15/30

**OPEN BOOK**

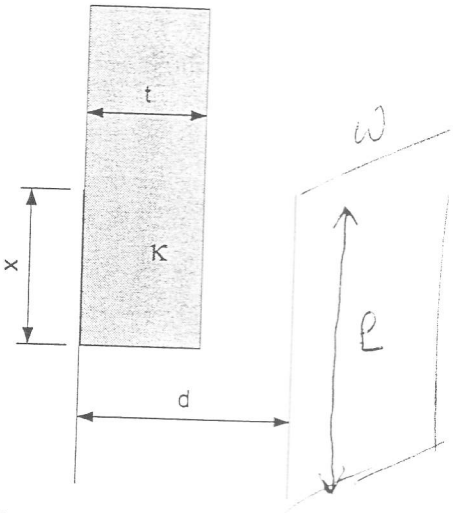
**Notre Dame University-Louaize**
**Faculty of Natural & Applied Sciences**
**Department of Sciences**

**PHS 213 – Modern Physics**
**Exam II - Fall 2007**
**Duration: 30 minutes (1/2h)**

**Name:** **ID:**

A parallel-plate capacitor of plate area A and plate separation d is given a charge Q and then disconnected from the battery. A dielectric slab of the same area but of thickness t<d is inserted between the plates.

a) Calculate the force, both magnitude and direction, acting on the slab as it is being inserted.
b) Find the capacitance when the slab is inserted completely.
c) Specify the surface charge densities on the surfaces of the plates and the dielectric slab.




a) $F = -\frac{dU}{dx} = -\frac{dU}{dC}\cdot\frac{dC}{dx}$ (1)

The Area A of the capacitor : $A = \ell w x$

The Area A of the dielectric : $A_d = \ell w x$

The Air fill an area $A_{air}$ : $A_{air} = \ell w (\ell - x)$

$$C_{air} = \frac{\varepsilon_0 A_{air}}{d} = \frac{\varepsilon_0 \ell w (\ell - x)}{t}$$

$$C_{diel} = k\frac{\varepsilon_0 A_{diel}}{d} = \frac{k\varepsilon_0 \ell w x}{t}$$ (1)

Since these capacitors are in parallel,

$$C = C_{air} + C_{diel} = \frac{\varepsilon_0 \ell w}{t}[(\ell - x) + kx]$$

$$\frac{dC}{dx} = (k-1)\frac{\varepsilon_0 \ell w}{t}$$

$$\frac{dU}{dC} = -\frac{1}{2}\frac{Q^2}{C^2}$$ (2)

$$F_x = \frac{Q^2}{2C^2}(k-1)\frac{\varepsilon_0 \ell w}{t}$$