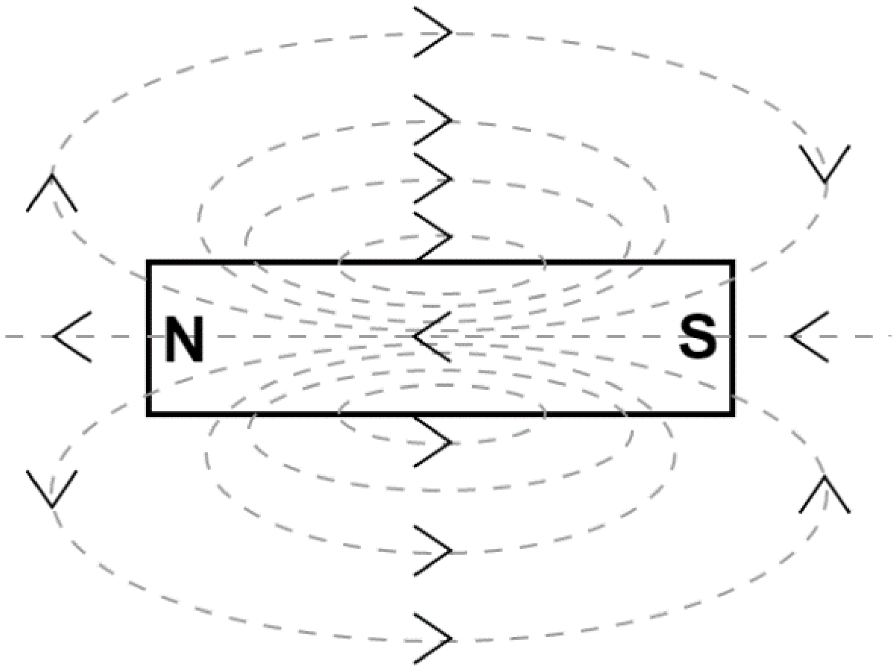
Flux Density, Field Strength & Motor Effect

YORK COLLEGE & UNIVERSITY CENTRE

Magnetic Field Lines

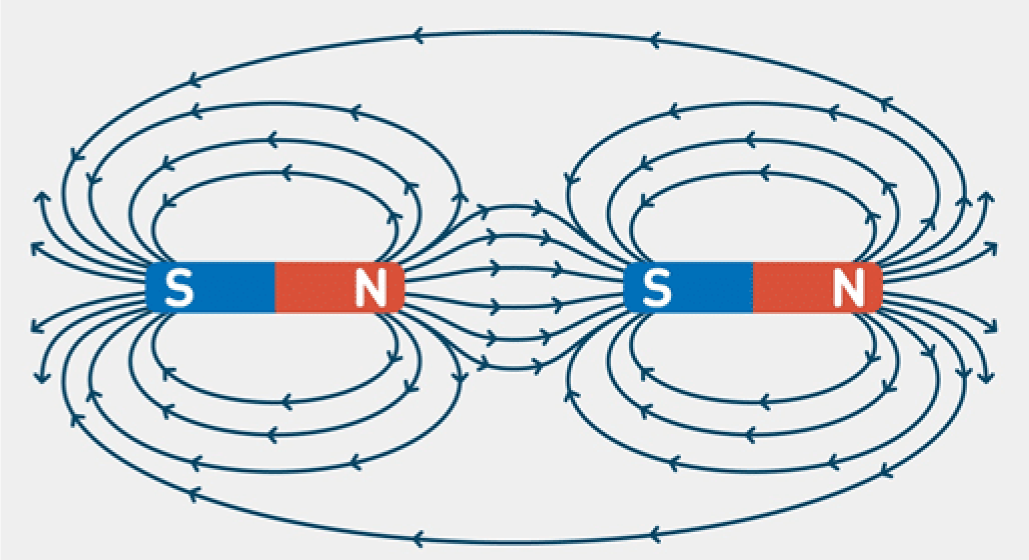
- Magnetic field lines flow from the **positively charged** (north) pole of a magnet to the **negatively charged (**south) pole of a magnet

- Magnetic field lines never cross and never break, this means they also flow through a magnet



Magnetic Field Lines

- We know magnetic field lines always flow from **north to south** (positive to negative)
- Therefore, if we lay two magnets facing the same way next to each other their **field lines join**
- This is why two magnets will move **attract each other** when put in this configuration

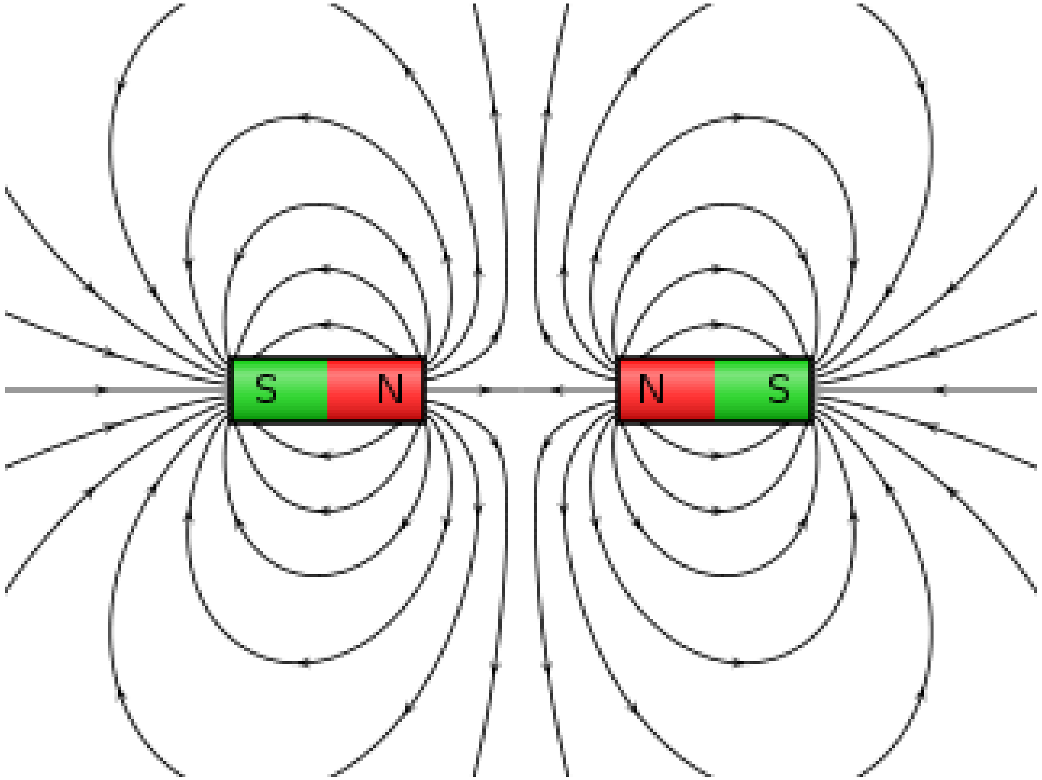


Magnetic Field Lines

- Field lines can't flow between two similarly charged areas (north and north)

- Therefore, if we lay two magnets facing each other their field lines are **squished** due to **repulsion**

- The closer together the magnets get to each other the denser the field lines and thus the **field density increases**

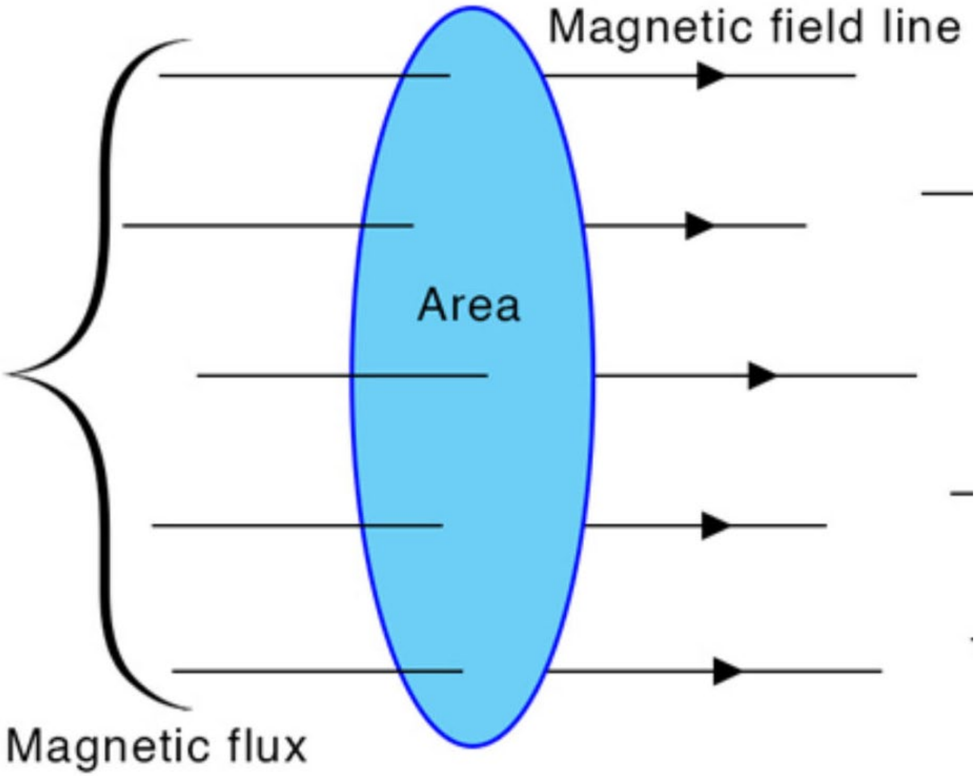


Magnetic Flux

- If we have a given area (say a circle) we can work out how much magnetism is going through it

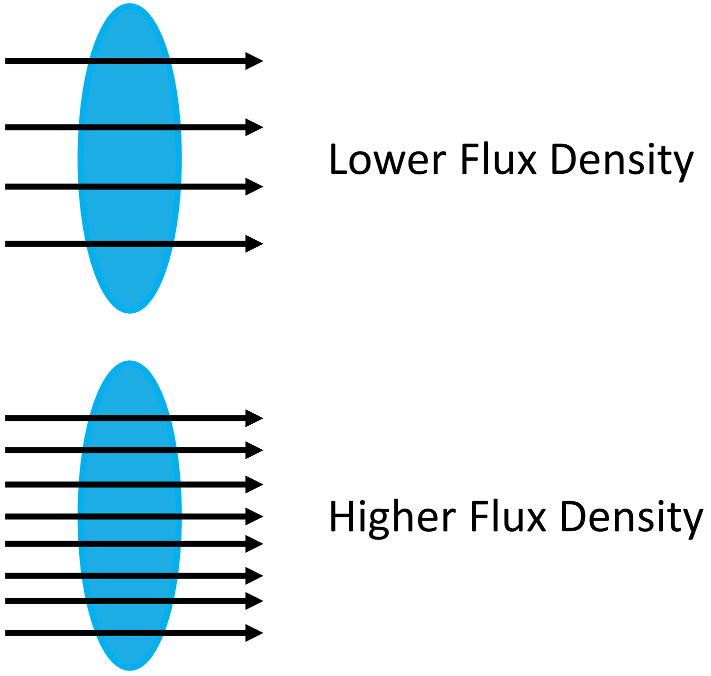
- The amount of magnetism going through this area is referred to as "flux" which has the symbol Phi "Φ"

- This flux has the unit "wb"



Flux Density

- Flux density is how compact all the field lines are in an area
- Flux density has the symbol B
- It also has the unit T (Tesla)

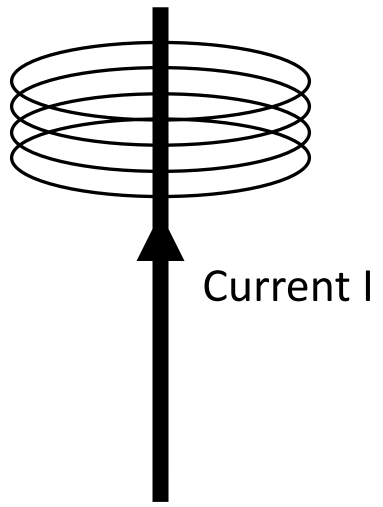


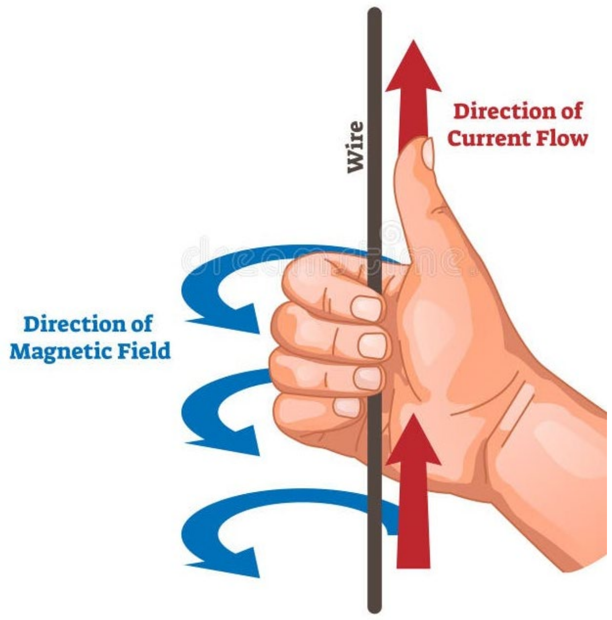
Relationship Between Flux and Flux Density

- The relationship between flux and flux density is: $B = \frac{\Phi}{A}$
- This can be rearranged to an equation which is found everywhere: $\Phi = BA$
- The units are (Wbm^{-2})

How does this link to electricity?

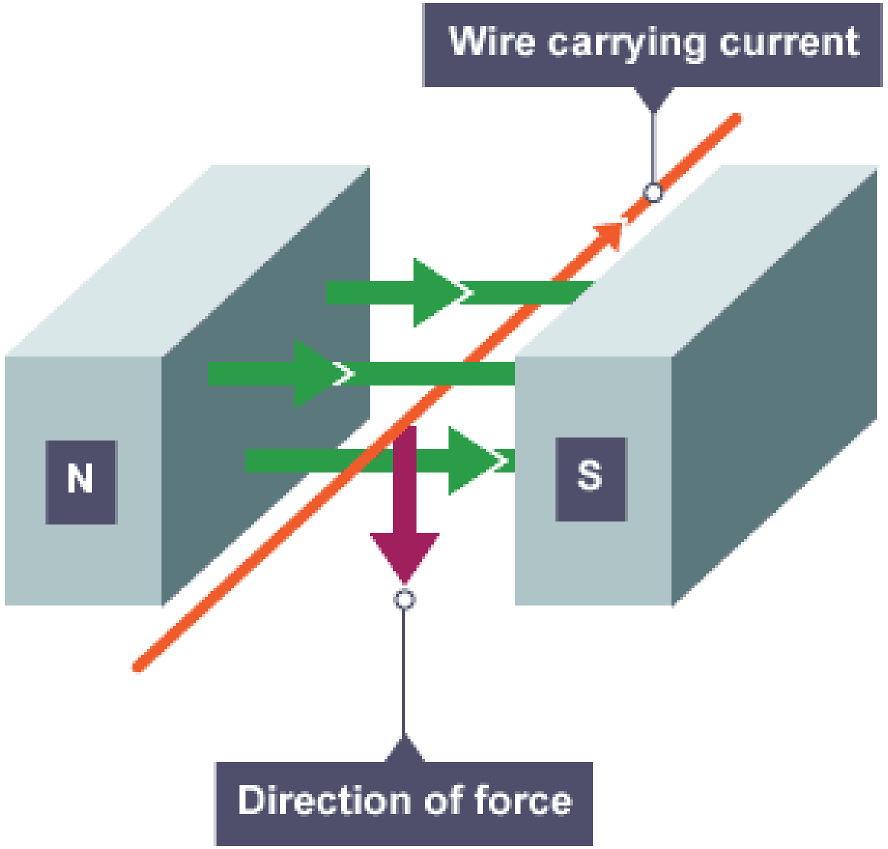
- Electricity and Magnetism are very closely linked
- When a current is flowing through a wire it creates a magnetic field
- We can tell which way this field flows using the right-hand curl rule





Motor Effect

- If we put a wire with current flowing through it between two magnets the fields that are generated interact
- This moves the wire and the magnets but usually the magnets are stuck in place
- This effect is the motor effect, whenever you see “motor” it means something is going to move



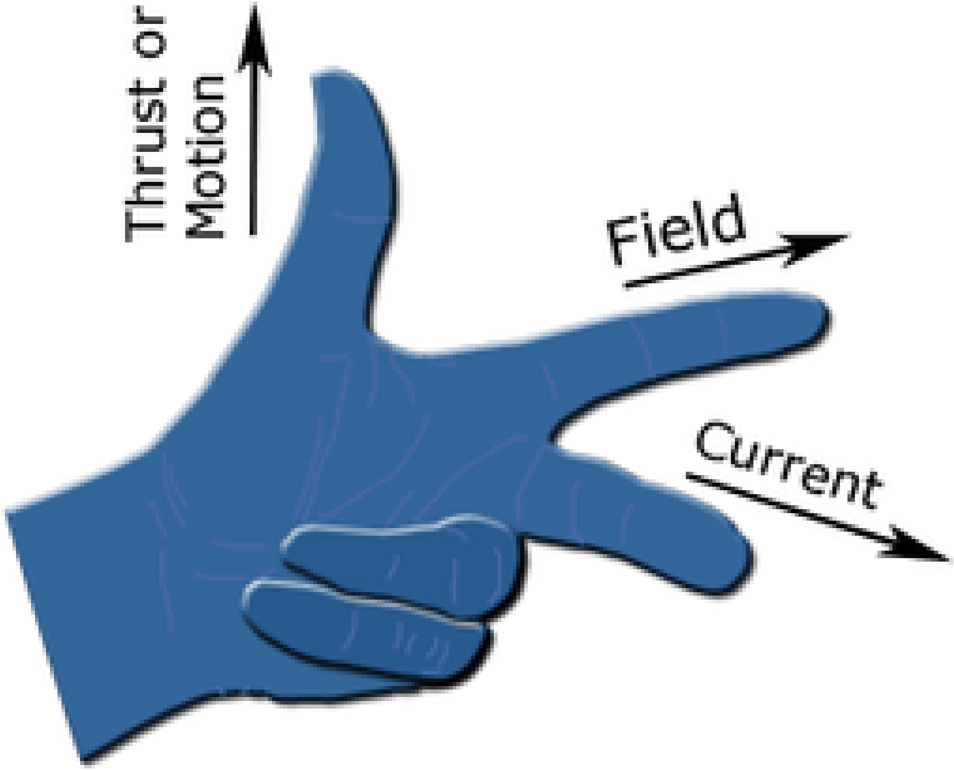
Motor Effect

- We can tell which way the wire will move based on Fleming's left-hand rule

- We know to use the left-hand rule because (Motor cars drive on the left)

- We can remember what finger does what based on this:

  - **Th**rust = **Th**umb
  - **Fi**rst finger = **Fi**eld
  - Se**c**ond finger = **C**urrent



Magnitude of the motor effect

- The magnitude of the force is measured in newtons

- The equation for the magnitude is

  - Force = Magnetic flux density * Current * Length of the wire
  - F = BIL
  - The units are ($NA^{-1}m^{-1}$)

- This equation is only true if the current and the flux density are at right angles to each other

What if they’re not entirely perpendicular

- If the current and flux density aren’t entirely at a right angle only a component of the force gets generated
- This component can be calculated by multiplying BIL by sinΘ
- Θ is the angle that the wire makes with the field
- At a right angle we have sin(90) which is 1 so it doesn’t do anything

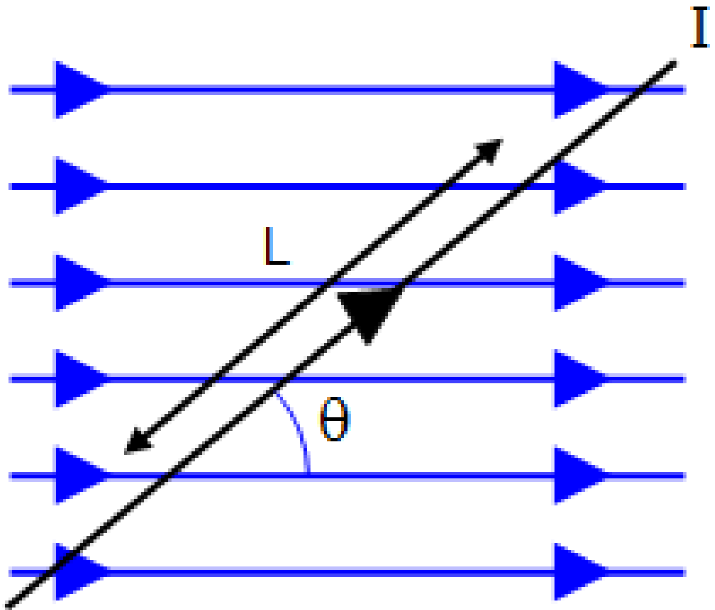
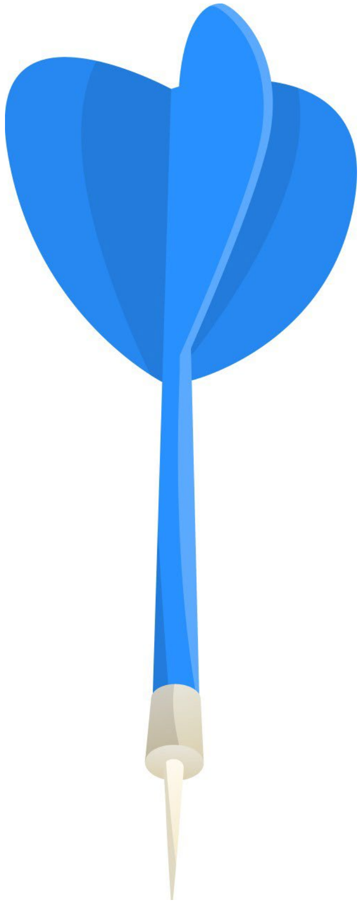


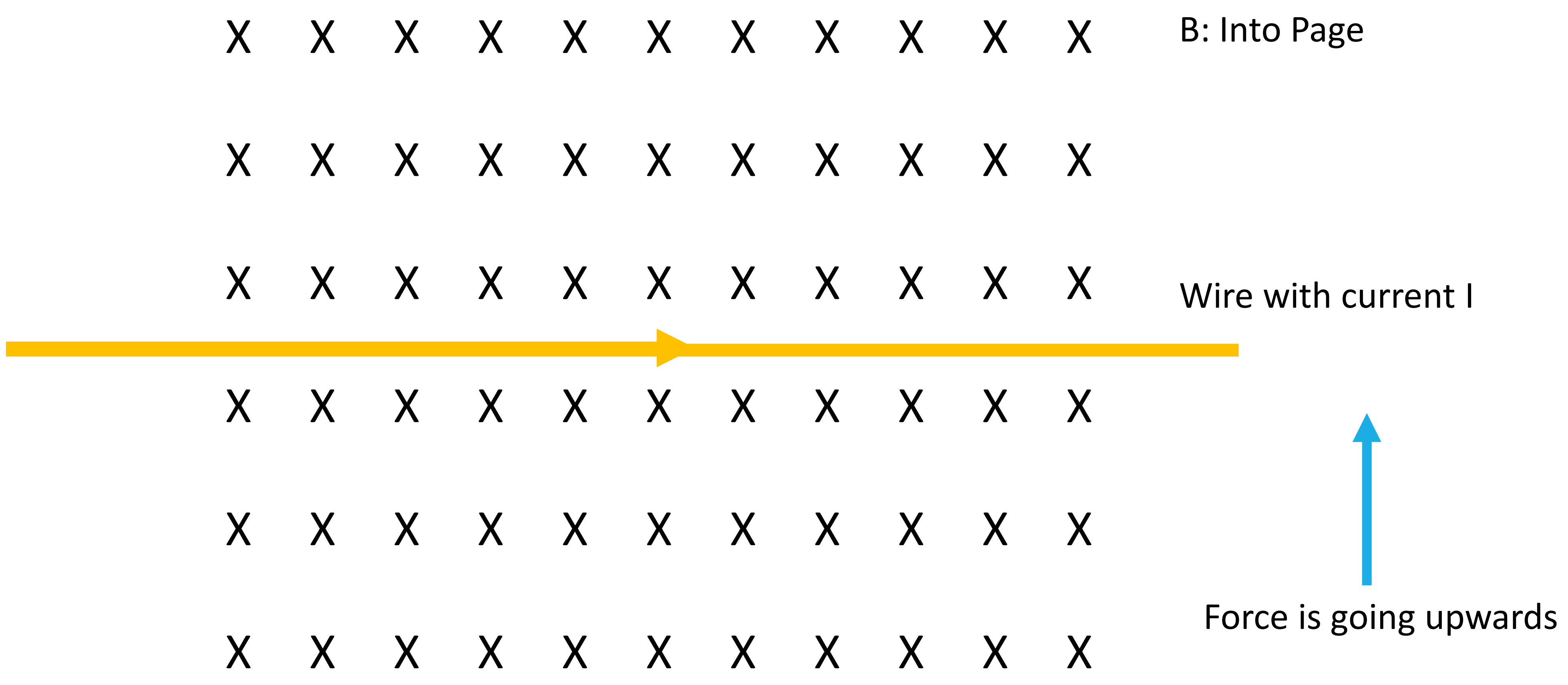
Figure 4

Drawing a 3D system in 2D

- If we need to draw the 3D representation of the system think DARTS
- If the dart is coming for you all you see is a **dot**, if the dart is flying away from you all you see is a **cross**
- A **dot** represents a field coming **out** of the page/plane
- A **cross** represents a field going **into** the page/plane
- Mostly the dot and cross method will be used to display the magnetic field



An example diagram



Definitions

- **Flux Density** (B): A measure of how much magnetic flux passes through a unit area (Tesla, T).
- **Field Strength** (H): The intensity of the magnetic field that produces a magnetic force (A/m).