Chapter 21-25: Summary

Coulomb’s Law

The magnitude of the electrical force between two charged particles is proportional to the product of their charges and inversely proportional to the square of their separation distance

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

Electric Field

- The magnitude of the electric field E set up by a point charge q at a distance r from the charge is

$$E = \frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}$$

- **Continuous Charge Distribution:** for a small element dq of a uniformly charged object:

$$dE = \frac{1}{4\pi\varepsilon_0}\frac{dq}{r^2}$$

- Force on a Point Charge in an Electric Field: When a point charge *q* is placed in an external electric field ***E***

$$\vec{F} = q\vec{E}$$

Gauss’ Law

$$\varepsilon_0\Phi = q_{enc} \quad \text{and} \quad \Phi = \oint \vec{E}\cdot d\vec{A}$$

Electric Potential

- The electric potential V at point P in the electric field of a charged object:

$$V = \frac{U}{q}$$

- If the particle moves through potential ΔV:

$$\Delta U = q\Delta V = q(V_f - V_i)$$

- **Finding V from E (and E from V):** The electric potential difference between two point i and f is

$$V_f - V_i = -\int_i^f \vec{E}\cdot d\vec{s} \quad \text{and} \quad E_s = -\frac{\partial V}{\partial s}$$

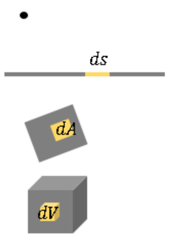
- **Continuous Charge Distribution:** for a small element dq of a uniformly charged object:

$$V = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r}$$

Uniform charge distribution

Some Measures of Electric Charge

Name	Symbol	SI Unit
Charge	q	C
Linear charge density	λ	C/m
Surface charge density	σ	C/m^2
Volume charge density	ρ	C/m^3



$\lambda = \frac{dq}{ds}$

$\sigma = \frac{dq}{dA}$

$\rho = \frac{dq}{dV}$

25. Capacitance

- The capacitance of a capacitor is defined as:

$$q = CV$$

- Use Gauss' law ($\varepsilon_0 \Phi = q_{enc}$; $\Phi = \oint \vec{E}.d\vec{A}$) and $V = \int_{-}^{+} E.ds$ to derive the capacitance for parallel-plate, cylindrical, spherical, and isolated sphere capacitor

- Capacitor in parallel ($C_{eq} = \sum_{j=1}^{n} C_j$) and series ($\frac{1}{C_{eq}} = \sum_{j=1}^{n} \frac{1}{C_j}$)

- Electrical potential energy: $U = \frac{q^2}{2C} = \frac{1}{2}CV^2$

- Capacitance and Gauss' law with dielectric:
  If the space between the plates of a capacitor is completely filled with a dielectric material, the capacitance C is increased by a factor κ, called the dielectric constant, which is characteristic of the material.

$$\varepsilon_0 \oint \kappa\vec{E}.d\vec{A} = q_{enc} \quad \text{or} \quad \varepsilon_0 \oint \vec{E}.d\vec{A} = q_f - q_i$$