

7.9 Mutual Induction : Mutual Inductance ✓

Consider a closed circuit C_2 placed in the magnetic field of closed circuit C_1 (fig. 7.28). The flux linked with C_2 depends upon its position and the current flowing in the coil C_1 . If the relative position of C_2 with respect to C_1 is fixed, the flux linked with C_2 is constant for a constant current in C_1 . As the magnetic field at any point produced due to the current flowing in C_1 is directly proportional to the current flowing in circuit C_1 ; hence the flux linked with the circuit C_2 will depend upon the current flowing in circuit C_1 . In general *whenever the current flowing through a circuit (C_1) changes, the magnetic flux linked with the neighbouring circuit (C_2) also changes. Hence an induced e.m.f. is set up in the neighbouring circuit. This phenomenon is called **mutual induction**. The circuit in which the current changes is called the primary circuit, while the neighbouring circuit in which e.m.f. is induced is called the secondary circuit.*

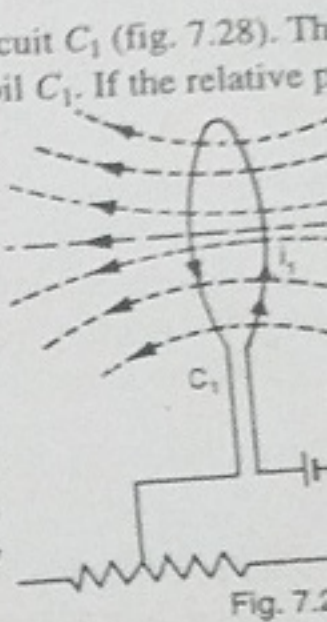


Fig. 7.28

Thus if i_1 is the current flowing in the circuit C_1 and $B_1(x, y, z)$ is the magnetic field at any point (x, y, z) in the space surrounding the circuit C_1 due to this current, the magnetic flux ϕ_2 linked with the coil C_2 due to this magnetic field is given by

$$\phi_2 = \iint_{S_2} B_1 \cdot \delta A_2$$

where S_2 represents the effective surface area enclosed by the coil C_2

If the shapes, orientations and the positions of the two circuits C_1 and C_2 are fixed, the flux ϕ_2 linked with circuit C_2 is proportional to the current i_1 flowing in circuit C_1 i.e.

$$\phi_2 \propto i_1$$

$$\phi_2 = M_{21} i_1$$

where M_{21} is constant of proportionality and is termed as mutual inductance (or coefficient of induction) of circuit C_2 with respect to circuit C_1 .

If the current flowing in the coil C_2 changes with time, then the flux linked with C_2 changes and so an e.m.f. e_2 is induced in the circuit C_2 which is given by

$$e_2 = - \frac{d\phi_2}{dt} = - \frac{d}{dt} (M_{21} i_1) \quad \text{using (1)}$$

i.e.
$$e_2 = - M_{21} \frac{di_1}{dt}$$

Now suppose that the current i_2 is flowing in the coil C_2 . If ϕ_1 is the flux linked with the circuit C_1 due to this current, then

$$\phi_1 \propto i_2$$

$$\phi_1 = M_{12} i_2$$

where M_{12} is the mutual inductance of circuit C_1 with respect to circuit C_2 .