Summary of chapter 25

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1. **Capacitor and Capacitance**

- A capacitor is a device that stores charge and electrical potential energy.
- The ***capacitance*** of a capacitor is defined as $C = \frac{q}{V}$

  where q is the charge on each plate of the capacitor and V is the potential difference between the plates.
- The unit of the capacitance is Coulomb/Volt = **Farad**.

2. The capacitance can be evaluated for

- **a parallel plate capacitor** $C = \varepsilon_o \frac{A}{d}$

  where A is the area of one plate and d is the distance between the plates.
- **a cylindrical capacitor** $C = \frac{L}{2k\, Ln(\frac{b}{a})}$

  where L is the length of the cylinder, a is the radius if the inner cylinder and b is the radius of the outer cylindrical shell.

- **a spherical capacitor** $C = \frac{ab}{k\,(b-a)}$

  where a is the radius of the inner sphere and b is the radius of the outer spherical shell.

* In the case of a charged spherical conductor, the capacitance C is given by $C = \frac{R}{k} = 4\pi\varepsilon_o R$

where R is the radius of the spherical conductor.

3. **Capacitors in series and parallel**

a) For **<u>parallel</u>** combination:

- ***The potential difference across each capacitor in the parallel combination is <u>the same</u> and equal to that on the equivalent capacitor.***

- ***The charge stored in the equivalent capacitor is <u>the sum</u> of the charges stored in each individual capacitor.***

The equivalent capacitance is $\mathbf{C_p = C_1 + C_2 + C_3 \qquad _n}$

b) For **<u>series</u>** combination:

- ***The magnitude of the charge on each capacitor is <u>the same</u> and equal to that on the equivalent.***

- ***The potential difference across the equivalent capacitor in a series combination is equal to <u>the sum</u> of the potential difference across the individual capacitors.***

The equivalent capacitance is $$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots + \frac{1}{C_n}$$

4. **The energy stored by a charged capacitor**

$$U = \frac{Q^2}{2C} = \frac{1}{2}QV = \frac{1}{2}CV^2 \qquad \text{(Joule)}$$

This energy is stored in the electric field between the plates of the capacitor.

In the case of a parallel plate capacitor the energy stored is also given by

$$U = \frac{1}{2}(\ _o Ad)E^2$$

The energy density u is the energy per unit volume; that is:

$$u = \frac{U}{volume} = \frac{1}{2} e_o E^2 \quad \text{(Joule/m}^3\text{)}$$

where E is the electric field between the plates.

5. ***When a dielectric material (non-conducting, such as rubber, glass, then;***

$$V = \frac{V_o}{k}$$

The potential difference across the capacitor **decreases**. Here V is voltage with the dielectric material and V_o is voltage without dielectric material.

$$C = k\, C_o$$

The capacitance **increases**. Here C is capacitance with the dielectric material and C_o is capacitance without dielectric material.

$$U = \frac{U_o}{k}$$

The stored energy **decreases**. Here U is energy with the dielectric material and U_o is energy without the dielectric material.

$$q = q_o$$

The charge on the plates remains **the same**.

***k* is the <u>dielectric constant</u>**. See table 26.1 in the textbook for dielectric constants of different materials.