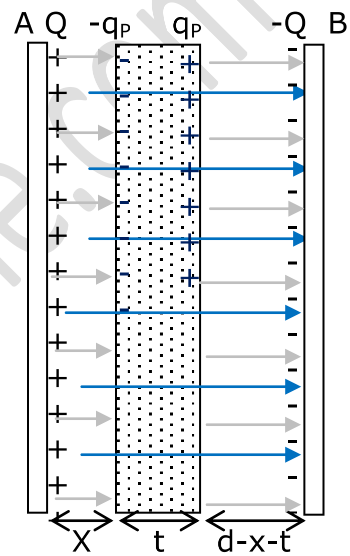
Q- Two parallel conducting pladtes are separated by the distance d, and the potential difference between the plates is maintained at the value V. A slab of dielectric with constant K and a uniform thickness t < d is insertd between the plates and parallel to them. Find the electric field $\vec{E}$ and displacement $\vec{D}$ both in the dielectric and the air inbetween. Neglect edge effects.

Let the distance of the dielectric slab from plate A be x as the thickness of the slab is t, the distance of plate B from the other surface of the slab will be (d–x-t).

Let the magnitude of field strength between the plate A and the slab is E.



As the potential difference between two points seperated by a distance *l* in a unifom field of strength E is given by $V = -\vec{E}\cdot\vec{l}$, the potential difference V_1 between plate A and the slab will be given by

V_1 = E*x ---------------------- (1)

Now due to the negative polarization charges the field strength in the slab will be reduced and is magnitude is given by

Es = E/k

As this field will continue till thickness t the potential difference between the two surfaces of the slab is given by

V_2 = Es*t = (E/k)*t ---------------------- (2)

As because of the positive polrization charges on the second surface on the slab the field between the second surface of the slab and plate B becoms E again, the potential difference between them will be given by

V_3 = E*(d-x-t) ---------------------- (3)

The total potential difference between the two plates is thus given by

$$V = V_1 + V_2 + V_3$$

Substituting the values from equations (1), (2) and (3) we get

$$V = E*x + \frac{E}{k}*t + E(d-x-t)$$

or $$V = \frac{E}{k}*t + E(d-t)$$

gives $$E = \frac{V}{(d-t)+\frac{t}{k}}$$

Or $$E = \frac{V.k}{(d-t).k+t}$$

The direction of this field will be from higher potential plate to the lower potential plate hence if the potential is decreasing along the positive x direction we can write

$$\vec{E} = \frac{V.k}{(d-t).k+t}(\hat{\imath}) \quad \text{---------------------- (4)}$$

The displacement vector D is given by the relation **D** = k***E** hence

(A) In the air the dielectric constant is 1 and thus both E vector and D vector are same and given by

$$\vec{E}_v = \vec{D}_v = \frac{V.k}{(d-t).k+t}(\hat{\imath})$$

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(B) In the dielectric the electric field is reduced to Ev/k due to the polarization charges and hence given by

$$\vec{E} = \frac{\vec{E}_v}{k} = \frac{V}{(d-t).k+t}(\hat{\imath})$$

And the displacement vector is given by

$$\vec{D} = k\vec{E} = k\frac{\vec{E}_v}{k} = \vec{E}_v = \frac{V.k}{(d-t).k+t}(\hat{\imath})$$

Hence from vacuum to the dielectric the electric field vector is not continuous but the displacement vector is continuous.

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