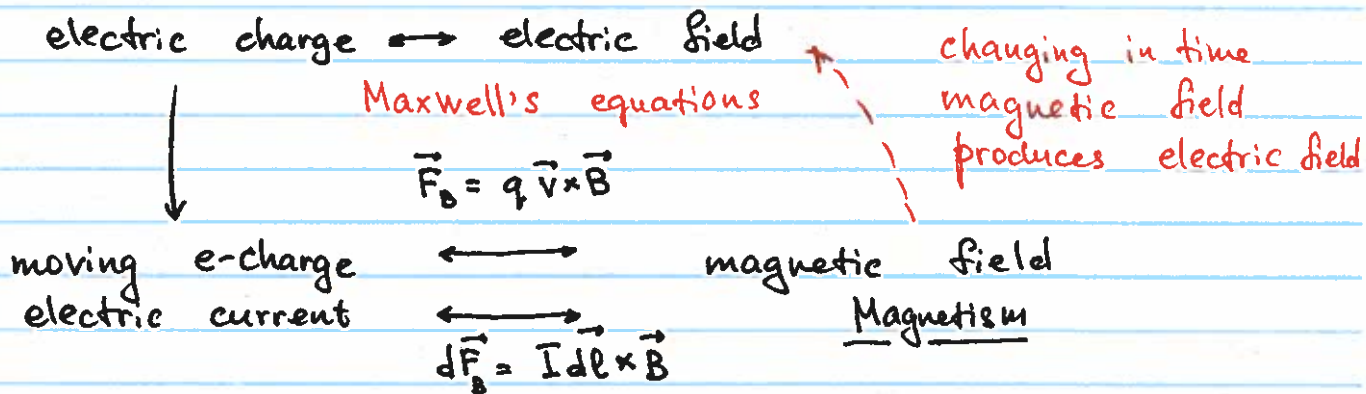


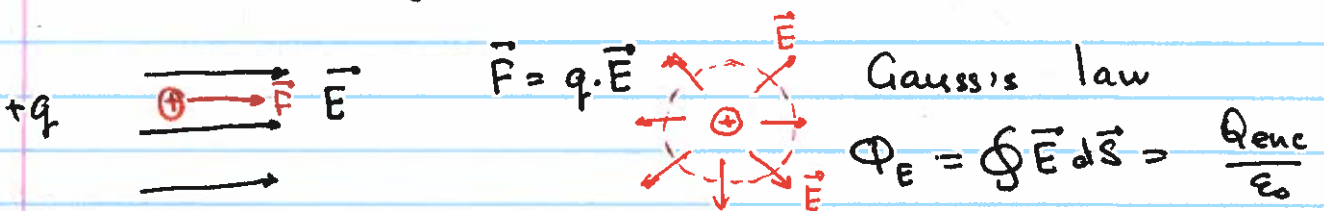
# Complicated relations b/w electric and magnetic fields

## Electricity



Reality: electro-magnetic interaction

Electric charges exist (positive, negative)



Magnetic charges do not exist!

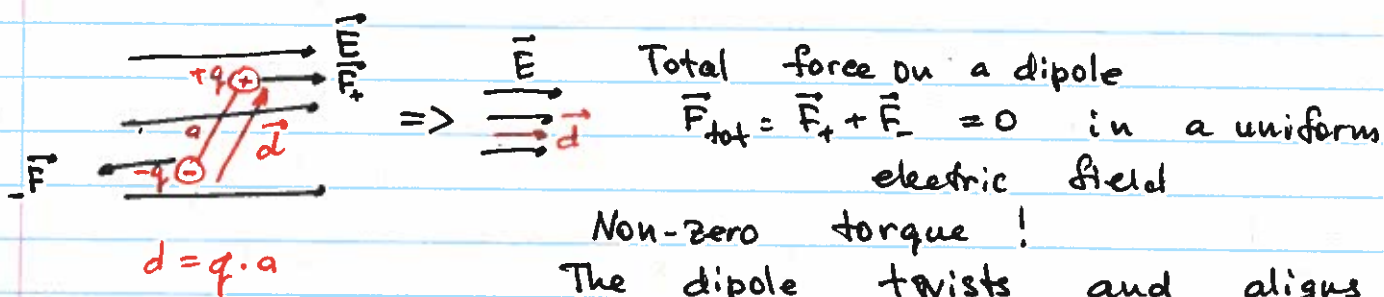
Gauss's law for magnetic field

$$\Phi_B = \oint \vec{B} \cdot d\vec{S} = 0$$

All magnetic field lines are closed on themselves

Rather than charges, we have magnetic dipoles, and these behave in magnetic field similar to how electric dipole behave in electric field.

## Quick detour in electric dipoles



(Note: if  $\vec{E}$  is not uniform, there may be some net electric force proportional to the field gradient)

Many atoms and molecules have internal magnetic moment (due to moving electrons and due to quantum nature of particles)

$\vec{\mu}$  - magnetic moment



Permanent magnets  $\rightarrow$  materials in which individual magnetic moments of ~~many~~ atoms are all aligned, so we have macroscopic magnetic dipole.

