Summary of chapter 24

I. Objective:

1. Calculate the **electric flux** through a surface. Find the **net** electric flux through a closed surface.

2. Use Gauss law to evaluate the electric field at points near a charge distribution, which is *spherical*, *cylindrical*, or *planar*.

3. Calculate the electric field due to a charged conductor.

II. Summary of Major Points:

The electric **flux** through a planar surface in a **uniform** electric field **E** is;

$$\Phi = EA \cos\theta \qquad (1)$$

where the angle θ is between the vector E and the vector A. The vector A is always ***normal*** to the surface in consideration.

*If the surface is not planar (general) and the electric field **E** is **not uniform** the flux will be;

$$\Phi = \int \vec{E}.d\vec{A} \qquad (2)$$

If the surface is closed, then the electric flux is given by;

$$\Phi = \oint \vec{E}.d\vec{A} \qquad (3)$$

The electric flux through a *closed surface* is also given by;

$$\Phi = \frac{q}{\varepsilon_o} \qquad (4)$$

where q is the charge enclosed by the closed surface.

Gauss law states that Φ_c, flux through a closed surface, is given by (by combining equations (3) and (4));

$$\Phi_c = \oint \vec{E}.d\vec{A} = \frac{q_{in}}{\varepsilon_o} \qquad (5)$$

where q_{in} is the charge enclosed by the Gaussian surface and ε_o is a the permitivity of free space equal to 8.85 x 10^{-12}

Examples of the use of Gauss law in calculating ***the electric field*** for highly symmetric charge distributions are given in the textbook.

- Example 24.4 for a *point charge*
- Example 24.5 for a *non-conducting solid charged sphere of radius a and charge Q.* In this case the electric field is calculated inside and outside the sphere
- Example 24.6 for a *charged spherical shell of radius a and charge Q.* In this case the electric field inside the shell is ZERO
- Example 24.7 for a *charged (one dimensional) infinite rod of linear charge density l*
- Example 24.8 for a *non-conducting charged planar infinite sheet of surface charge density s*

Note: *Problem # 35 in the textbook is an example of an infinite non-conducting* ***cylindrical*** *charge distribution of charge density r. In this case, the electric field is calculated inside and outside the cylinder.*

In all these examples, **equation (5)** is used in calculating the electric field. The idea is to choose a Gaussian surface, which has the same symmetry as the charge distribution.

A conductor in **electrostatic equilibrium** has the following properties:

- ✓ The electric field is ZERO everywhere inside the conductor
- ✓ Any excess charge on an isolated conductor resides on its surface
- ✓ The electric field just outside a charged conductor is perpendicular to the surface and has magnitude of $E = \sigma/\varepsilon_o$.

  (For a spherical shape: $E = kQ/R^2$, where R is the radius of the sphere).