University Physics with Modern Physics Electromagnetism Notes

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21   Electric Charge and Electric Field

21.1   Electric Charge

- Electrons have a much smaller mass than neutrons and protons

- Neutrons and protons have a very similar mass

- Electrons and protons have the same magnitude of charge

- The number of protons in an atom determins its **atomic number**

- If an electron is added to a neutral atom it becomes a **negative ion**, if one is removed it becomes a **positive ion** — this is called **ionisation**

- The **principle of conservation of charge** states that the algebraic sum of all the electric charges in any closed system is constant

- The electron or proton's magnitude of charge is a natural unit of charge — every observable amount of electric charge is an integer multiple of this

21.2   Conductors, Insulators, and Incuded Charges

- **Conductors** pemit easy movement of charge, **insulators** do not

- Holding a charged object near an uncharged object causes free electrons in the latter to move away/towards the former, resulting in a net charge on either side — this is called **induced charge**

21.3 Coulomb's Law

- The SI unit of charge is called one **coulomb** (1 C) and is defined such that $1.602176634 \times 10^{-19}$ C is equal to the charge of an electron or proton

- **Coulomb's law** describes the electric force between two point charges

$$F = \frac{1}{4\pi\epsilon_0} \frac{|q_1 q_2|}{r^2}$$

where the **electric constant** $\epsilon_0 = 8.854 \times 10^{-12}$ C^2/N$\cdot$m^2, q_1 and q_2 are the magnitudes of the charges, and r is the distance between them

- The electric force is always directed along the line between the two charges, attracting opposite charges and repelling like charges

- $\frac{1}{4\pi\epsilon_0}$ can be approximated as 9.0×10^9 N$\cdot$m^2/C^2

- The principle of superposition of forces also applies to electric charges