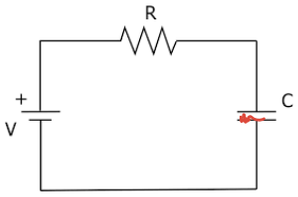
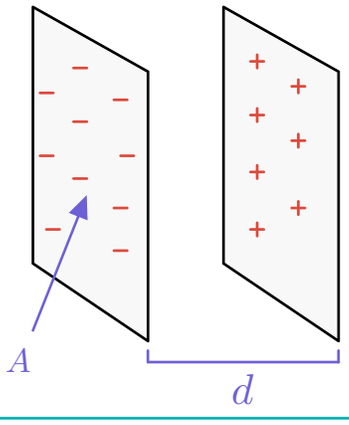
Chapter 25
Capacitance

Capacitors

$$q = CV$$



$$C = \varepsilon_0 \frac{A}{d}$$



- the SI UNIT for C is F (farad)

C = capacitance | سعة المكثف
V = electric potential
q = charge
A = area
d = the distance between the plates

العوامل المؤثرة على قيمة C هي d و A وليس q و V

Q1. A parallel plate capacitor with plate area $15cm^2$ And seperation of 30 mm is charged by 125 V. The capcitance of the capacitor is:

Q2. a capacitor with capacitance 3.5 nF is charged by 15 V, the total charge is:

Q3. A capacitor plate with capacitance C and seperation d. Find the capacitance if the seperation doubled

a) C b) $2C$ c) $C/2$ d) zero

Q4. A capacitor plate with capacitance C is applied by a voltage V. Find the capacitance if the voltage is 4V

a) $4C$ b) C c) $C/2$ d) zero

Q5. A capacitor plate with capacitance C and area A. Find the capacitance if the area has doubled

a) $2C$ b) C c) $C/2$ d) zero

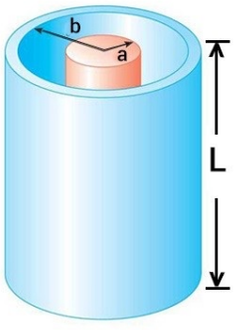
Capacitors

Cylindrical capacitance

$$C = \frac{L}{2k \cdot \ln(b/a)}$$

L = length of the capacitor
a = inner radius
b = outer radius

$$b > a$$

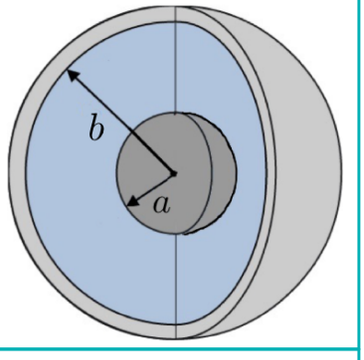


Spherical capacitance

$$C = \frac{ab}{k\,(b-a)}$$

a = inner radius
b = outer radius

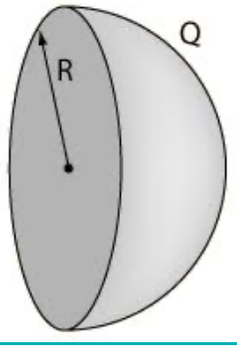
$$b > a$$



Isolated conductor sphere

$$C = \frac{R}{k}$$

R = radius



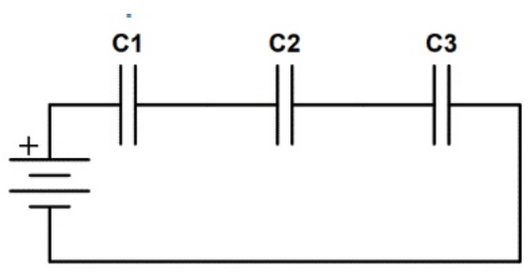
Q6. A coaxial cable of length 30 cm and radii 10 mm and 5 mm is connected by a battery of 8 V if the charge on each cable is 8 nC find the capacitance

Q7. A coaxial cable of radii 8 mm and 13 mm is connected by a battery of 12 V if the charge on each cable is 6 nC find the length of the capacitor

Q8. Two spherical shells of radii 2 cm and 4 cm has a charge of 3 C. Find the capacitance

Capacitors in series and parallel

Series



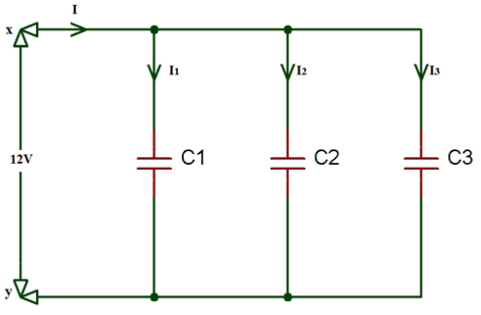
$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\ldots\right)^{-1}$$

$$q_1 = q_2 = q_3$$

$$V = V_1 + V_2 + V_3 + \ldots\ldots$$

$$q = C_{eq}V \qquad q = C_1V_1$$

Parallel



$$C_{eq} = C_1 + C_2 + C_3 + \ldots\ldots$$

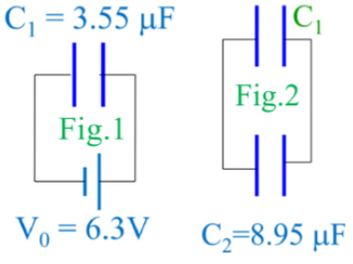
$$V_1 = V_2 = V_3$$

$$q = q_1 + q_2 + q_3 + \ldots\ldots$$

$$q = C_{eq}V \qquad q_1 = C_1V$$

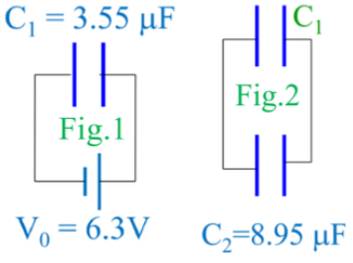
Changing a battery to a capacitor

$$V = \frac{C_1 V_o}{C_1 + C_2}$$

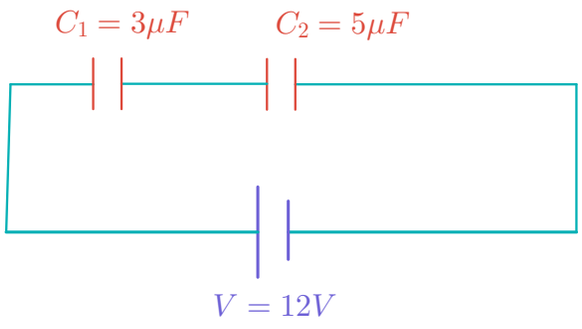


V = new voltage
Vo = old voltage
C = capacitance

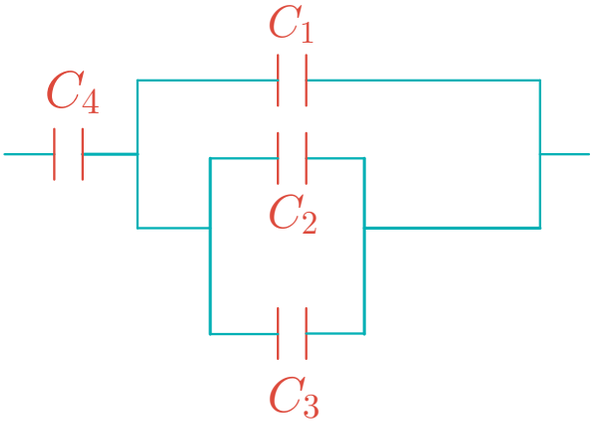
Q9. Example: The battery in fig.1 is removed and replaced by uncharged capacitor C_2 as shown in fig.2. Find the charge on each capacitor in fig.2



Q10. According to the figure find the voltage on C2



Q11. According to the figure find the equivelant capacitance if C1 = 2 nF, C2 = C3 = 4 nF, C4 = 10 nF



Potential energy in capacitors

Electric potential energy

$$U = \frac{q^2}{2C} \qquad U = \frac{1}{2}CV^2$$

U = potential energy
q = charge
C = capacitance
V = electric potential

Energy density

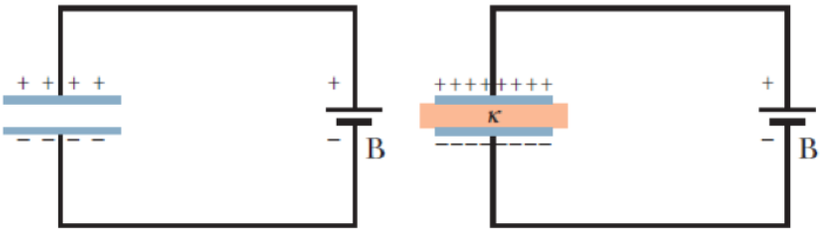
$$u = \frac{1}{2}\varepsilon_0 E^2$$

u = energy density
E = electric field

Q12. An capacitor has a charge of 3 nC and applied by electric potential of 12 V, find the potential energy stored in the capacitor

Capacitor with dielectric

$$C_n = kC_{Air}$$



C n = new capacitance
k = dielectric constant
C air = capacitance without k (normal C)

Q13. A capacitor plates with capacitance of 15 nF is charged by a battery to a potential difference V = 12.5 V a dielectric material is slipped between the plate to make the capacitance = 97.5 nF. Find the dielectric constant (k).

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$$q = CV$$

$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots\ldots\right)^{-1}$$

$$C = \varepsilon_0 \frac{A}{d}$$

$$C_{eq} = C_1 + C_2 + C_3 + \ldots\ldots$$

$$C = \frac{L}{2k \cdot \ln(b/a)}$$ Cylindrical

$$V = \frac{C_1 V_o}{C_1 + C_2}$$

$$C = \frac{ab}{k\,(b-a)}$$ Spherical (2 radiuses)

$$U = \frac{q^2}{2C}$$

$$C = \frac{R}{k}$$ Isolated conducting sphere (1 radius)

$$U = \frac{1}{2} C V^2$$

$$C_n = kC_{Air}$$

$$u = \frac{1}{2} \varepsilon_0 E^2$$