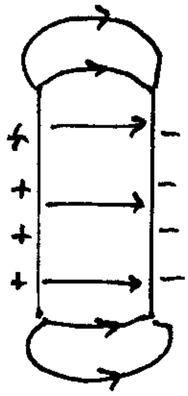
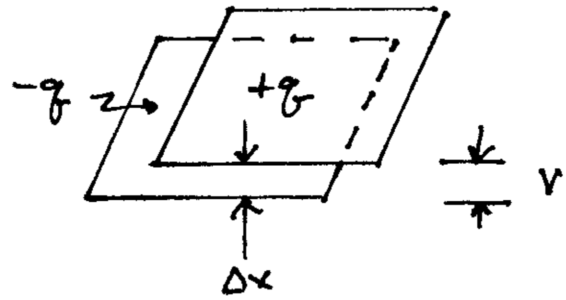
CAPACITANCE

USES
1. STORE ENERGY
2. MICROSCOPIC MEMORY BANKS
3. ELEMENTS OF CIRCUITS





$$C = \frac{q}{V} \quad [\text{COUL/VOLT}] \qquad 1 \text{ FARAD} = 1\, C/V$$

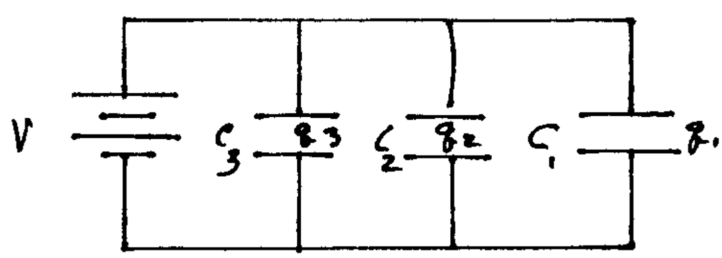
$$\Delta V = \int dV = -\int_{-}^{+} \vec{E} \cdot d\vec{s} \qquad \Delta V = E\,\Delta x \,; \; q = \epsilon_0 \int \vec{E} \cdot d\vec{A} = \epsilon_0 E A$$

IN TERMS OF GEOMETRY $\quad C = \frac{\epsilon_0 A E}{\Delta x E} = \frac{\epsilon_0 A}{\Delta x}$

EXAMPLE I A ∥ PLATE CAPACITOR 4CM × 4CM HAS A PLATE SEPARATION OF ½ CM. DETERMINE THE CAPACITORS VALUE

$$C = \frac{\epsilon_0 A}{\Delta x} = \frac{8.85 \times 10^{-12} (.04)^2}{0.005} = 2.83 \times 10^{-12} = 2.83\, pf$$

PARALLEL CAPACITORS

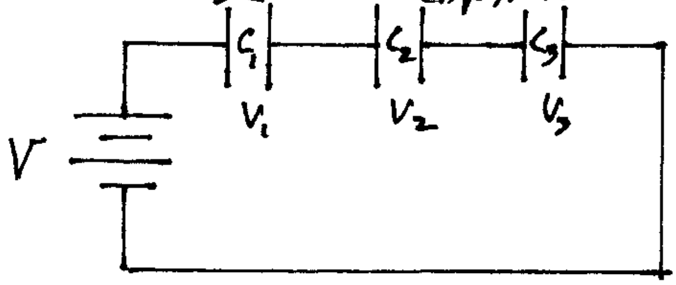


$$C_1 = \frac{q_1}{V} \qquad C_2 = \frac{q_2}{V} \qquad C_3 = \frac{q_3}{V}$$

$$q_{TOT} = q_1 + q_2 + q_3 = (C_1 + C_2 + C_3)V$$

$$C_{eq} = C_1 + C_2 + C_3 \qquad (\parallel \text{ CAPACITORS})$$

SERIES CAPACITORS



$$C = \frac{q}{V}$$

$$q_{c1} = q_{c2} = q_{c3}$$

$$V_1 = \frac{q}{C_1} \quad V_2 = \frac{q}{C_2} \quad V_3 = \frac{q}{C_3}$$

$$V = V_1 + V_2 + V_3 = q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right) = \frac{q}{C_{eq}}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \quad \text{(SERIES CAPACITORS)}$$

$$C_{eq} = \frac{C_1 \times C_2}{C_1 + C_2} \quad \text{(FOR 2 CAPACITORS IN SERIES)}$$

EXAMPLE II

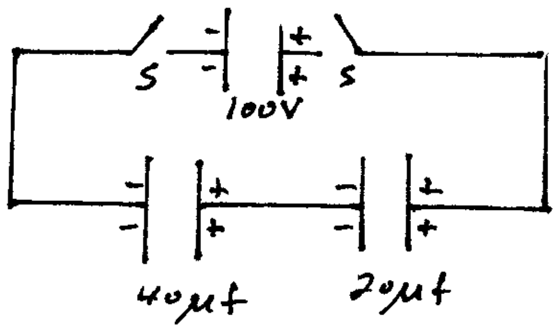
A 33 μf CAPACITOR & A 47 μf CAPACITOR ARE CONNECTED IN SERIES find C_{eq}

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{33} + \frac{1}{47} = .0303 + .0213 = .0516$$

$$C_{eq} = \frac{1}{.0516} = 19.4 \times 10^{-6}$$

(NOTE - I ALWAYS LEAVE OUT THE 10^{-6} UNTIL THE VERY END)

CAPACITOR CIRCUITS



LOOP EQUATION

$$V_{10} - V_{20} - V_{40} = 0$$

$$V_{10} = V_{20} + V_{40}$$

FIND THE VOLTAGE ACROSS EACH CAPACITOR WHEN THE SWITCHES ARE CLOSED

$$V_{10} = V_{20} + V_{40} \qquad 10^{-3} = q_{TOTAL} = q_{10} + q_{20}$$

(CHARGE ON C_{40} IS NOT NEW BUT IS A REALLIGNMENT)

$$\frac{q_{10}}{10\mu f} = \frac{q_{20}}{20\mu f} + \frac{q_{40}}{40\mu f} = \frac{q_{20}}{20\mu f} + \frac{q_{20}}{40\mu f} \quad \text{SINCE } q_{20} = q_{40}$$

$$\frac{q_{10}}{10} = q_{20}\left(\frac{1}{20} + \frac{1}{40}\right) = q_{20}\left(\frac{40+20}{40 \times 20}\right) = 0.075\, q_{20}$$

$$q_{10} = 0.75\, q_{20}$$

FROM THE CHARGE EQUATION

$$10^{-3} = 0.75\, q_{20} + q_{20} = 1.75\, q_{20}$$

$$q_{20} = 0.00057 \text{ C}$$

$$q_{10} = 0.75\, q_{20} = 0.75\,(0.00057) = 0.00048$$

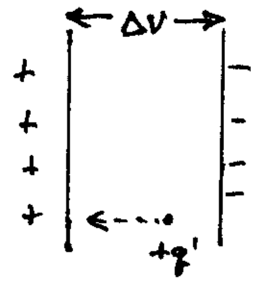
$$q_{TOTAL} = q_{10} + q_{20} = 0.000428 + 0.000571 = 9.99 \times 10^{-3} \approx 10 \times 10^{-3}$$

$$V_{20} = \frac{q_{20}}{C_{20}} = \frac{0.000571}{20 \times 10^{-6}} = 28.5\text{V}$$

$$V_{40} = \frac{q_{40}\,(= q_{20})}{C_{40}} = \frac{0.000571}{40 \times 10^{-6}} = 14.25\text{V}$$

$$V_{10} = \frac{q_{10}}{C_{10}} = \frac{0.000428}{10 \times 10^{-6}} = 42.8\text{V}$$

ENERGY STORED IN A CAPACITOR



$$C = \frac{q'}{V}$$

TO MOVE AN INCREMENT OF CHARGE $+dq'$ FROM THE − PLATE TO THE + PLATE REQUIRES WORK dW

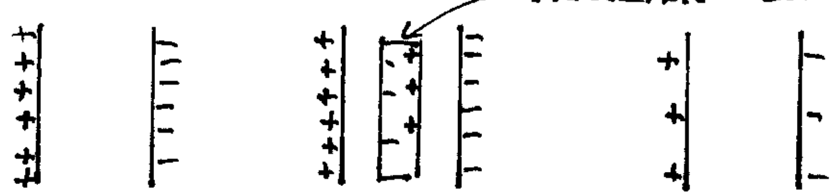
$$W_{TOT} = \int W = \int V\,dq' = \int \frac{q'}{C}\,dq' = \frac{q^2}{2C}$$

ENERGY REQUIRED $\quad U = \frac{q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}qV$

CAPACITORS WITH DIELECTRICS

THE CAPACITY OF A CAPACITOR TO STORE CHARGE MAY BE INCREASED BY INSERTING A NON CONDUCTING MAT'L BETWEEN THE PLATES

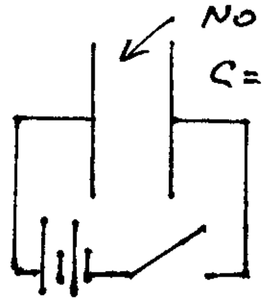
DIELECTRIC CONSTANT κ



MAT'L	κ
AIR	1
PAPER	3.5
MICA	5.4
ETHANOL	25

$C = \frac{q}{V}$ $\qquad$ $C = \kappa\frac{q}{V}$

EXAMPLE III



$q_{\text{ON THE PLATES}} = CV = 10\times10^{-6}(100) = 10^{-3}\,C$

NOW INSERT A DIELECTRIC WITH $\kappa = 3$

$C' = \kappa C$

$q' = VC' = VC\kappa = 100(10\times10^{-6})(3) = 3\times10^{-3}\,C$

SO THE CHARGE HAS TRIPLED

REMOVING THE BATTERY & κ $\quad V = \frac{q'}{C} = \frac{3\times10^{-3}}{10\times10^{-6}} = 300V$