rollers then melt the toner into the paper which is also given an excess positive charge to produce the permanent impression of the document.

## (ii) Inkjet Printers

An inkjet printer (Fig. 12.12 a) is a type of printer which uses electric charge in its operation. While shuttling back and forth across the paper, the inkjet printer "ejects" a thin stream of ink. The ink is forced out of a small nozzle and breaks up into extremely small droplets. During their flight, the droplets pass through two electrical components, a "charging electrode" and the "deflection plates" (a parallel plate capacitor). When the printhead moves over regions of the paper which are not to be inked, the charging electrode is left on and gives the ink droplets a net charge. The deflection plates divert such charged drops into a gutter and in this way such drops are not able to reach the paper. Whenever ink is to be placed on the paper, the charging control, responding to computer, turns off the charging electrode. The uncharged droplets fly straight through the deflection plates and strike the paper. Schematic diagram of such a printer is shown by Fig. 12.12 (b).

![FIGURE: 12.12(a)](Fig. 12.12(a) An inkjet printer.)

![FIGURE: 12.12(b)](Fig. 12.12(b) An inkjet printhead ejects a steady flow of ink droplets. The charging electrodes are used to charge the droplets that are not needed on the paper. Charged droplets are deflected into a gutter by the deflection plates, while uncharged droplets fly straight onto the paper.)

Inkjet printers can also produce coloured copies.

## 12.5 ELECTRIC FLUX

When we place an element of area in an electric field, some of the lines of force pass through it (Fig. 12.13 a).

The number of the field lines passing through a certain element of area is known as electric flux through that area. It is usually denoted by Greek letter Φ. For example the flux Φ through the area A in Fig. 12.13 (a) is 4 while the flux through B is 2.

In order to give a quantitative meaning to flux, the field lines are drawn such that the number of field lines passing through

![FIGURE: 12.13(a)](Fig. 12.13(a) Electric flux through a surface normal to E.)
a unit area held perpendicular to field lines at a point represent the intensity E of the field at that point. Suppose at a given point the value of E is 4NC(^{-1}). This means that if 1m(^{2}) area is held perpendicular to field lines at this point, 4 field lines will pass through it. In order to establish relation between electric flux (\Phi), electric intensity E and area A we consider the Fig.12.13 (b,c,d) which shows the three dimensional representation of the electric field lines due to a uniform electric field of intensity E.

In Fig.12.13 (b), area is held perpendicular to the field lines, then EA, lines pass through it. The flux (\Phi) in this case is

where (A\_{E}) denotes that the area is held perpendicular to field lines. In Fig.12.13 (c), area A is held parallel to field lines and, as is obvious no lines cross this area, so that flux (\Phi) in this case is

where (A\_{E}) indicates that A is held parallel to the field lines. Fig.12.13 (d) shows the case when A is neither perpendicular nor parallel to field lines but is inclined at angle (\theta) with the lines. In this case we have to find the projection of the area which is perpendicular to the field lines. The area of this projection; (Fig. 12.13 d) is (A \cos \theta). The flux (\Phi) in this case is

Usually the element of area is represented by a vector area A whose magnitude is equal to the surface area A of the element and whose direction is direction of normal to the area. The electric flux (\Phi), through a patch of flat surface in terms of E and A is then given by

where (\theta) is the angle between the field lines and the normal to the area.

Electric flux, being a scalar product, is a scalar quantity. Its SI unit is Nm(^2)C(^{-1}).

## 12.6 ELECTRIC FLUX THROUGH A SURFACE ENCLOSING A CHARGE

Let us calculate the electric flux through a closed surface, in shape of a sphere of radius r due to a point charge (q)

[FIGURE: 12.13 (b) Maximum]

[FIGURE: 12.13 (c) Minimum]

[FIGURE: 12.13 (d)]
placed at the centre of sphere as shown in Fig. 12.14. To apply the formula for the computation of electric flux, the surface area should be flat. For this reason the total surface area of the sphere is divided into n small patches with areas of magnitudes . If n is very large, each patch would be a flat element of area. The corresponding vector areas are respectively. The direction of each vector area is along perpendicular drawn outward to the corresponding patch. The electric intensities at the centres of vector areas are respectively.

According to Eq. 12.12, the total flux passing through the closed surface is

The direction of electric intensity and vector area is same at each patch. Moreover, because of spherical symmetry, at the surface of sphere,

Now imagine that a closed surface S is enclosing this sphere. It can be seen in Fig. 12.15 that the flux through the closed surface S is the same as that through the sphere. So we can conclude that total flux through a closed surface does not depend upon the shape or geometry of the closed surface. It depends upon the medium and the charge enclosed.

## 12.7 GAUSS'S LAW

Suppose point charges are arbitrarily distributed in an arbitrary shaped closed surface as shown in Fig. 12.16. Using idea given in previous section, the electric flux passing through the closed surface is

[FIGURE: 12.14]

[FIGURE: 12.15]

[FIGURE: 12.16]