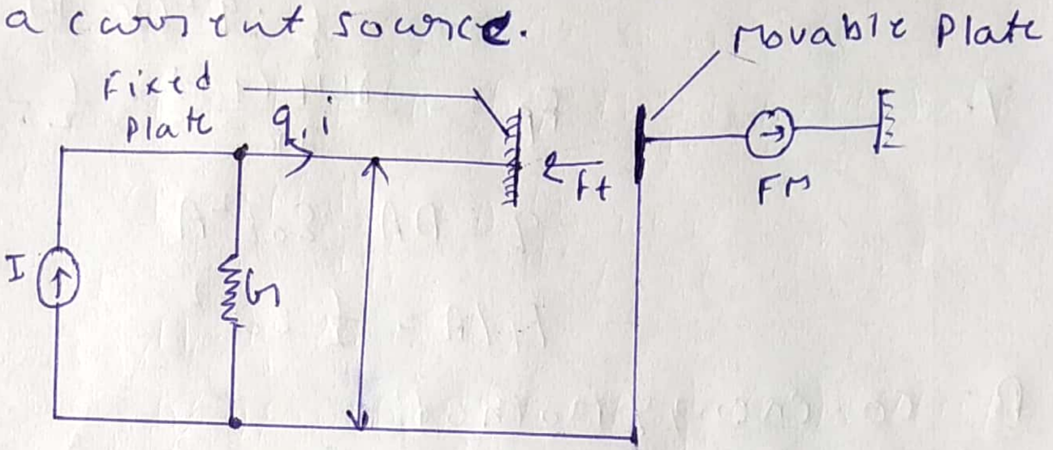
Q.2

Ans A) Energy Method:-

1. Show a Parallel Plate condenser with a fixed and a movable plate. The condenser is fed from a current source.



2. Let us assume that the movable plate of the condenser is held fixed in position x.

3. The electrical energy input to the condenser gets stored in the electric field so that.

$$dw_e = v\,dq = dw_f$$

The total field energy is

$$w_f = \int_0^q v\,dq$$

4. In a condenser v and q are linearly related is

$C = q/v$ = capacitance of the device.

$$w_f = \frac{1}{2}\frac{q^2}{c}$$

5. Thus capacitance C is a function of x (is the position of movable plate) and can be expressed as.

$$C(x) = \frac{\varepsilon_0 A}{(x_0 - x)}$$

A = Plate area

ε_0 = Permittivity of free space.

6. Thus Wf, the field energy is a function to two independant variables q and x i.e.

$$W_f(q,x) = \frac{1}{2}\frac{q^2}{C(x)}$$

$$= \frac{1}{2} \cdot q^2 (x_0 - x)$$

7. $$F_f = -\frac{\partial W_f(q,x)}{\partial x} = \frac{1}{2}\frac{q^2}{A\varepsilon_0}$$

$$q = DA = \varepsilon_0 E^2 A$$

$$F_f / A = \frac{1}{2}\varepsilon_0 E^2$$

B. Co-energy method:-

1. The field co-energy is

$$W'_f(v,x) = \frac{1}{2}Cv^2 = \frac{1}{2}v^2\frac{A\varepsilon_0}{(x_0 - x)}$$

2. Now,
$$F_r = \frac{\partial W_f'(v,x)}{\partial x} = \frac{1}{2}v^2\frac{A\varepsilon_0}{(x_0 - x)^2}$$

$$v = \frac{1}{2}\varepsilon_0 E^2 A$$

$$F_r / A = \frac{1}{2}\varepsilon_0 E^2$$

C. Numerical:-

Given = $E = 3\times10^6$ V/m

To find = F_f / A.

$$f_e / A = \frac{1}{2}\frac{B^2}{\mu} = \frac{1}{2}\times\frac{(1.6)^2}{4\pi\times10^{-7}}$$

~~= 1.02~~

$= 1.02 \times 10^6$ N/m² Ans