مؤمنة مثنى هاشم / قسم الفيزياء

جامعة الموصل
كلية العلوم – قسم الفيزياء

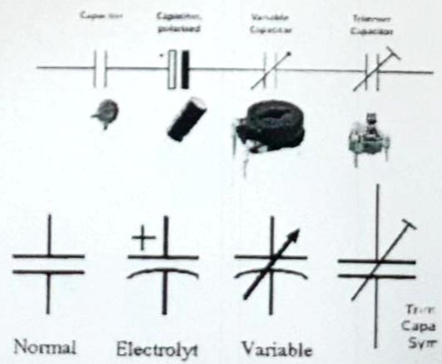
المستوى الاول
المقرر 103
مبادئ الكهربائية والمغناطيسية

الاستاذ الدكتور

ليث محمد سعدون الطعان

٢٠١٩-٢٠٢٠

Prof. Dr. Laith Al-Taan



السعة أو المكثف

Capacitors

Capacity ; is the ratio of the magnitude of charge on the conductor to its electrical potential difference.

فرق الجهد الكهربائي

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

فرق الجهد بين الصفيحتين

But we know that electric potential is given by: $$V = \frac{q}{4\pi \varepsilon_0 r}$$

so; $$C = 4\pi \varepsilon_0 r$$

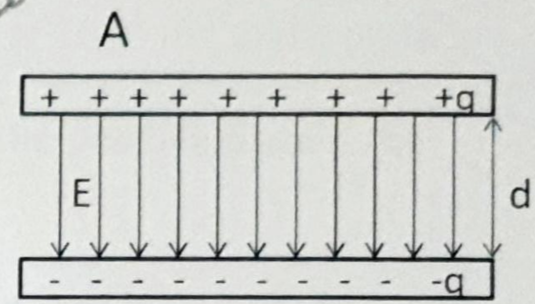
The capacitor unit is : **farad (F) = coulomb per volt (C/V)**

1 F = 1C/1 V

The Parallel– Plate Capacitor

The capacitance of a device depends on the geometric arrangement of the conductors.

The capacitance of a parallel-plate capacitor with plates separated by air (see Fig.) can be easily calculated from *three facts*:



(1) The charge on one plate is given by: $q = \sigma A$, ...(1)

A , *is the area of the plate*

(2) The potential difference between two plates is: $\Delta V = E d$, ...(2)

d *, is the distance between the plate.*

(3) The electric field between two plates is given by: $E = \frac{\sigma}{\epsilon_o}$, ...(3)

σ , *surface density of charge i.e. (the charge per unit area on each plat)*

Substituting these three facts (1,2,and 3) into the definition of capacitance gives the following result:

$$C = \frac{q}{\Delta V} = \frac{\sigma A}{Ed} = \frac{\sigma A}{(\sigma/\epsilon_0)d}$$

$$C = \epsilon_0 \frac{A}{d}$$

Example: A parallel-plate capacitor has an area A=$2 \times 10^{-4}\ m^2$ and a plate separation d= 1×10^{-3}m.
(***a***) Find its capacitance. (***b***) How much charge is on the positive plate if the capacitor is connected to a 3.00 -V battery?

Solution
(a) Find the capacitance.

Substitute into Equation

$$C = \epsilon_0 \frac{A}{d} = (8.85 \times 10^{-12}\ C^2/N \cdot m^2)\left(\frac{2.00 \times 10^{-4}\ m^2}{1.00 \times 10^{-3}\ m}\right)$$

$$C = 1.77 \times 10^{-12}\ F = 1.77\ pF$$

(b) Find the charge on the positive plate after the capacitor is connected to a 3.00-V battery.

Substitute into Equation 16.8:

$$C = \frac{Q}{\Delta V} \rightarrow Q = C\Delta V = (1.77 \times 10^{-12}\ F)(3.00\ V)$$

$$= 5.31 \times 10^{-12}\ C$$

Energy Stored in a Charged Capacitor: $W = \frac{1}{2} Q\Delta V$

w= qV???

we can express the energy stored three different ways: $= \frac{1}{2}Q\Delta V = \frac{1}{2}C(\Delta V)^2 = \frac{Q^2}{2C}$

Capacitor with Dielectric:

A **dielectric** *is an insulating material, such as rubber, plastic, or waxed paper.*

ان شدة عزل المواد العازلة اكبر من الهواء لذا تؤدي الى زيادة قدرة المتسعة على تحمل الفولتية، وهذا يساعد في تحمل المتسعة الانهيار الكهربائي والتلف.

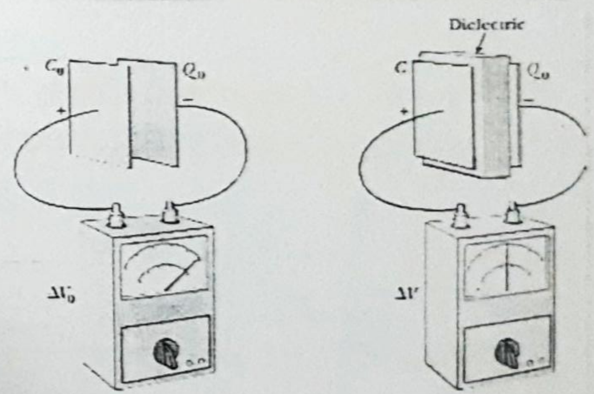
When a dielectric is inserted between the plates of a capacitor, the capacitance increases. (تعليل : الاجابة في الصفحة التالية)

If the dielectric completely fills the space between the plates, the capacitance is multiplied by the factor **K** , called the ***dielectric constant***

اي ان وضع العازل بين لوحي المتسعة سيجعل سعتها تزداد بقدر (K) من المرات

$$C = \kappa \epsilon_0 \frac{A}{d}$$

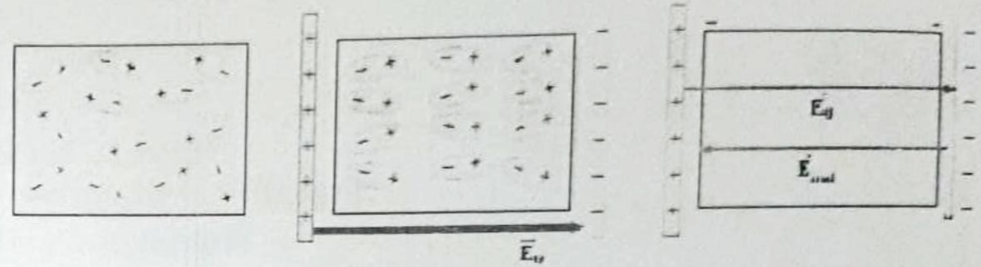
$K = \frac{C}{C_o}$	C السعة بوجود العازل Co السعة بغياب العازل
$K = \frac{\epsilon}{\epsilon_o}$	ϵ السعة بوجود العازل ϵ_o السعة بغياب العازل



واجب : حل المثال رقم 5 في الصفحة ١٨٥

أهمية العوازل في المتسعات

Polarization



(a) (b) (c)

(a) In the absence of an external electric field, polar molecules are randomly oriented.
(b) When an external electric field **Eo** is applied, the molecules partially align with the field.
(c) The charged edges of the dielectric can be modeled as an additional pair of parallel plates establishing an electric field in the direction opposite to .

اذن وضع العازل بين لوحي المتسعة يولد مجالا معاكسا للمجال الاصلي وهذا يقلل الجهد بين لوحي المتسعة ويزيد من سعتها كما في المعادلة ($C = \frac{q}{\Delta V}$)

Example: A parallel-plate capacitor has area 80 cm2. The plates are separated by a 5 mm. Calculate the capacitance with and without a paraffin wax layer between the plates. If the relative permittivity K=2.

Solution:

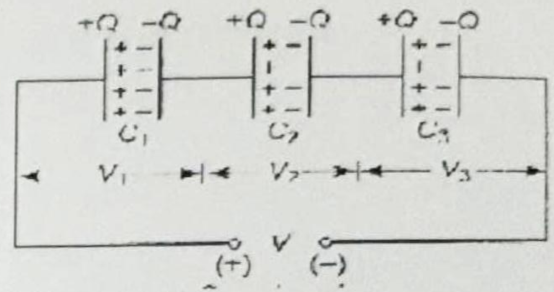
From **C= K εo A/ d**

$$without\ dielectric\ (air\ K = 1): \quad C = \frac{1\times8.8\times10^{-12}\times80\times10^{-4}}{5\times10^{-3}} = 14\times10^{-12}\text{F} = 14\ \text{F}$$

$$with\ dielectric\ (K = 2): \quad C = \frac{2\times8.8\times10^{-12}\times80\times10^{-4}}{5\times10^{-3}} = 28.3\times10^{-12}\text{F} = 28.3\ \text{F}$$

توالي

Capacitors in series



the **current** flowing through the circuit is **same**
and the **voltage** across the series components is **different**.
The total voltage applied by the battery is given by:

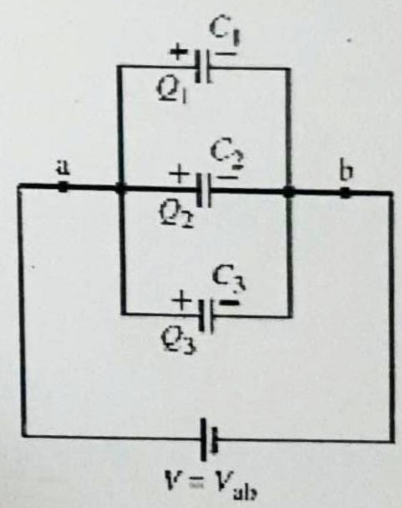
$$V_{DC}=V_1+V_2+V_3+V_4$$

we know that (V = Q/C) ==➔ $\therefore \frac{Q}{C_{eq}}=\frac{Q}{C_1}+\frac{Q}{C_2}+\frac{Q}{C_3}+\frac{Q}{C_4}$

Divide throughout by Q, We get:

$$\frac{1}{C_{eq}}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+\frac{1}{C_4}$$

Capacitors in parallel combination



the **voltage** across the capacitor is **same** in all the components.
and **current** flowing through the circuit is **different.**
Therefore:

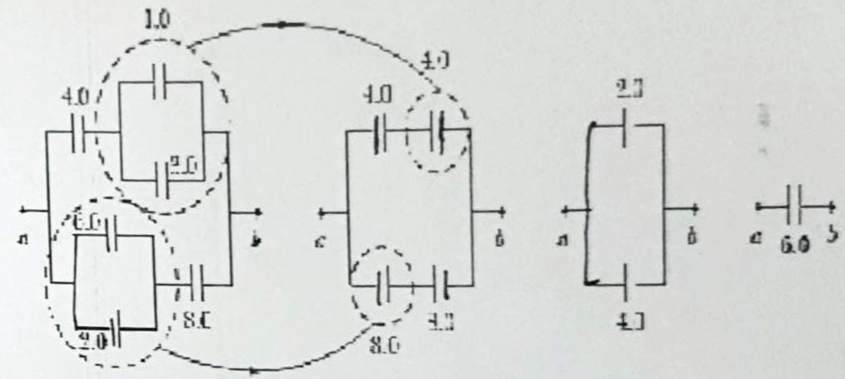
$$I_{eq}=I_1+I_2+I_3+I_4$$

$$V_{DC}=V_1=V_2=V_3=V_4$$

the equivalent capacitance is given by,

$$C_{eq}=C_1+C_2+C_3+.....+C_n$$

Example: Calculate the equivalent capacitance between *a* and *b* for the combination of capacitors shown in Figure.
All capacitances are in *microfarads* μF.



(a) (b) (c) (d)

<u>*Solution*</u>: for (fig - a)

$$C_{eq} = C_1 + C_2 = 1.0\ \mu F + 3.0\ \mu F = 4.0\ \mu F$$

$$C_{eq} = C_1 + C_2 = 2.0\ \mu F + 6.0\ \mu F = 8.0\ \mu F$$

for (fig - b)

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{4.0\ \mu F} + \frac{1}{4.0\ \mu F}$$

$$- \frac{1}{2.0\ \mu F} \rightarrow C_{eq} - 2.0\ \mu F$$

$$\frac{1}{C_{eq}} - \frac{1}{C_1} + \frac{1}{C_2} - \frac{1}{8.0\ \mu F} + \frac{1}{8.0\ \mu F}$$

$$= \frac{1}{4.0\ \mu F} \rightarrow C_{eq} = 4.0\ \mu F$$

for (fig - c) $C_{eq} = C_1 + C_2 = 2.0\ \mu F - 4.0\ \mu F = 6.0\ \mu F$