UBC Physics 102

Lecture 8

Rik Blok

Outline

- ▷ Capacitors
- ▷ Capacitance
- ▷ Series and parallel
- ▷ Energy storage
- ▷ Dielectrics
- ▷ Electric current
- ▷ Ohm's law
- ▷ Resistivity
- ▷ End

Capacitors [Text: Sect. 24-1]

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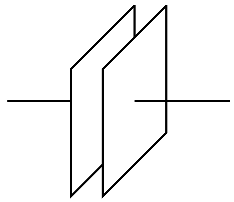

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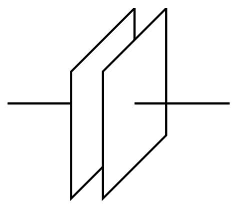

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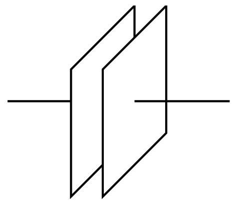

  - Circuit diagram symbol: $\dashv\vdash$
  - When voltage V applied to plates they acquire charges $\pm Q$ where

$$\boxed{Q = CV.}$$

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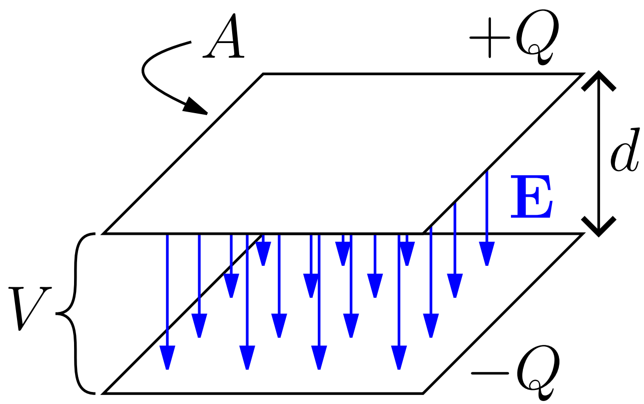
  - To derive capacitance solve for relationship between V and Q. Will find $Q \propto V$. C is proportionality constant.

Capacitance, contd

- **Derivation: Parallel plate capacitance**



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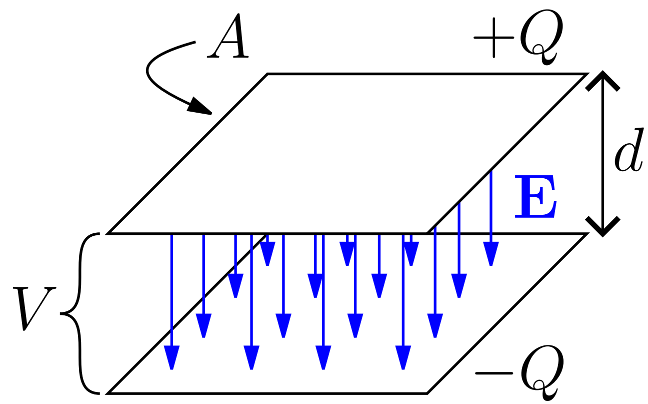

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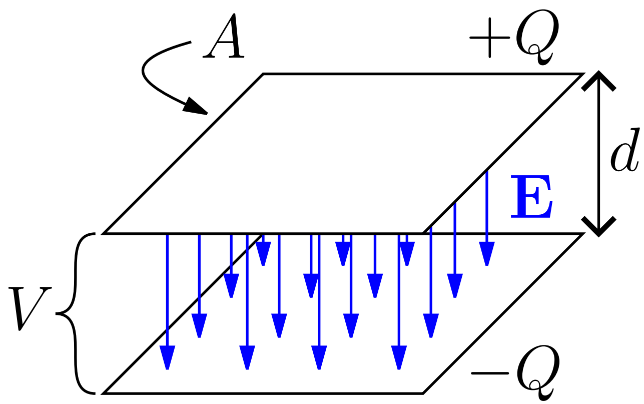

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- σ is surface charge density, $\sigma = \frac{Q}{A}$.

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$$V = \frac{\sigma d}{\epsilon_0} = \frac{Qd}{\epsilon_0 A}.$$

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  - Can use similar method for other shapes.

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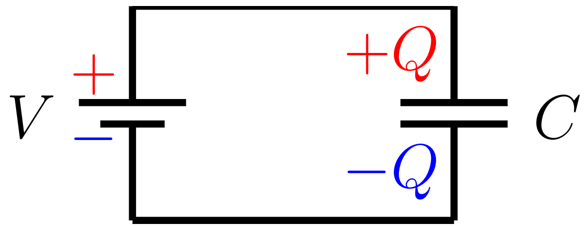
  - Net voltage change over any loop must be zero. (Analogy: net height change$=0$.)



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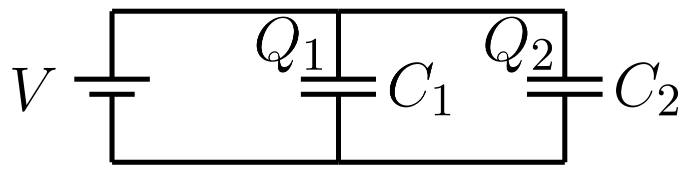

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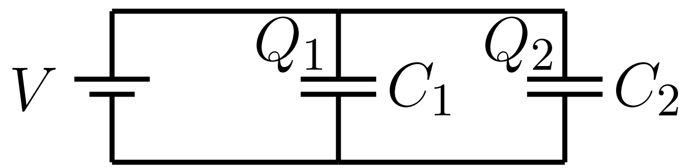

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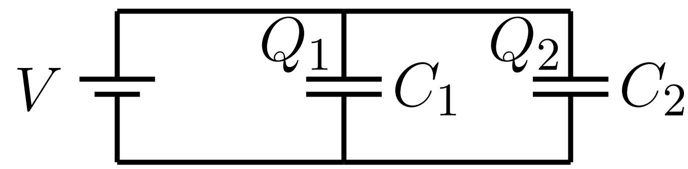

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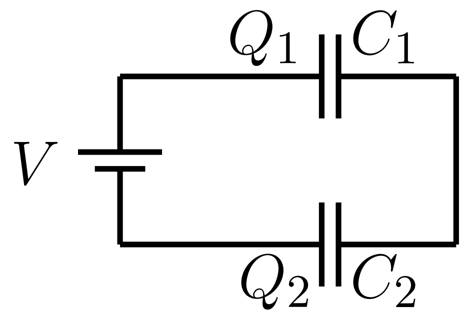

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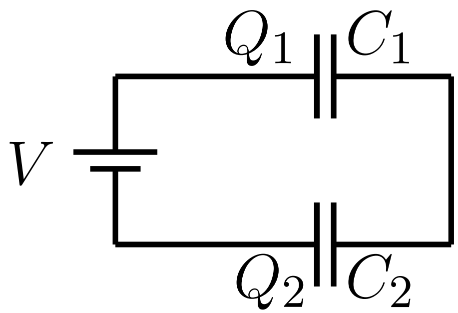

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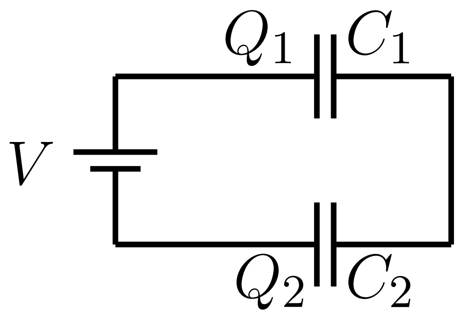

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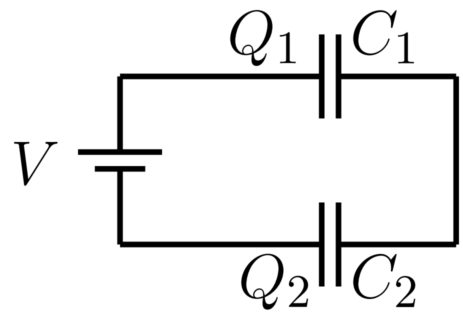

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  - Recall, energy of charge Q at voltage $\widehat{V}$ is $U = Q\widehat{V}$.
  - But both Q and $\widehat{V}$ changing so can't use $U = QV$.

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  - Total potential is sum of increments, $U = \int_0^V C\widehat{V}\, d\widehat{V}$,

$$\boxed{U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}.}$$

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  - Changing C changes potential energy U capacitor will hold.

Dielectrics, contd

- **Interactive Quiz: PRS 08b**

Dielectrics, contd

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- **Example: Pr. 75**

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  - A parallel-plate capacitor is isolated with a charge $\pm Q$ on each plate. If the separation of the plates is halved and a dielectric (constant K) is inserted in place of air, by what factor does the energy storage change? To what do you attribute the change in stored potential energy?

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  - We know charge Q held constant.

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  - From $\boxed{C = \frac{\epsilon_0 A}{d}}$ this has the effect of doubling the capacitance,

$$C_1 = 2C_0.$$

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  - So both changes happened spontaneously.

Dielectrics, contd

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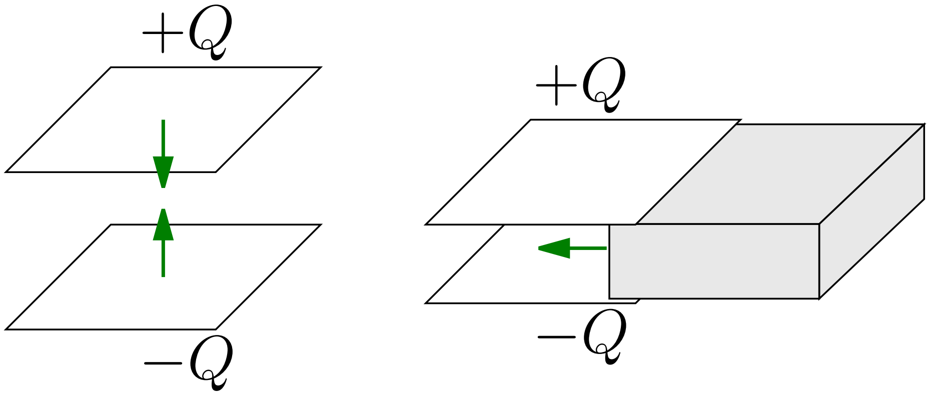

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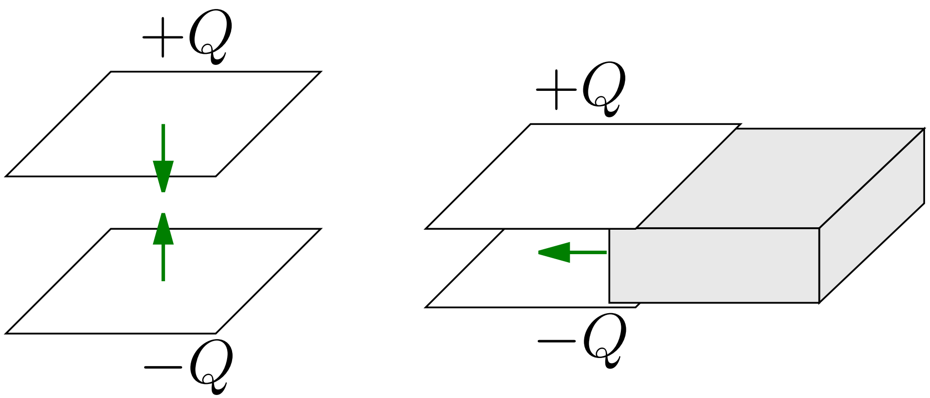

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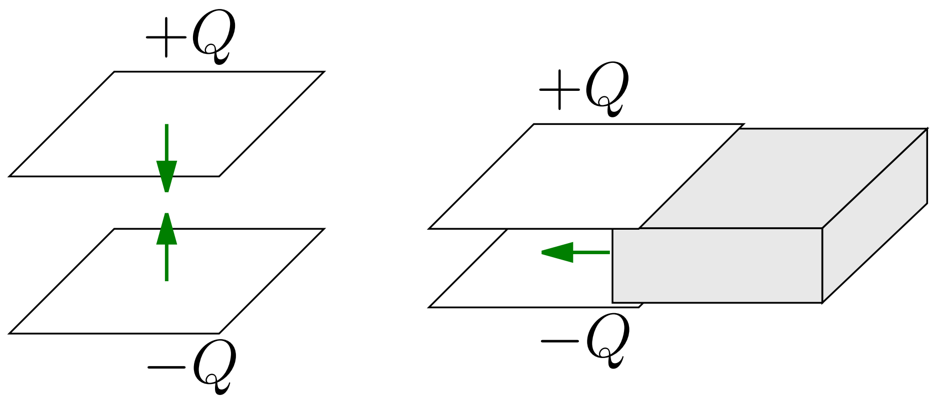

- Step 1: Releasing plates allowed them to move closer together (attraction of plates).
- Step 2: Capacitor drew in dielectric when we brought it close (dielectric polarized in proximity of capacitor then attracted to it). □

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- **Unit: Ampere,** A
  - Unit of current

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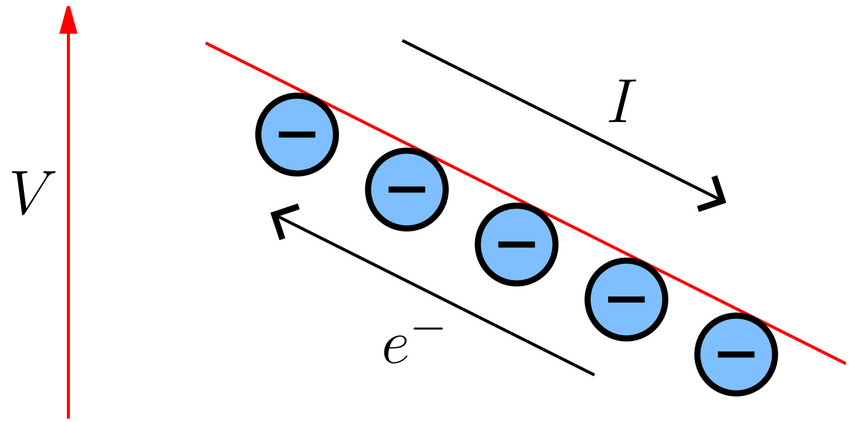

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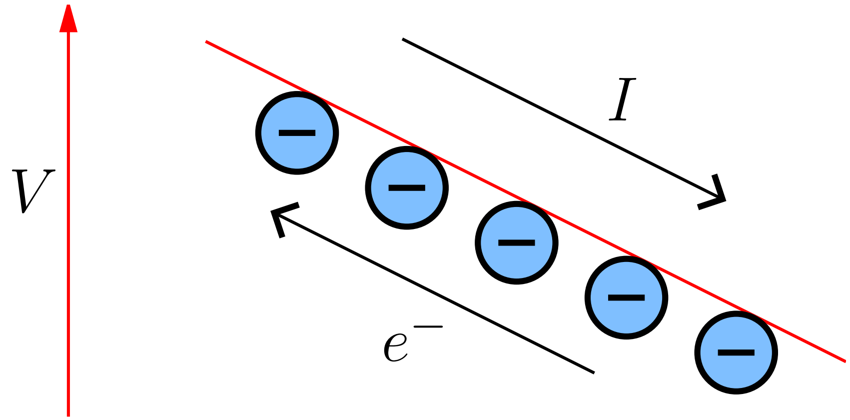

  - Doesn't matter, except in rare cases.

Ohm's law [Text: Sect. 25-3]

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  - Not always true (will see in lab).

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- **Unit: Ohm,** Ω

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Resistivity [Text: Sect. 25-4]

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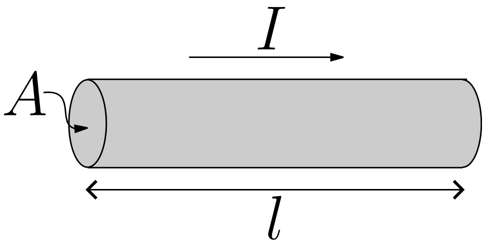

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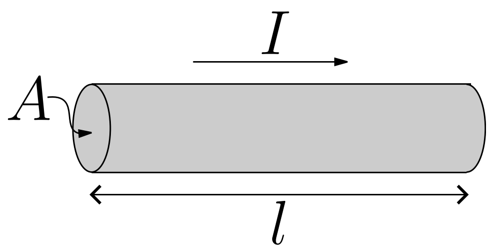

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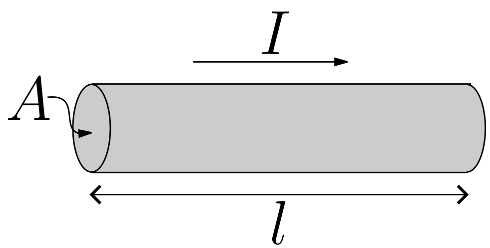

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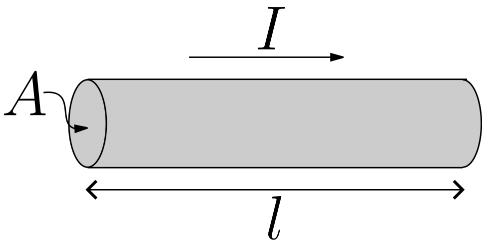

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