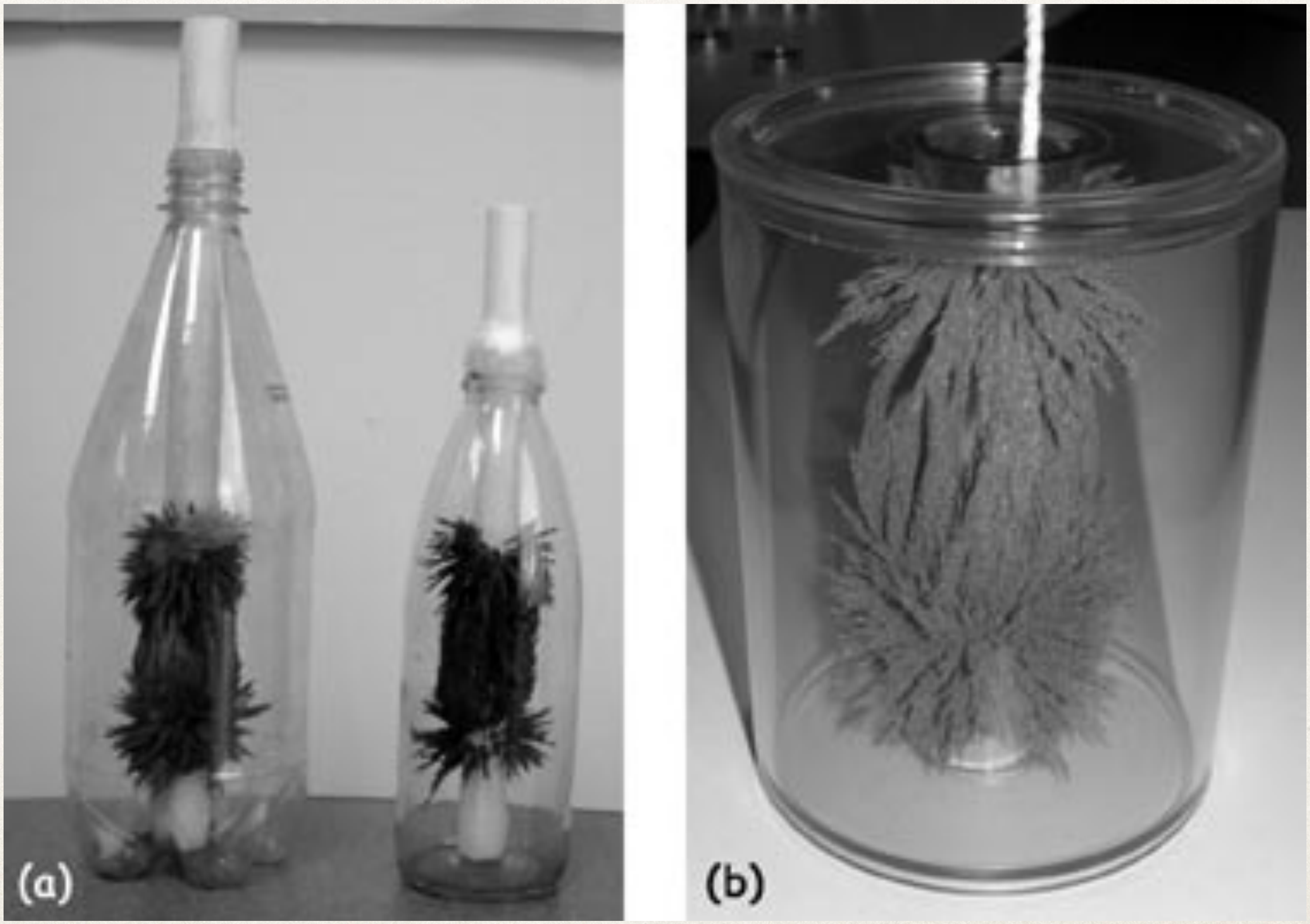
Magnets

- Keys
  - No Mono-poles, always in pairs
  - Magnetic Field lines go N -> S **outside** of the magnetic material
  - Geographic North ~ Magnetic South-ish
  - Magnetic Fields are 3-Dimensional

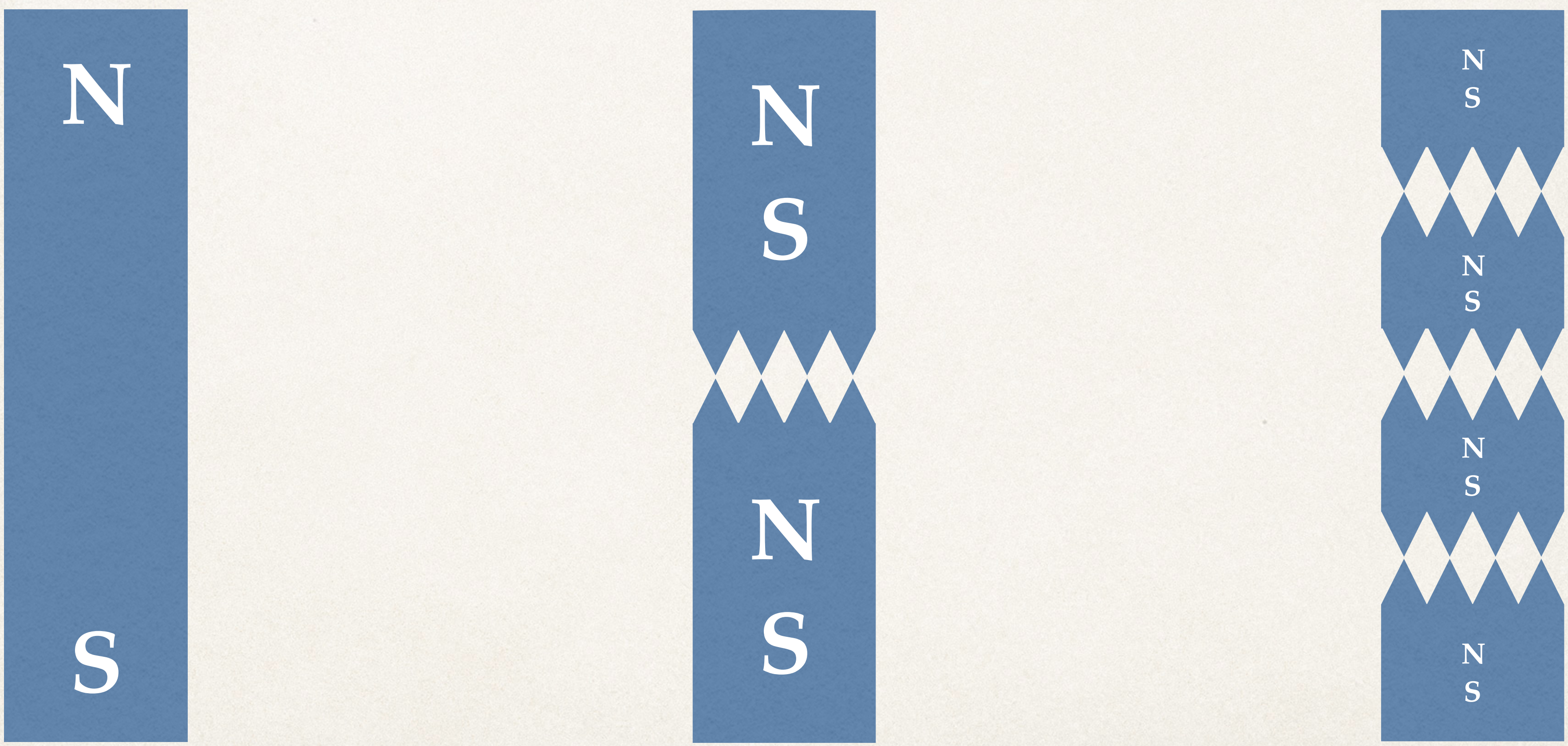
Magnetic Fields - 2D



Magnetic Fields - 3D

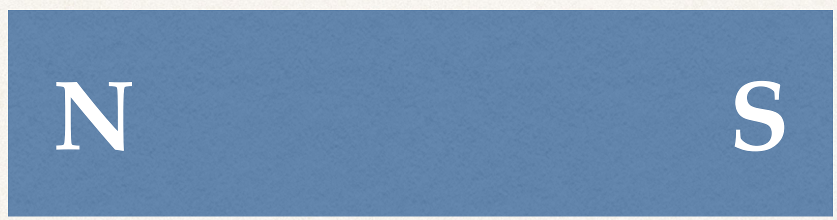


No Mono-poles?



Magnetic Field Lines

- A single North-South Magnet

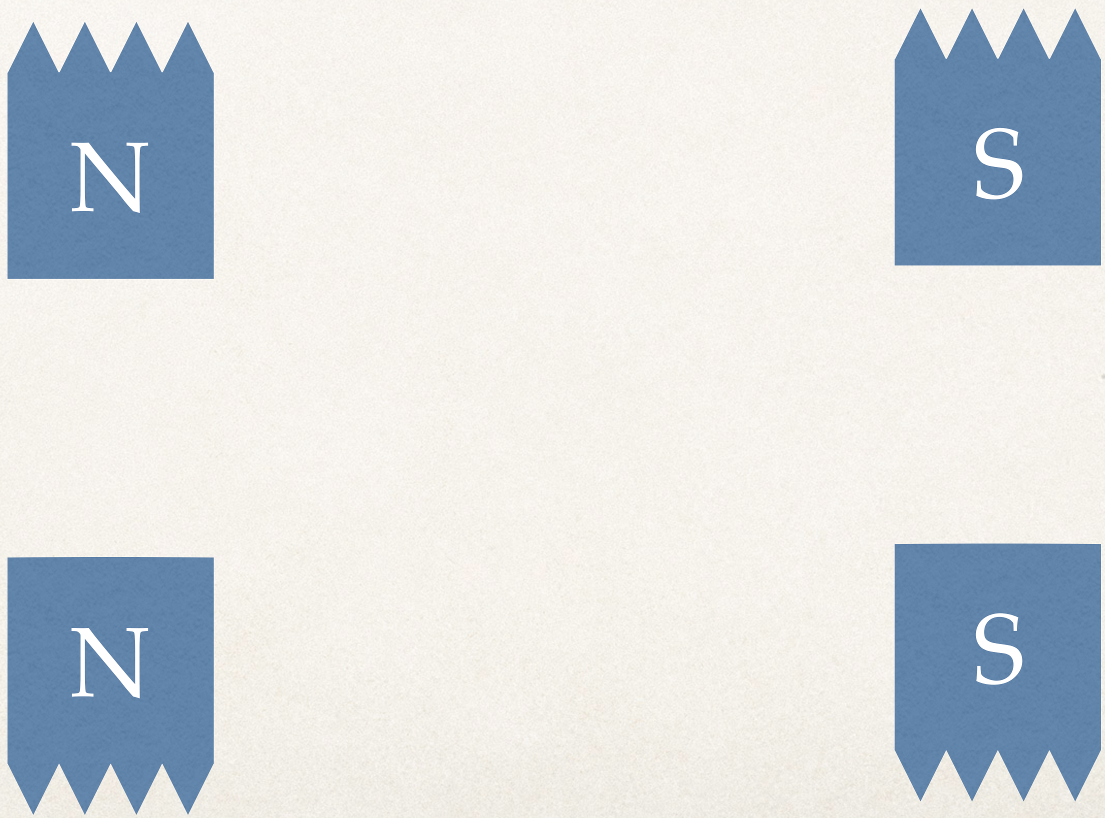


Magnetic Field Lines

- A north end and south end of two magnets

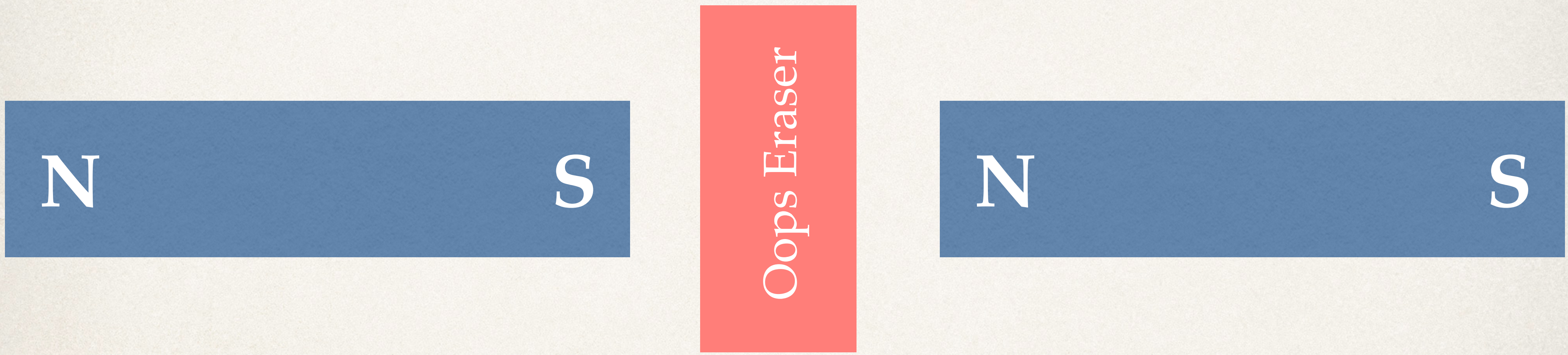
Magnetic Field Lines

- Same ends of two magnets



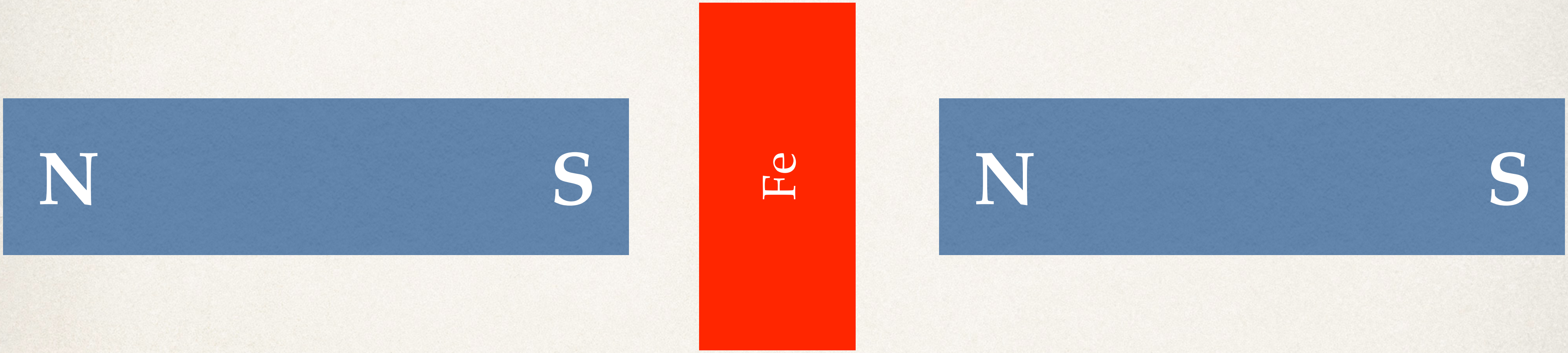
Magnetic Field Lines

- Two magnets with an eraser in the middle



Magnetic Field Lines

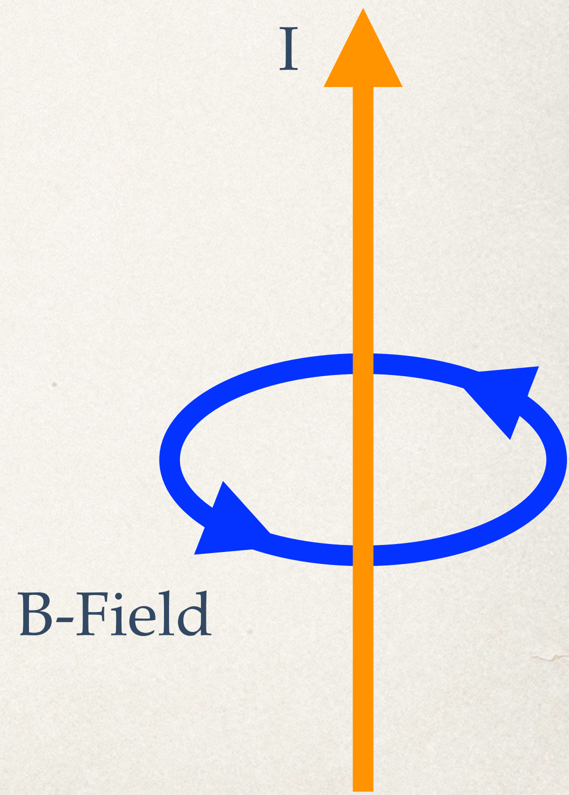
- Two magnets with a piece of Iron in the middle.



Right Hand Rule #1

- **PURPOSE:** Determine the direction of the B-field given the current in a wire.

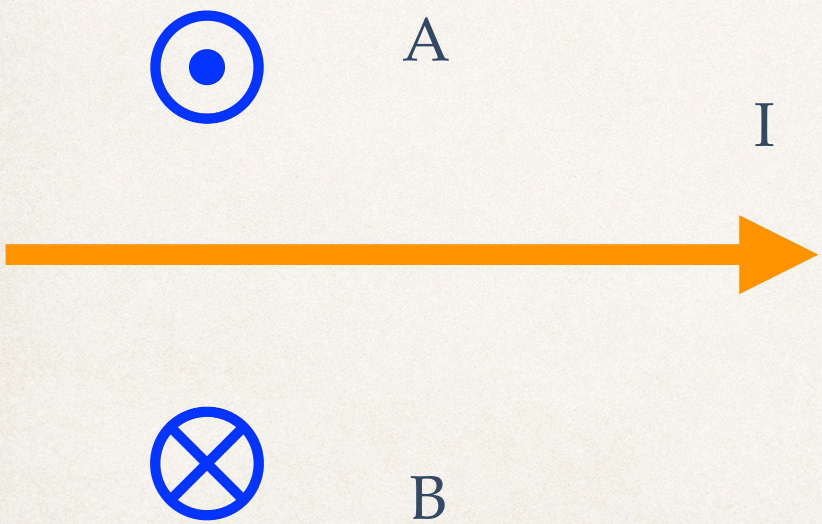
1. Thumb in the direction of the **conventional current**.
2. Fingers wrap in the direction of the B-Field



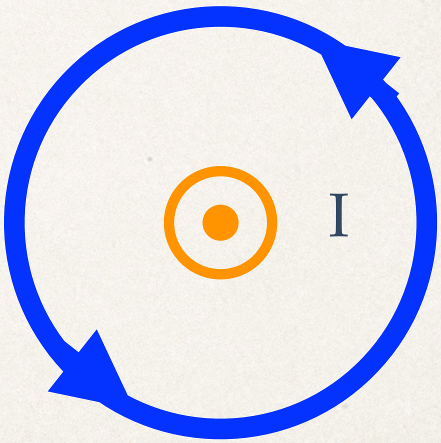
Right Hand Rule #1

- What is the direction of the magnetic field at A? at B?

Out of the page



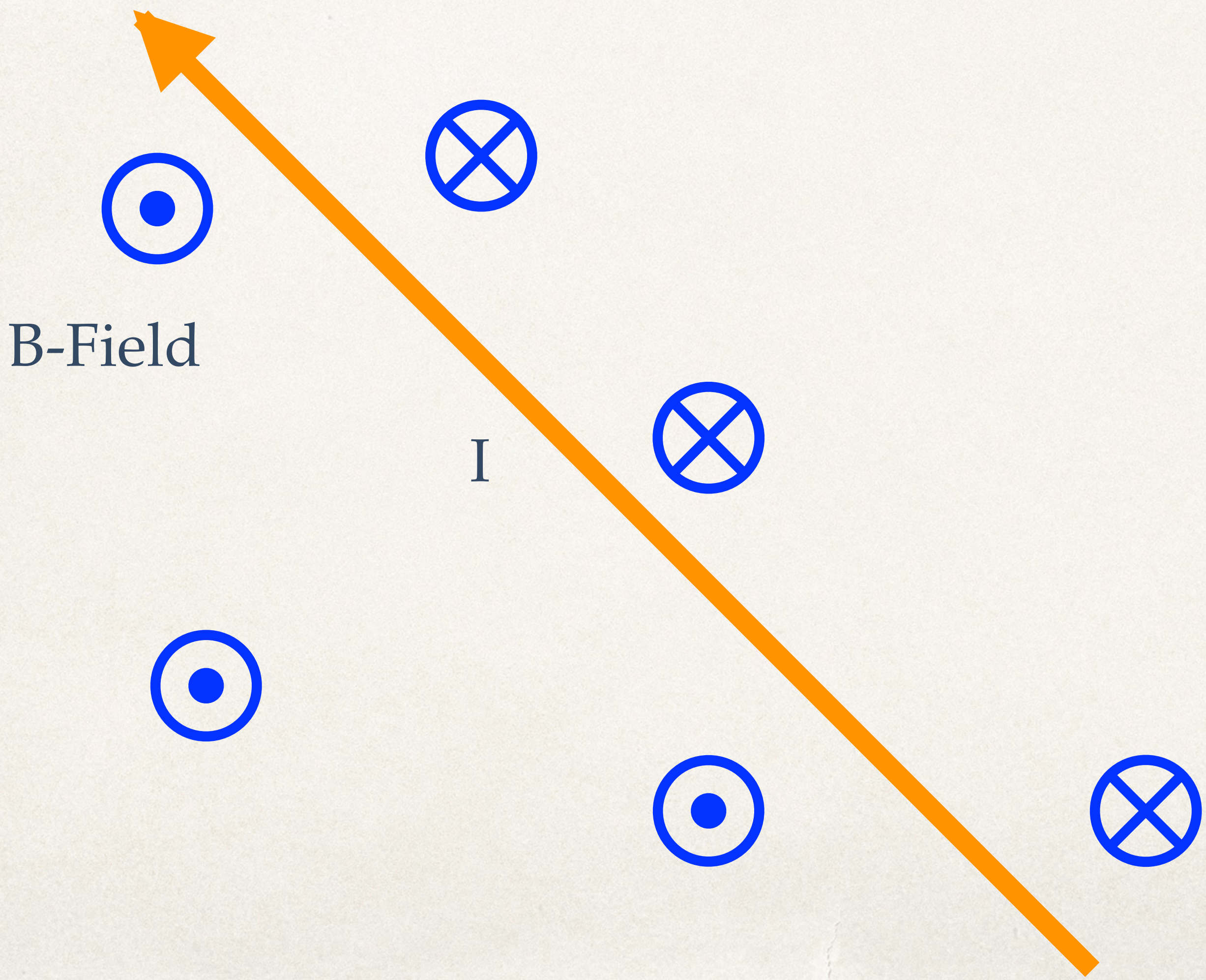
Into the page



B-Field

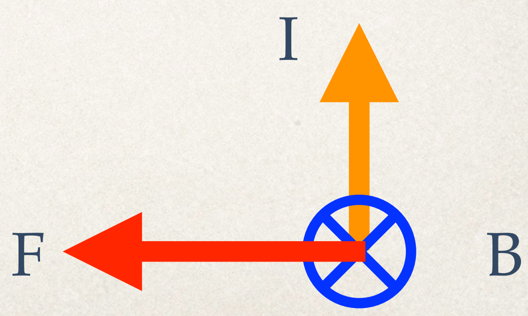
Right Hand Rule #1

- Where is the wire and which direction is the current going?



Right Hand Rule #2

- **PURPOSE:** Determine the direction of the force on a CURRENT CARRYING wire that is EXPERIENCING an external B-field.
- Fingers point in the direction of the current in the wire.
- Palm points in the direction of the B-Field
- Thumb points in the direction of the force on the wire.



Force on a Current Carrying Wire

- A 2.5 Tesla B-Field goes into the board. A 1.00m wire carries a current 1.5 Ampere current in that magnetic field. What is the minimum force the wire can experience? What is the maximum force the wire can experience?

B = 2.5 T
I = 1.5 A
ℓ =1.00 m
θ = ?
F = ?

What is the effect of
B, I, ℓ, and θ on Force?

$$F\left(B,I,\ell,\theta\right)=?$$

Force on a Current Carrying Wire

TABLE 20.4 Magnetic force data for the experiment in Figure 20.14

Current I in the wire (A)	Length L of wire (m)	Orientation angle θ between the current and the $\vec{B}$ field	Magnitude of magnetic force F exerted on the wire (N)
I	L	90°	F_1
$2I$	L	90°	$2F_1$
$3I$	L	90°	$3F_1$
I	L	90°	F_1
I	$2L$	90°	$2F_1$
I	$3L$	90°	$3F_1$
I	L	0°	0
I	L	30°	$0.5F_1$
I	L	60°	$0.87F_1$
I	L	90°	F_1

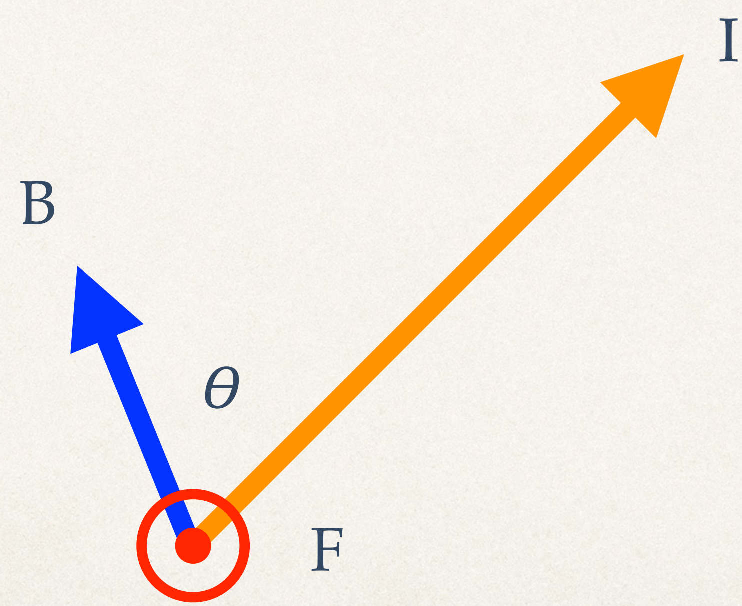
Force on a Current Carrying Wire

- What is the relationship between B and F?
  - Direct
- What is the relationship between I and F?
  - Direct
- What is the relationship between ℓ and F?
  - Direct
- What is the relationship between θ and F?
  - Direct, kinda… it's complicated

Force on a Current Carrying Wire

- What is the Force on a Current Carrying Wire?

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



Direction of Force?

(Hint: RHR #2)

Force on a Current Carrying Wire

- A 2.5 Tesla B-Field goes into the board. A 1.00m wire carries a 1.5 Ampere current in that magnetic field. What is the minimum force the wire can experience? What is the maximum force the wire can experience?

$B = 2.5\ \mathrm{T}$

$I = 1.5\ \mathrm{A}$

$\ell = 1.00\ \mathrm{m}$

$\theta = ?$

$F = ?$

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

$$F = \left(2.5\ \mathrm{T}\right)\left(1.0\ \mathrm{m}\right)\left(1.5\ \mathrm{A}\right)\sin\theta$$

Force on a Current Carrying Wire

- Continued

  $B = 2.5\ \mathrm{T}$
  $I = 1.5\ \mathrm{A}$
  $\ell = 1.00\ \mathrm{m}$
  $\theta = ?$
  $F = ?$

If $\theta = 0°$

$$F = \left(2.5\ \mathrm{T}\right)\left(1.0\ \mathrm{m}\right)\left(1.5\ \mathrm{A}\right)\sin 0°$$

$$F = 0\ \mathrm{N}!$$

If $\theta = 90°$

$$F = \left(2.5\ \mathrm{T}\right)\left(1.0\ \mathrm{m}\right)\left(1.5\ \mathrm{A}\right)\sin 90°$$

$$F = 3.75\ \mathrm{N}!$$