When a patient receives a shock from a defibrillator, the energy delivered to the patient is initially stored in a capacitor. We will study capacitors and capacitance in this chapter.

Physics 042

L8

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CH 26: Capacitance

What are we going to talk about today?

26.1 Definition of Capacitance

- 26.1 Definition of Capacitance
- 26.3 Combinations of Capacitors
- 26.4 Energy Stored in a Charged Capacitor

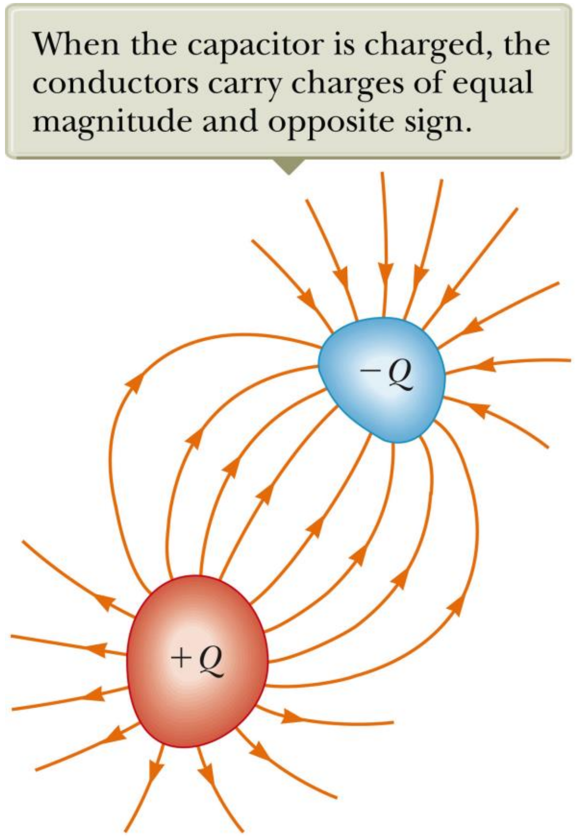
26.1 Definition of Capacitance

The capacitance is a measure of the capacitor's ability to store charge, it is consists of two conductors, these conductors are called plates, when the conductor is charged, the plates carry charges of equal magnitude and opposite directions.

Definition of Capacitance

The capacitance, C, of a capacitor is defined as the ratio of the magnitude of the charge on either conductor to the potential difference between the conductors.

$$C \equiv \frac{Q}{\Delta V}$$



- The SI unit of capacitance is the farad (F), where 1 F = 1 C/V
- Capacitance will always be a positive quantity
- The capacitance of a given capacitor is constant.

26.1 Definition of Capacitance

Exercise 1

When $40\mu C$ charge are placed on a conductor, the potential is 8 V. What is the capacitance?

$Q = 40\ \mu C$ $\Delta V = 8\text{Volt}$ $C = ?$

$$C = \frac{Q}{\Delta V}.$$

$$C = \frac{Q}{\Delta V} = \frac{40\ \mu C}{8}$$

$$C = 5\ \mu F$$

26.3 Combinations of Capacitors

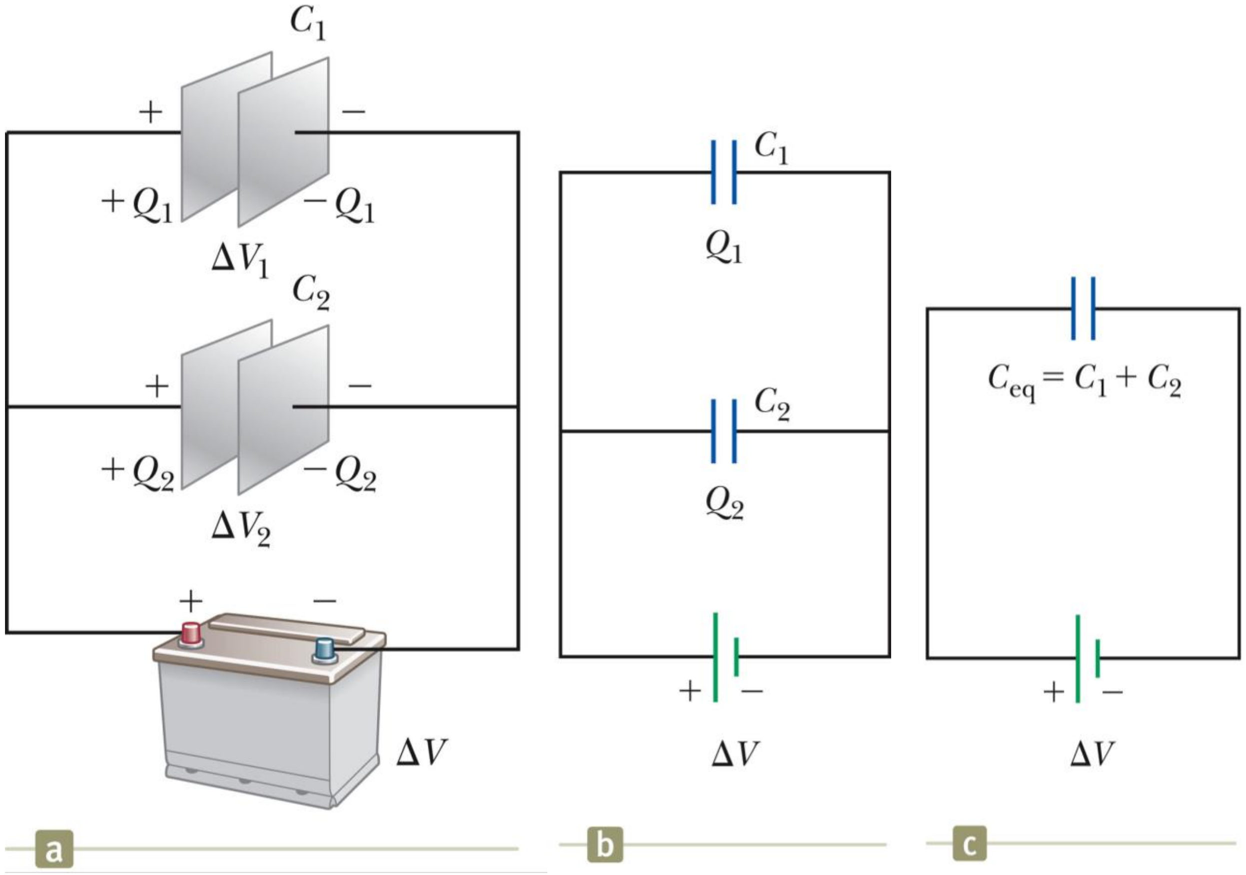
Circuit Symbols

A circuit diagram is a simplified representation of an actual circuit, where lines represent wires,  represent capacitor,  represent battery and  represent switch.

1– Capacitors in Parallel

If two or more capacitors are connected in parallel, the potential difference is the same across all capacitors. The equivalent capacitance of a parallel combination of capacitors is

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

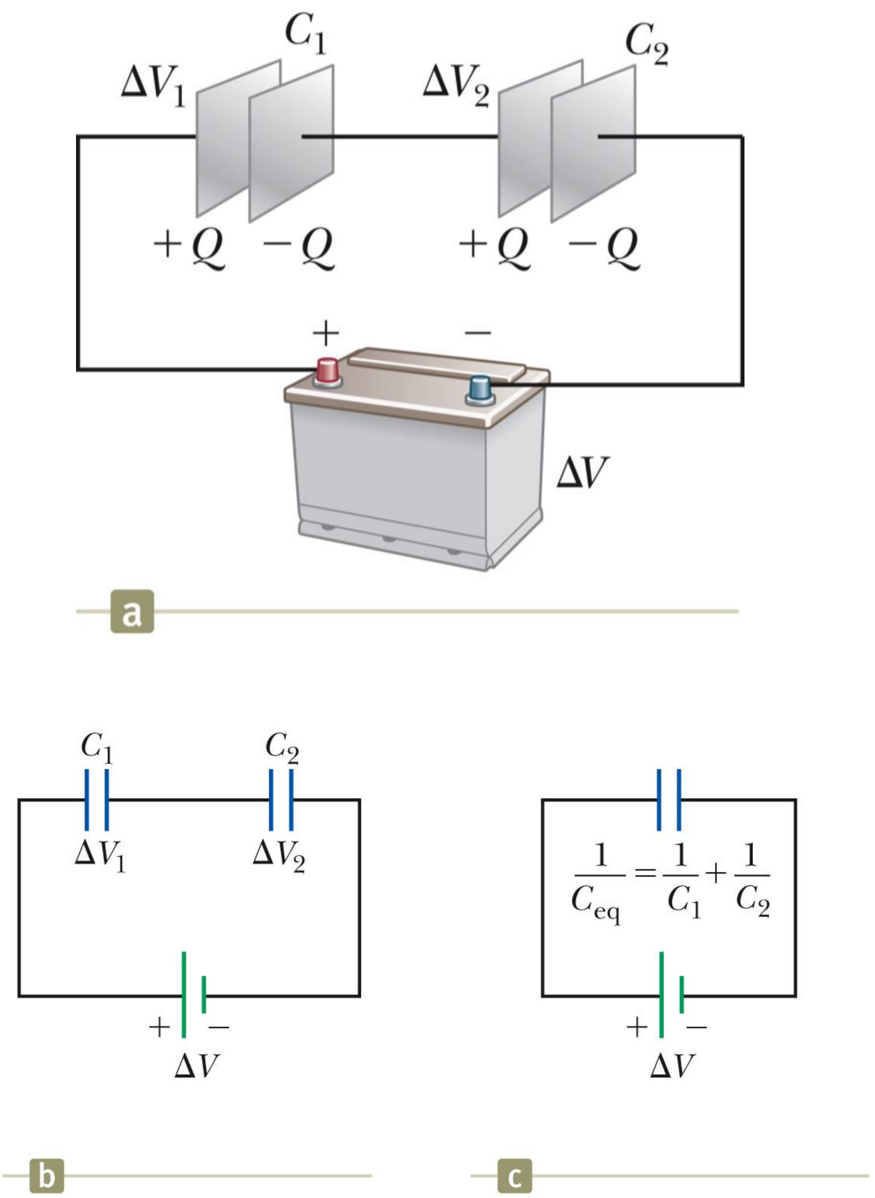


26.3 Combinations of Capacitors

2– Capacitors in Series

If two or more capacitors are connected in series, the charge is the same on all capacitors, and the equivalent capacitance of the series combination is given by

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



These two equations (equivalent capacitors in parallel and series) enable you to simplify many electric circuits by replacing multiple capacitors with a single equivalent capacitance.

Exercise 2

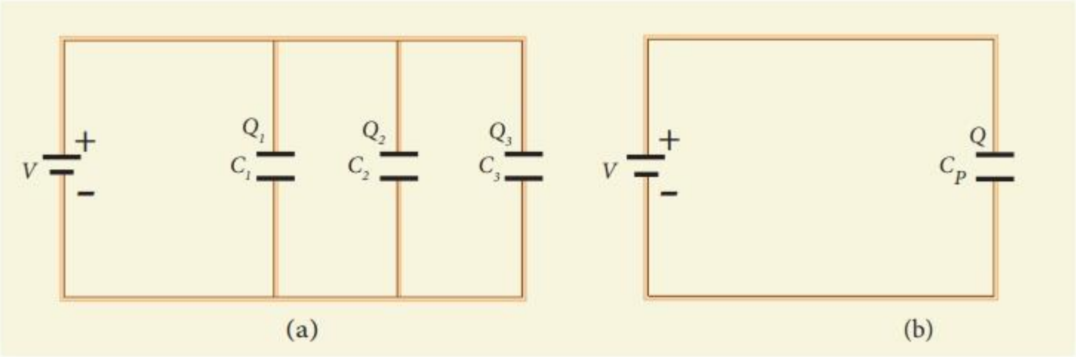
Find the total capacitance for three capacitors connected in parallel, given their individual capacitances are 1 µF, 5 µF, and 8 µF.

$\boldsymbol{C_1 = 1\ \mu F}$ $\boldsymbol{C_2 = 5\ \mu F}$ $\boldsymbol{C_3 = 8\ \mu F}$ $\boldsymbol{C_{eq} = ?}$

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

$$C_{eq} = 1\ \mu F + 5\ \mu F + 8\ \mu F$$

$$C_{eq} = 12\ \mu F$$



Exercise 3

Find the total capacitance for three capacitors connected in series, given their individual capacitances are 1 µF , 5 µF , and 8 µF .

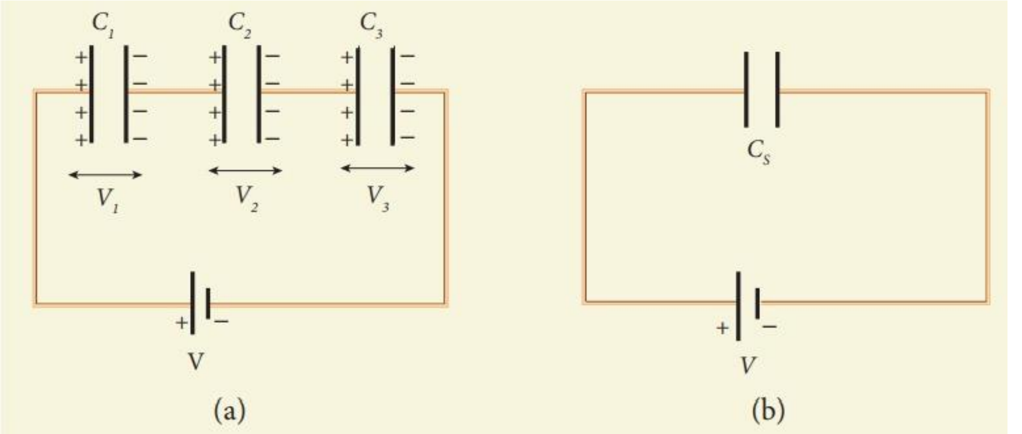
$C_1 = 1\ \mu F \qquad C_2 = 5\ \mu F \qquad C_3 = 8\ \mu F \qquad C_{eq} = ?$

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

$$\frac{1}{C_{eq}} = \frac{1}{1\mu F} + \frac{1}{5\mu F} + \frac{1}{8\mu F}$$

$$\frac{1}{C_{eq}} = \frac{53}{40\mu F}$$

$$C_{eq} = \frac{40\mu F}{53} = 0.75\mu F$$



26.4 Energy Stored in a Charged Capacitor

Circuit Symbols

Energy is stored in a charged capacitor because the charging process is equivalent to the transfer of charges from one conductor at a lower electric potential to another conductor at a higher potential. The energy stored in a capacitor of capacitance C with charge Q and potential difference Δ V is :

$$U_E = \frac{Q^2}{2C}$$

or

$$U_E = \frac{1}{2} Q\Delta V$$

or

$$U_E = \frac{1}{2} C(\Delta V^2)$$

Exercise 4

If the capacitance to $4\ \mu F$, the voltage , the voltage $2\ \mathrm{V}$, and the charge $8\ \mu C$. Find the potential energy.

$C = 4\ \mu F \qquad \Delta V = 2\ Volt \qquad Q = 8\ \mu C \qquad U_E = ?$

$$U_E = \frac{1}{2} C(\Delta V^2)$$

$$U_E = \frac{1}{2} 4\ \mu(2^2)$$

$$U_E = 8\ \mu\ J$$


Any Questions?