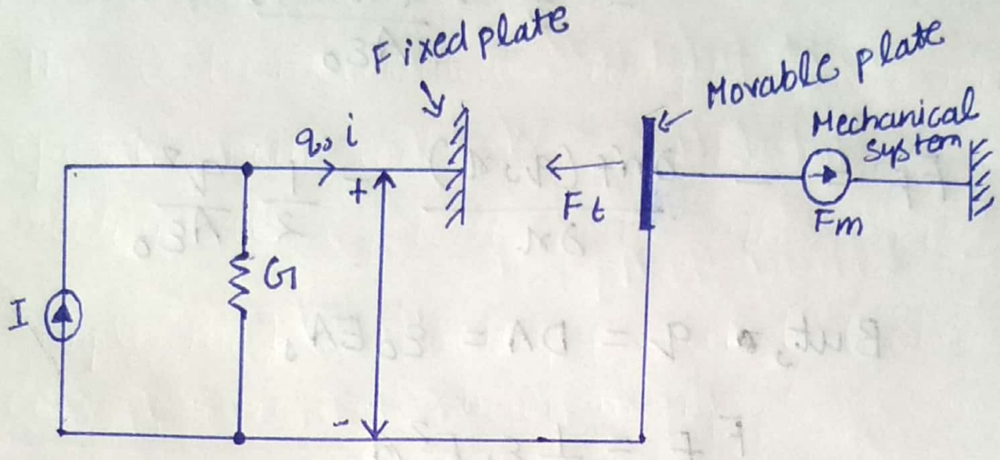
Q.2

Ans:- Energy Method:-

1. Shows 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 electric energy input to the Condenser gets stored in the electric field so that

$$\boxed{dW_e = v\,dq = dW_f} \quad -\text{eq}^n \text{ (1)}$$

the total Field energy is

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

4. In a Condenser v and q are linearly related as

$$C = q/V$$

$$W_f = \frac{1}{2}\frac{q^2}{C} \quad - \text{eq}^n \text{ (2)}$$

5. The Capacitance C is a function of x and can be expressed as $C(x) = \frac{\varepsilon_0 A}{(x_0 - x)}$

A = plate area

ε_0 = permittivity of free space.

⑥ W_f, the field energy is a function of two independent variables q and x, i.e.

$$W_f(q,x) = \frac{1}{2}\frac{q^2}{C(x)} \quad \text{— eq}^n \text{ ③}$$

$$= \frac{1}{2}\frac{q^2(x_0-x)}{A\varepsilon_0}$$

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

But, $q = DA = \varepsilon_0 EA$,

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

$$F_f/A = \frac{1}{2}\varepsilon_0 E^2 \quad \text{— eq}^n \text{ — ④}$$

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

But $V = E(x_0-x)$

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

$$F_f/A = \frac{1}{2}\varepsilon_0 E^2 \quad \text{— eq}^n \text{ ⑤}$$

C. Numerical :-

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

$$F_f/A = 1/2\,\varepsilon_0 E^2 = \frac{1}{2}\times(3\times10^6)^2\times 8.85\times10^{-12}$$

$$= 39.8 \text{ N/m}^2$$ Ans.