Summary of chapter 26

I. Objective:

1. Calculate the capacitance of a capacitor for simple geometries like parallel plates, cylindrical, and spherical.

2. Learn how to calculate the equivalent capacitance of a group of capacitors and calculate the charge on each capacitor and the potential difference across each capacitor when a known potential is applied.

3. Calculate the energy stored in a charged capacitor and calculate the capacitance, potential difference, and energy stored in a capacitor with dielectric.

II. Summary of major points:

1. How to calculate the capacitance of a capacitor:

The capacitance of a capacitor is defined as: $C = \frac{Q}{V}$

where C is capacitance, Q is charge and V is voltage across the capacitor.

- ***For parallel plate capacitor*** $C = e_0 \frac{A}{d}$

Where e_0 is a constant = 8.85 X 10^{-12}, A is the area of the plates and d is the distance between the plates.

- ***For cylindrical capacitor*** $C = \frac{l}{2k \ln\left(\frac{b}{a}\right)}$

Where k is a constant = 9 x 10^{9} , l is length of the cylinder , b is outer radius and a is inner radius of the cylinder.

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

Where b is the outer radius and a is the inner radius of the sphere.

The units for C is: $\left(\frac{\text{Coulomb}}{\text{Volt}}\right)$ of Farad (F).

The capacitance of an isolated spherical conductor is

$$C = 4\pi\varepsilon_o R$$

where R is the radius of the conducting sphere.

2. Capacitors in series and parallel:

a) **For parallel combination:**

- The **potential difference** across each capacitor in **the parallel** circuit is the same (**v is the same**) as the potential in the equivalent capacitor.

- The charge (total) stored by the capacitor is the sum (Q_T is **the sum** of the charge in the equivalent capacitor).

The equivalent capacitance is $C_p = C_1 + C_2 + C_3 + \ldots$

b) For **series** combination:

- **The magnitude of the charge** should be **the same** on all the plates. (Q is the same as the charge on the equivalent).
- **The potential difference** across any number of capacitors in **series** is **equal to the sum** of the potential difference across the individual capacitors.(V_T is the sum).

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

3. The energy stored by a charged capacitor:

$$U = \frac{Q^2}{2C} = \frac{1}{2}QV = \frac{1}{2}CV^2$$

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

$$U = \frac{1}{2}(\text{å}_o Ad)E^2$$

where E is the electric field between the plates.

When a dielectric material (non-conducting, like rubber, glass) is inserted between the plates of a capacitor then;

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

where V is voltage with dielectric and V_o is voltage without dielectric.

$$C = k\ C_o$$

where C is capacitance with dielectric and C_o is capacitance without dielectric

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

where U is energy with dielectric and U_o is energy without dielectric

k: dielectric constant. See table 26.1 in the textbook for dielectric constants of different materials.