

SECOND MIDTERM

3

Name: _____

Discussion Instructor (circle): Gillman Rodriguez Shepherd Webb

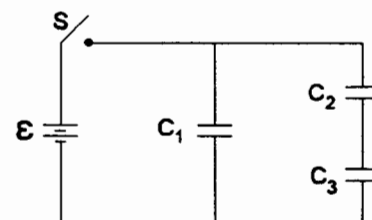
Student ID #: _____

SHOW ALL WORK!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

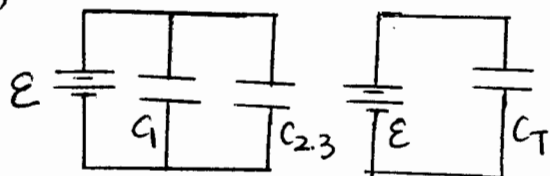
In the diagram shown the switch is closed for a long time and then opened. Now a dielectric of $\kappa = 3.25$ is inserted into C_3 . Capacitors values are given without dielectric.

- Find the new voltage across C_1 .
- Find the new voltage across C_2 .
- Find the charge that flows and the direction it flows when the dielectric is inserted.

$\epsilon = 15.0 \text{ V}; C_1 = 155 \text{ pF}; C_2 = 125 \text{ pF}; C_3 = 250 \text{ pF}$



(a.)



When S was closed, the effective capacitor or the total capacitor is given by:

$$C_T = C_1 + C_{23}$$

$$\text{with } C_{23} = \frac{1}{\frac{1}{C_2} + \frac{1}{C_3}}$$

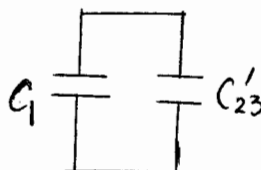
$$\text{So } C_T = 155 + \frac{1}{\frac{1}{125} + \frac{1}{250}} = 238.3 \text{ pF.}$$

$$\therefore C = \frac{Q}{V}$$

$$\therefore Q_T = C_T \epsilon = 3575 \text{ pC.}$$

Total charges will be conserved after the switch is opened.

$$\text{So } Q_T' = Q_T$$



After S is opened and a dielectric is inserted into C_3 :

$$C_3' = \kappa C_3$$

$$C_{23}' = \frac{1}{\frac{1}{C_2} + \frac{1}{C_3'}}$$

$$C_T' = C_1 + C_{23}' = C_1 + \frac{1}{\frac{1}{C_2} + \frac{1}{C_3'}} = C_1 + \frac{1}{\frac{1}{C_2} + \frac{1}{\kappa C_3}}$$

$$= 155 + \frac{1}{\frac{1}{125} + \frac{1}{3.25 \times 250}} = 263.3 \text{ pF.}$$

$$\therefore V_T' = \frac{Q_T'}{C_T'} = \frac{Q_T}{C_T'} = \frac{3575}{263.3} = 13.6 \text{ V.}$$

$V_1 = V_T' = 13.6 \text{ V.}$

(b.) The charge on C_1 when S is open is:

$$Q_1' = C_1 V_1' = 155 \times 13.6 = 2104 \text{ pC.}$$

\therefore the charge on C_2 is:

$$Q_2' = Q_T - Q_1' = 1471 \text{ pC.}$$

$$\therefore V_2' = \frac{Q_2'}{C_2} = \frac{1471}{125} = 11.8 \text{ V.}$$

(c.) The charge getting away from C_1 is:

$$\Delta Q = Q_1 - Q_1' = 2325 - 2104 = 221 \text{ pF. with } Q_1 = C_1 V_1 = C_1 E = 2325 \text{ pF.}$$

The direction is from C_1 to C_2 and C_3 .