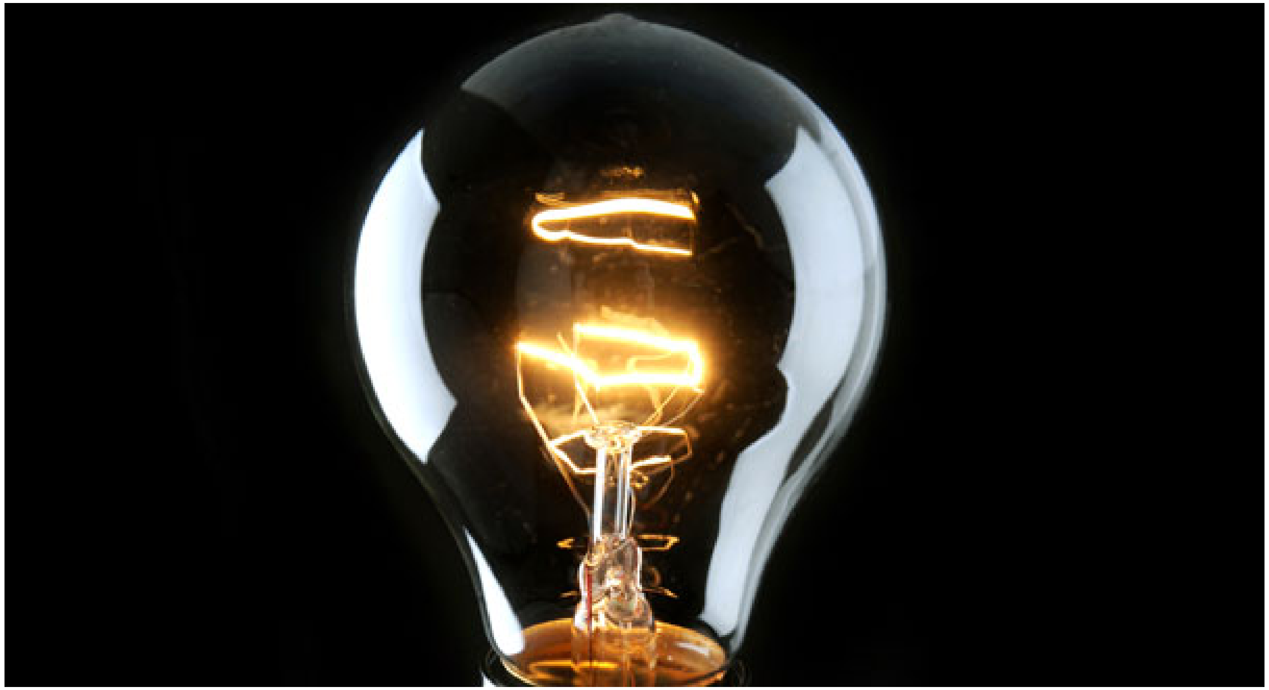
FIZ102E – Lecture 5
Current, Resistance, and Electromotive Force



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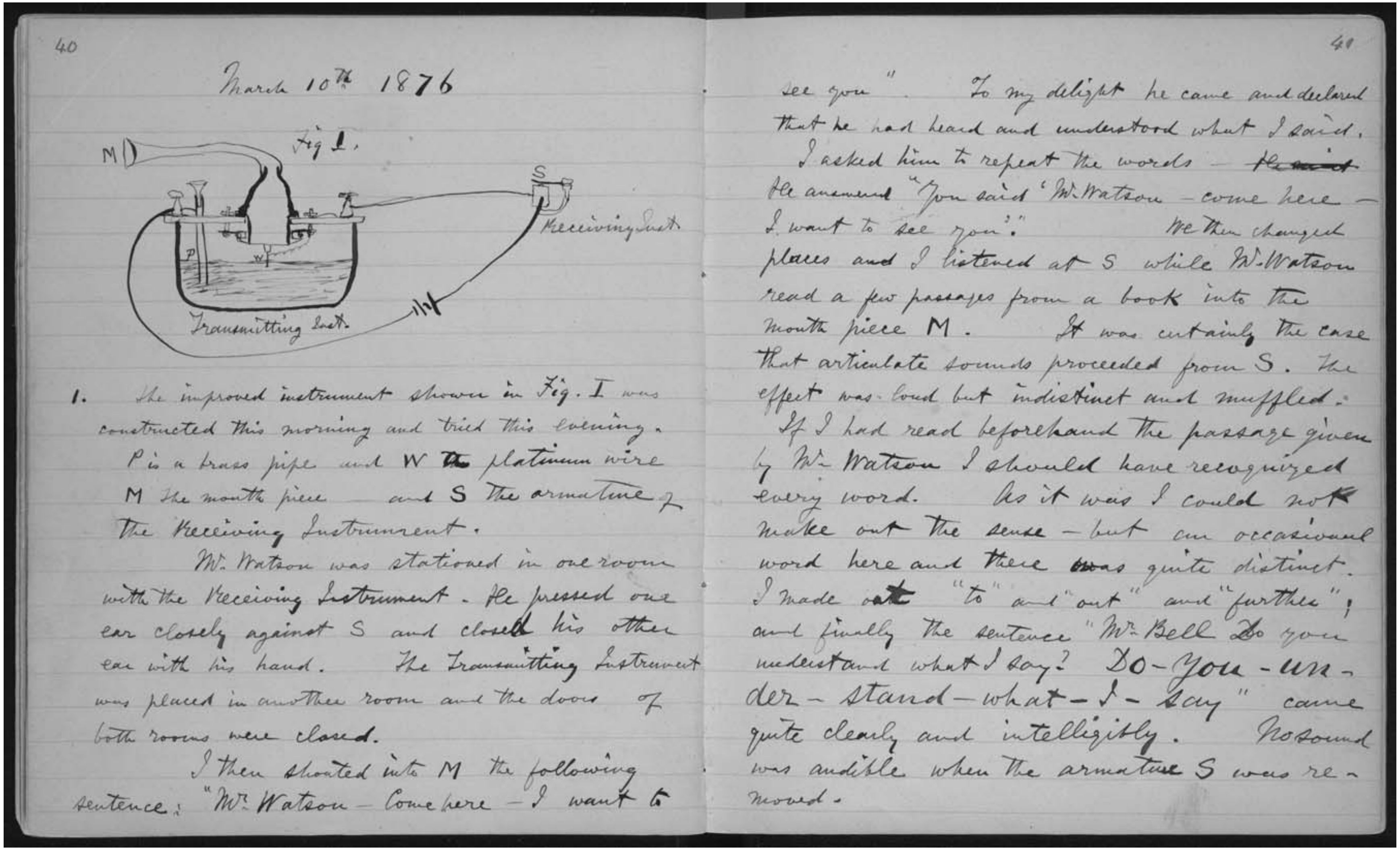
What did we cover last week?



1. The improved instrument shown in Fig. I was constructed this morning and tried this evening. P is a brass pipe and W the platinum wire M the mouth piece and S the armature of the Receiving Instrument.

Mr. Watson was stationed in one room with the Receiving Instrument. He pressed one ear closely against S and closed his other ear with his hand. The Transmitting Instrument was placed in another room and the doors of both rooms were closed.

I then shouted into M the following sentence: "Mr. Watson — Come here — I want to

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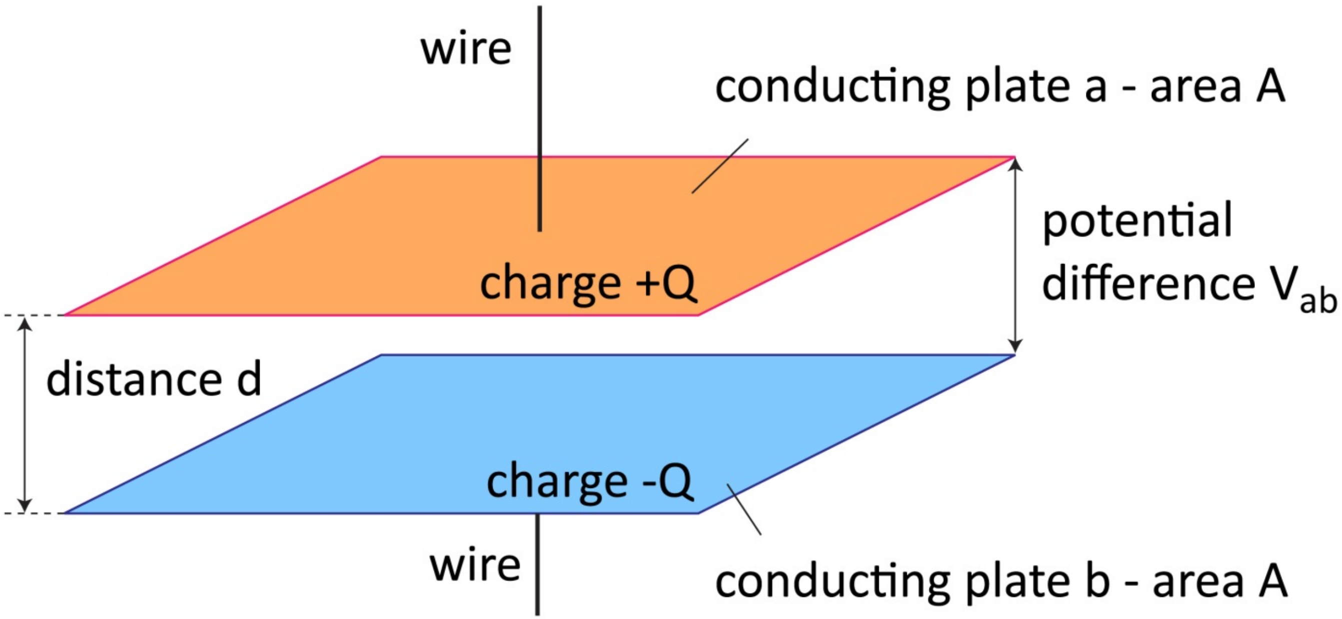
see you". To my delight he came and declared that he had heard and understood what I said. I asked him to repeat the words — He answered "You said 'Mr. Watson — come here — I want to see you.'" We then changed places and I listened at S while Mr. Watson read a few passages from a book into the mouth piece M. It was certainly the case that articulate sounds proceeded from S. The effect was loud but indistinct and muffled. If I had read beforehand the passage given by Mr. Watson I should have recognized every word. As it was I could not make out the sense — but an occasional word here and there was quite distinct. I made out "to" and "out" and "further"; and finally the sentence "Mr. Bell Do you understand what I say? Do — you — un-der — stand — what — I — say" came quite clearly and intelligibly. No sound was audible when the armature S was removed.

Parallel plate capacitor

Capacitor = two conductors separated by an insulator or vacuum



Capacitance

$$C = \frac{Q}{V_{ab}}$$

Units:

1 Farad [F] = 1 C/V

Charged parallel plate capacitor → uniform electric field between the plates

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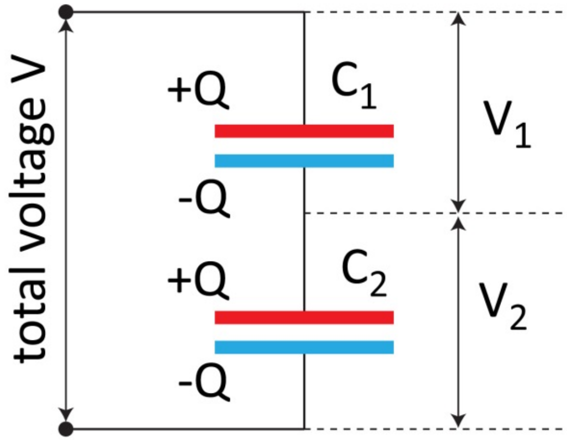
Capacitance in vacuum: $$C = \varepsilon_0 \frac{A}{d}$$

Capacitors in series and parallel



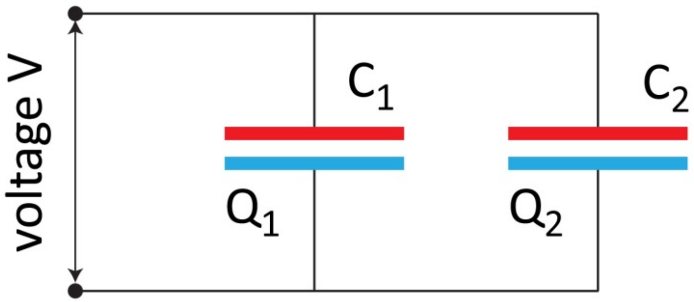
Capacitors in series

All capacitors have the same charge Q

$$V = V_1 + V_2 = \frac{Q}{C_1} + \frac{Q}{C_2} = Q\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$$

$$\boxed{\frac{1}{C} = \frac{V}{Q} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)}$$

In general: $\boxed{\frac{1}{C} = \sum_i \frac{1}{C_i}}$



Capacitors in parallel

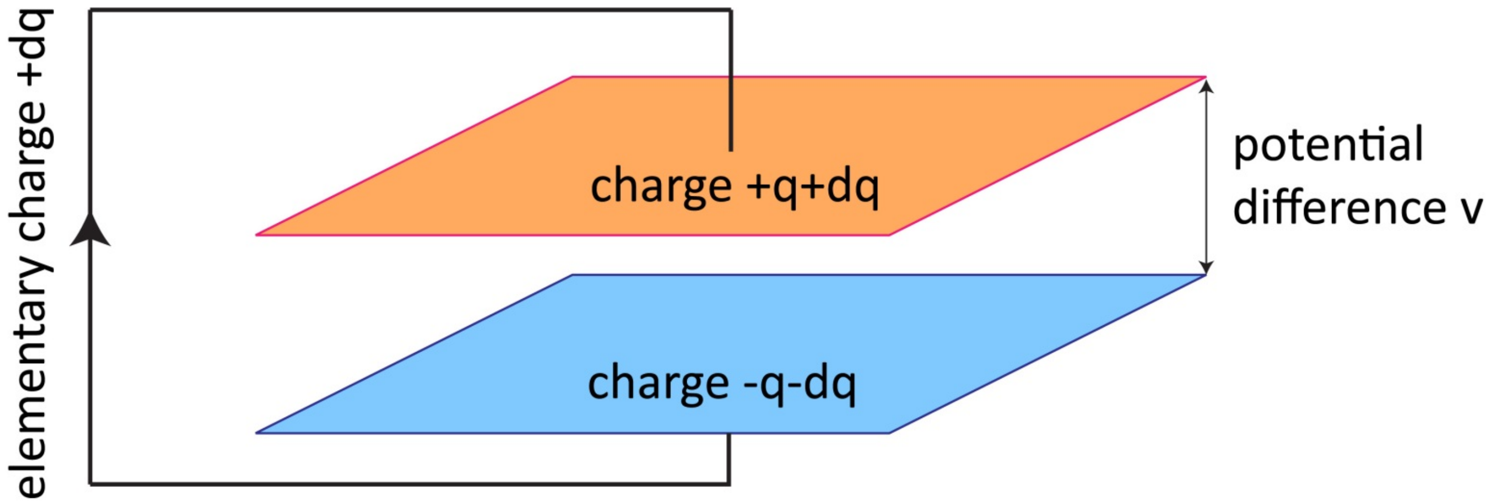
All capacitors have the same voltage V

$$Q = Q_1 + Q_2 = C_1 V + C_2 V = (C_1 + C_2)V$$

$$\boxed{C = \frac{Q}{V} = C_1 + C_2}$$

In general: $\boxed{C = \sum_i C_i}$

Energy storage in capacitors



Capacitor charging:

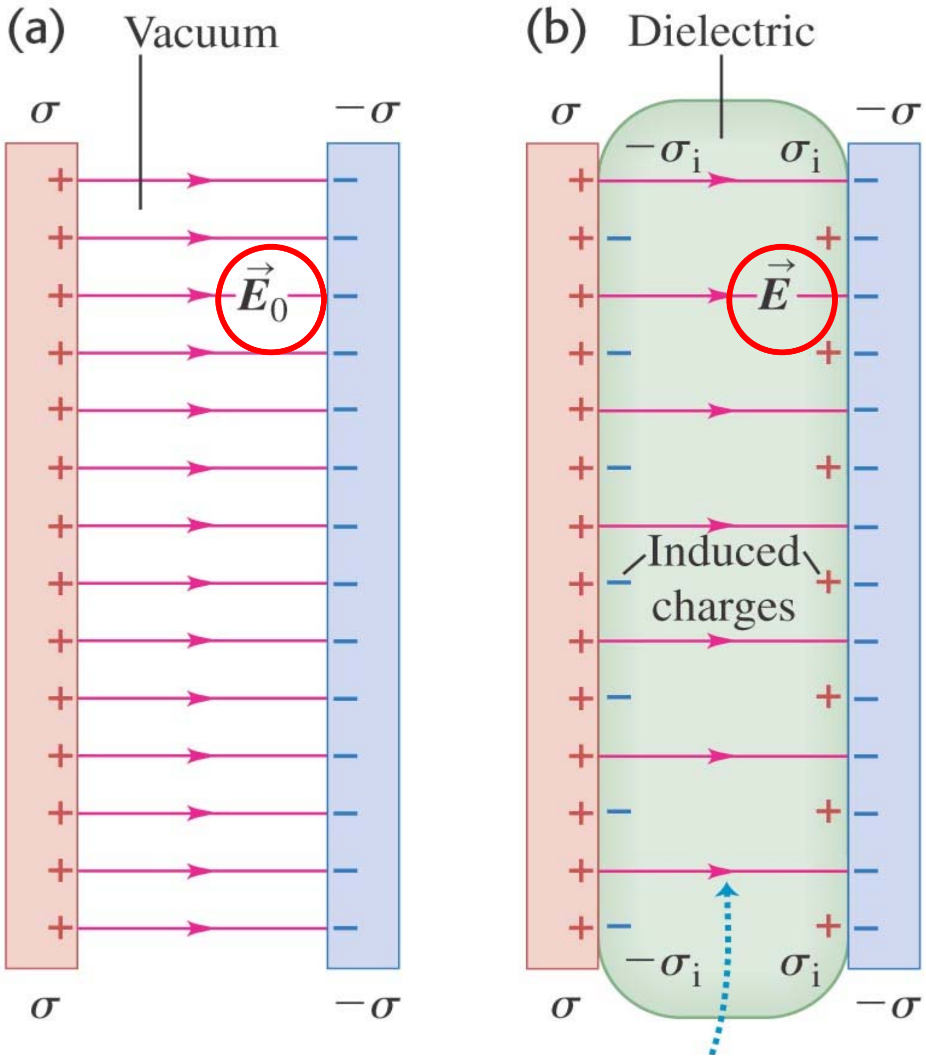
Work for moving charge *dq* between plates with potential difference *v*

$$dW = v\,dq = \frac{q}{C}\,dq$$

Total work for charging the capacitor from 0 to final charge Q

$$W = \int_0^Q dW = \int_0^Q \frac{q}{C}\,dq = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

Dielectrics



Electric field E_0

Capacitance C_0

Electric field E

Capacitance C

Dielectric = insulating material between capacitor plates

Dielectric polarizes in electric field due to charge induction

→ electric field is attenuated

<u>Dielectric constant</u>

$$K = \frac{E_0}{E} = \frac{C}{C_0} \geq 1$$

Dielectrics

Induced charge modifies effective charge density on the capacitor plates

σ . . . charge density on capacitor plates

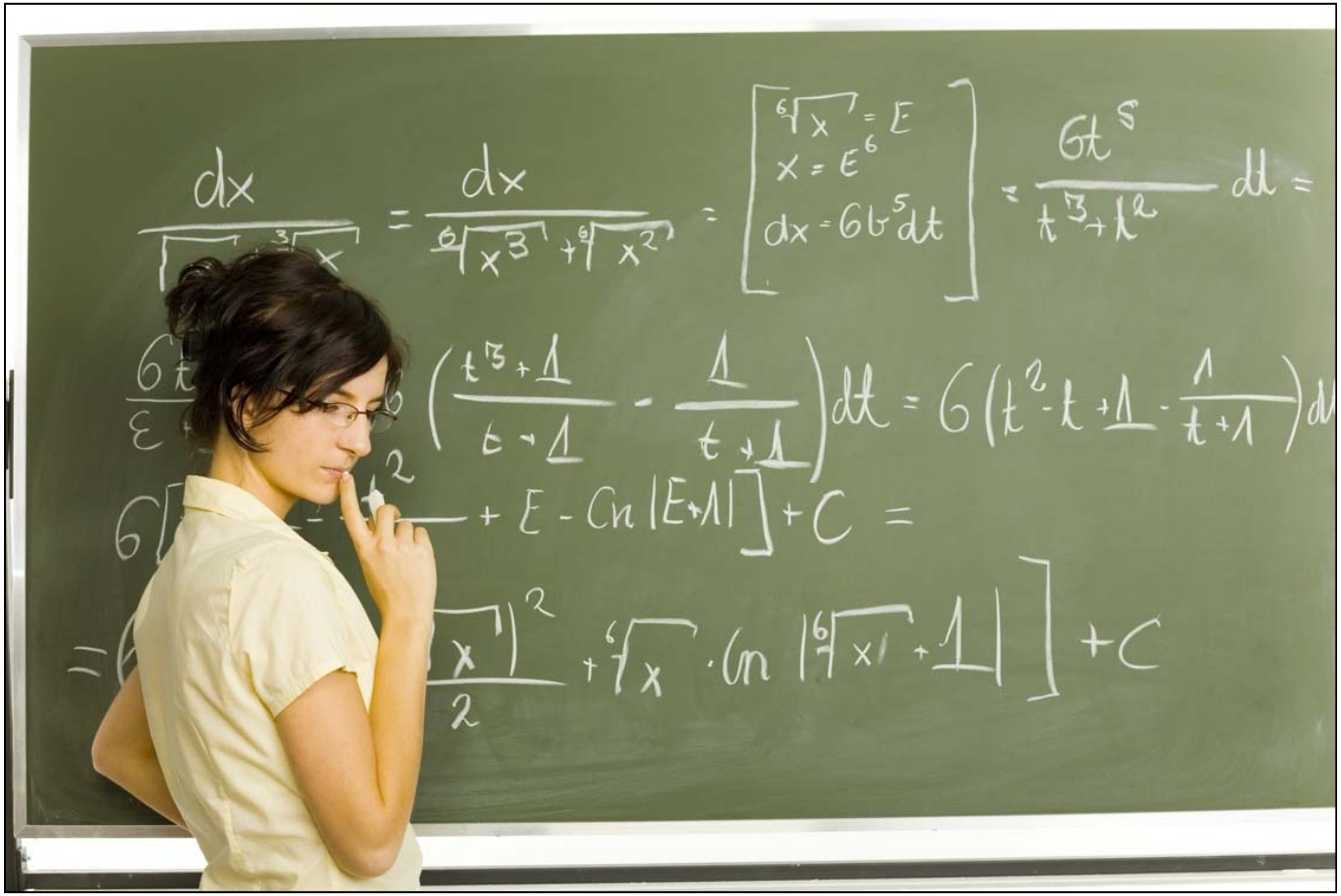
σ_i . . . induced charge density

➡ $\sigma - \sigma_i$ . . . effective charge density

	Vacuum	Dielectric
Electric field in a capacitor	$E_0 = \dfrac{\sigma}{\varepsilon_0}$	$E = \dfrac{\sigma - \sigma_i}{\varepsilon_0} = \dfrac{E_0}{K} = \dfrac{\sigma}{K\varepsilon_0} = \dfrac{\sigma}{\varepsilon}$
Capacitance	$C_0 = \varepsilon_0 \dfrac{A}{d}$	$C = \varepsilon \dfrac{A}{d}$
Gauss's law	$\underset{\text{closed surface } S}{\oiint} \vec{E} . d\vec{A} = \dfrac{Q_{enclosed}}{\varepsilon_0}$	$\underset{\text{closed surface } S}{\oiint} \vec{E} . d\vec{A} = \dfrac{Q_{enclosed}}{\varepsilon}$

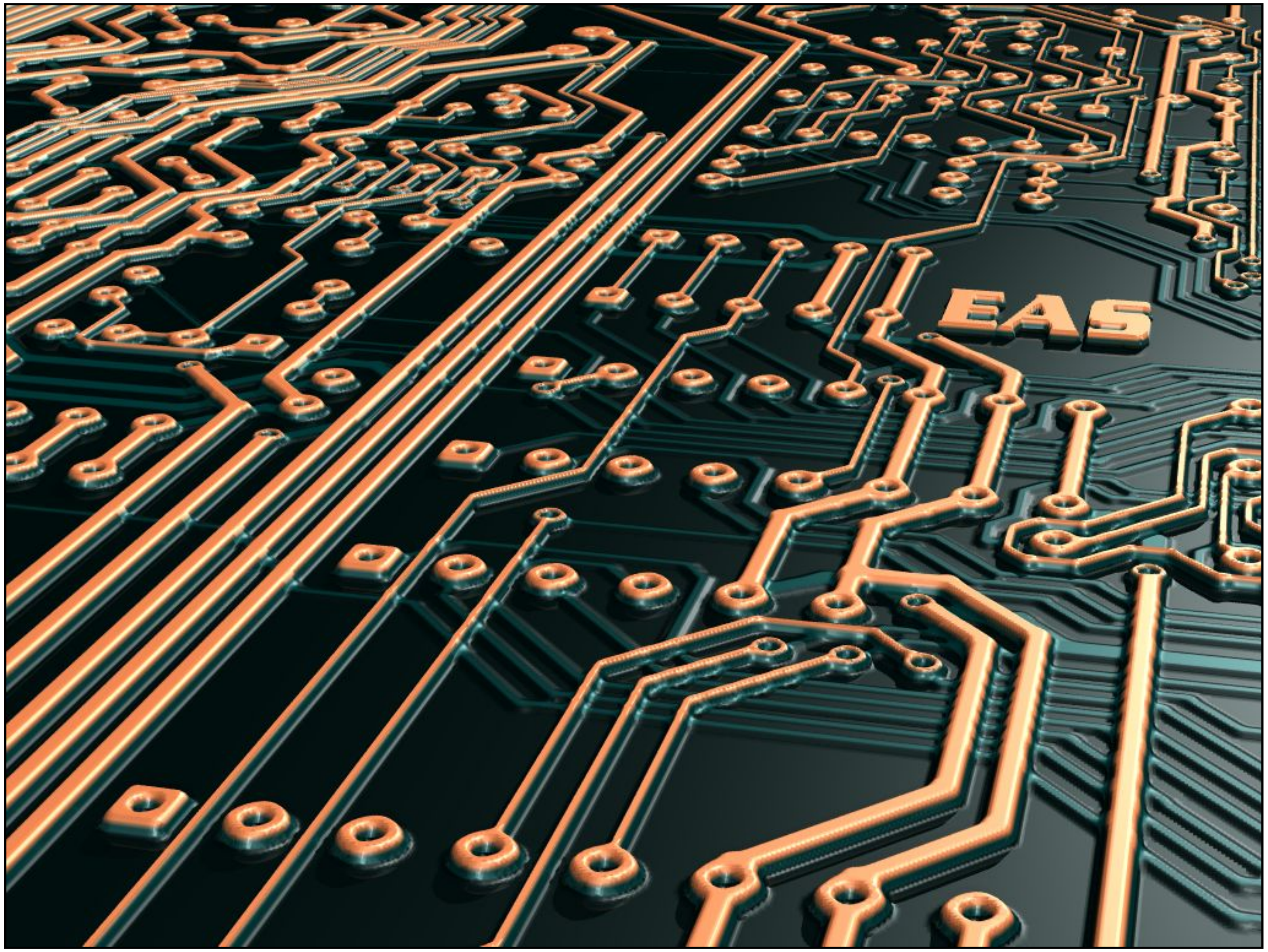
where $\varepsilon = K\varepsilon_0$ is the dielectric permittivity

What will we cover today?



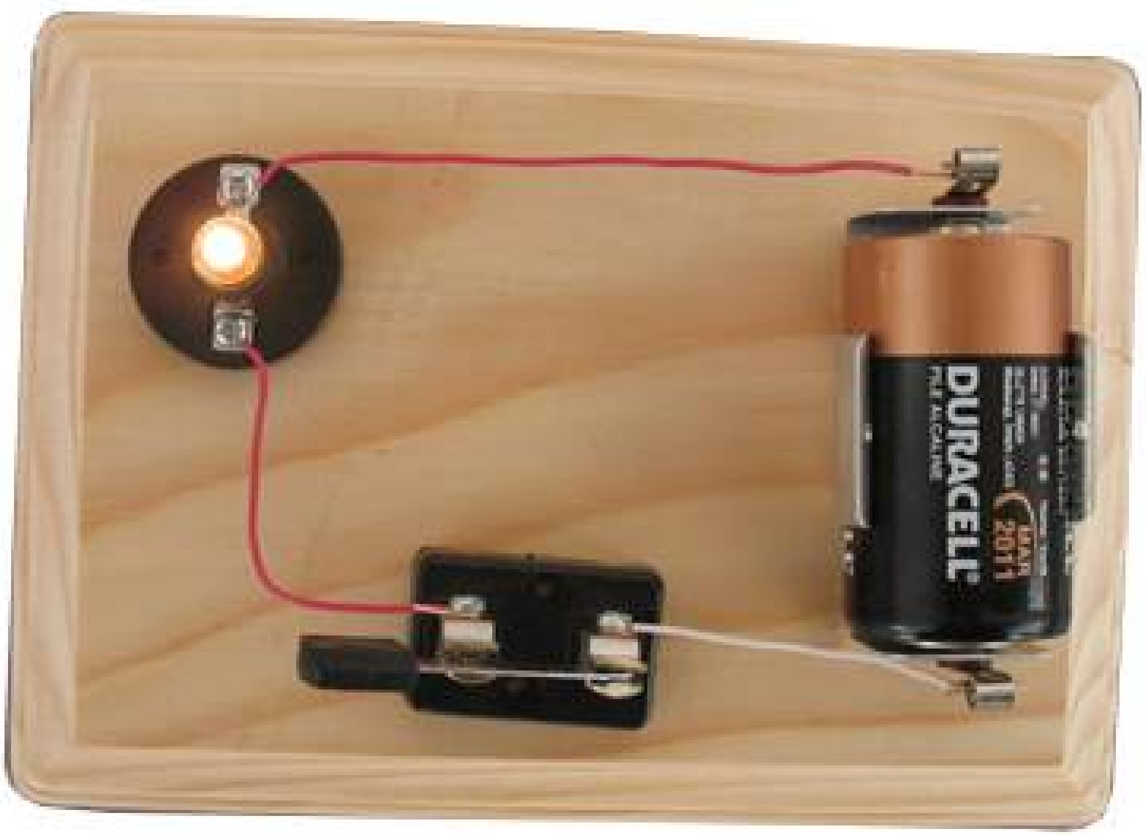
Current

Resistivity



Resistance

Electromotive force and circuits



Energy and power in electric circuits