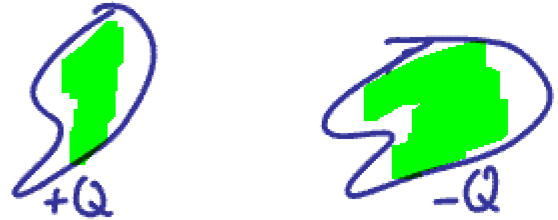
Physics 142 – September 30, 2008

- Exam 1 – Oct 7 0800–0920 B+L 109
  NOT Oct 2 during class time
  - Calculators
  - 1 3x5 index card (both sides) formulas
  - Past P142 exams
  - formula sheet + integral tables supplied
  - material coverage
    - START up to Dielectrics
    - P.S. 1–4 (except probs 13–15 of PS4)
    - Workshops 1–4
    - Lectures Thru start of Dielectrics today
    - Text chaps 22 – 26.2, 1st page of 26.4

Graded P.S. Available thru P.S. 3

Last Time –

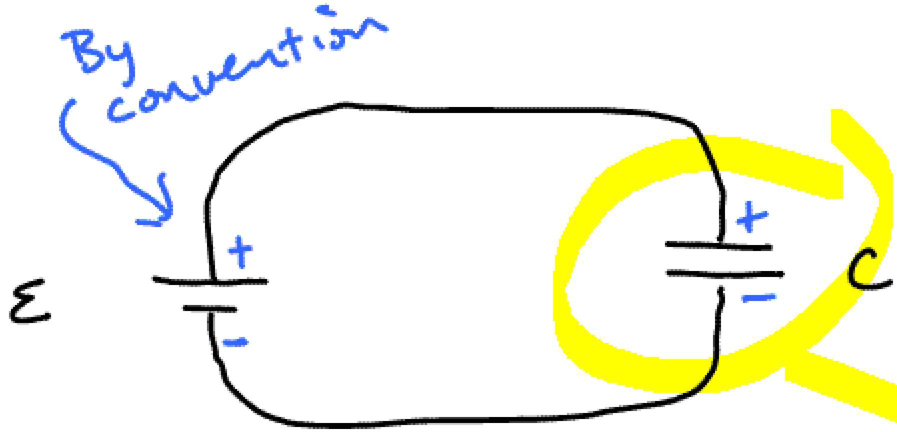


Potential (Difference) $\propto$ Q

$$V = QC$$

C ≡ capacitance (Farads ≡ mks unit)

Depends on <u>geometry</u>

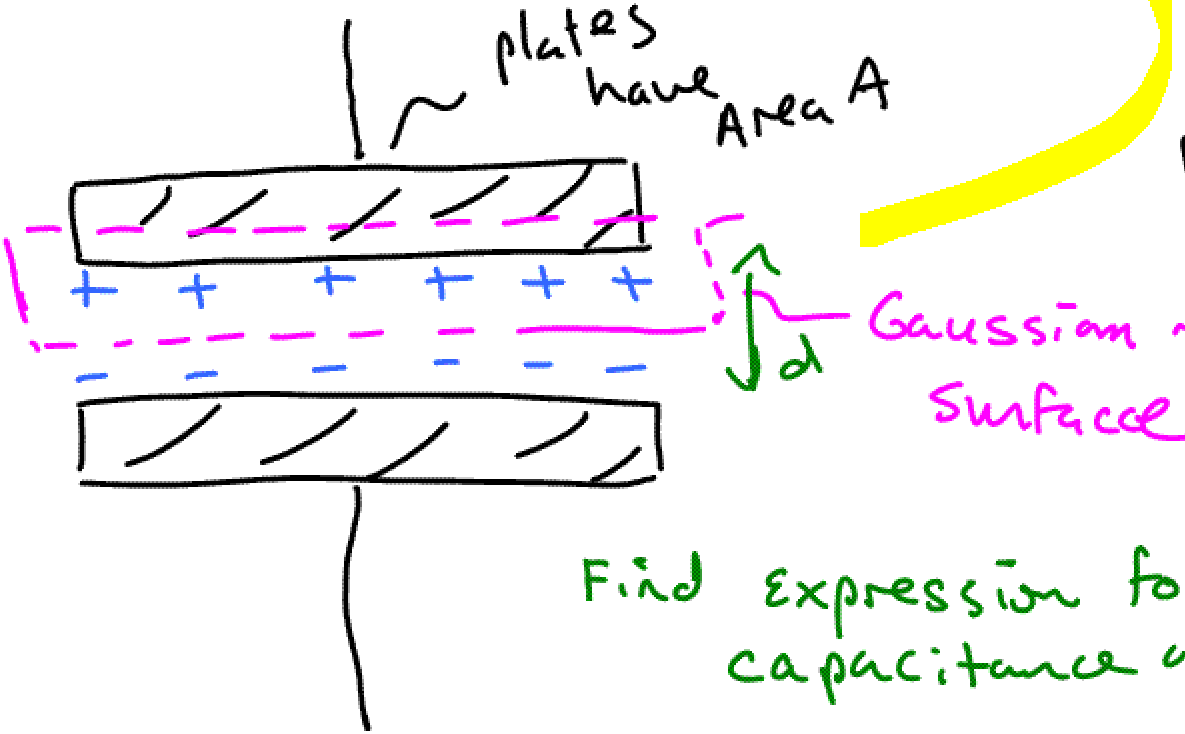


each plate

$Q \equiv$ charge

$A \equiv$ Area

$\sigma = Q/A$



Find expression for capacitance of system

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

$E=0$

$$|\vec{E}|\,A = \frac{\sigma A}{\epsilon_0}$$

of Bottom of Box

$$V = \frac{W}{q} = \frac{Fd}{q} = Ed$$

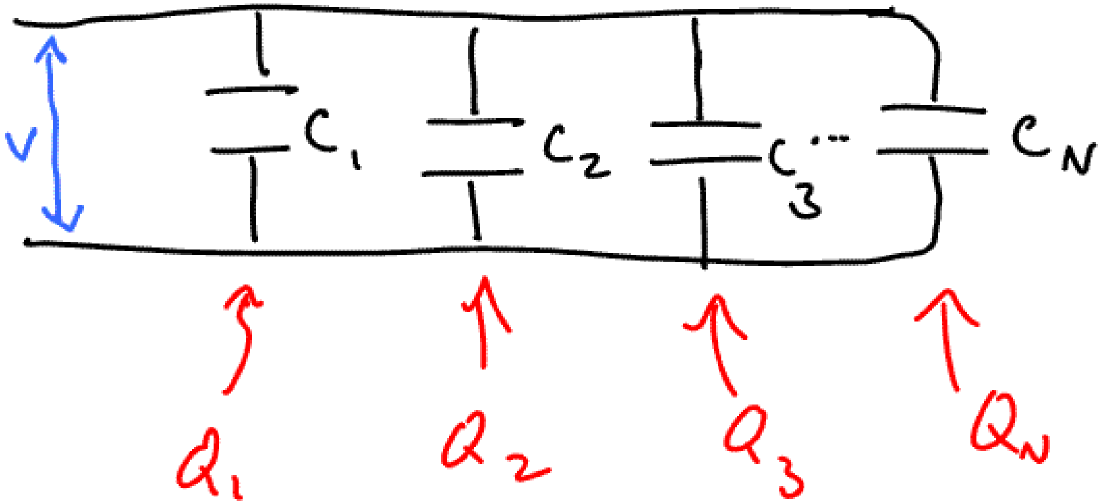
for // plates

$$|\vec{E}| = \frac{\sigma}{\epsilon_0}$$

$$C = \frac{Q}{V} = \frac{\sigma A}{Ed} = \frac{A\epsilon_0}{d}$$

only geometry

Capacitors in Parallel



$$Q_{TOT} = Q_1 + Q_2 + \cdots + Q_N$$

$$Q_{TOT} = C_{TOT} V$$

Total capac. of circuit

$$Q_1 = C_1 V$$

$$Q_2 = C_2 V$$

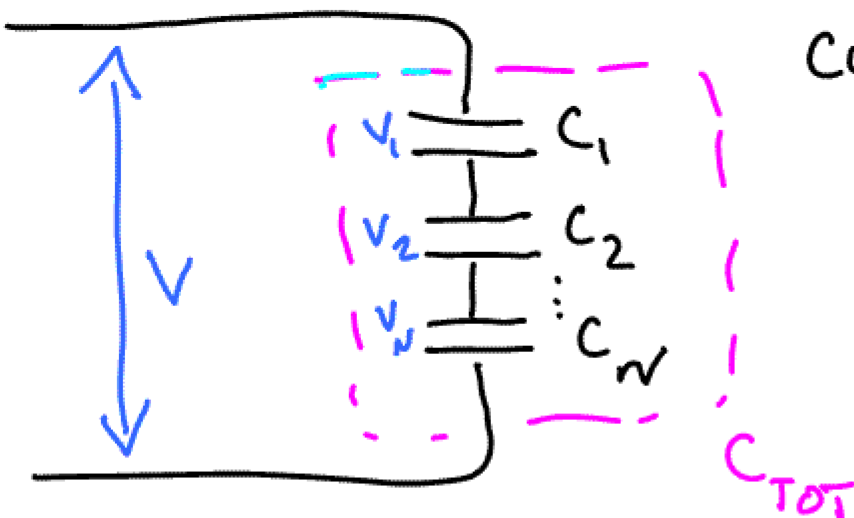
$$\vdots$$

$$Q_N = C_N V$$

$$C_{TOT} V = C_1 V + C_2 V + \cdots + C_N V$$

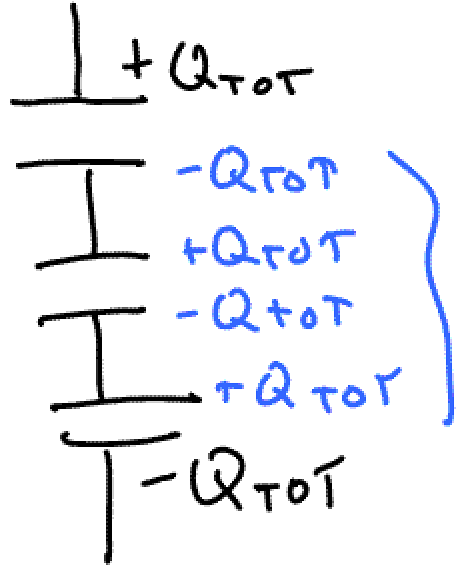
$$C_{TOT} = C_1 + C_2 + \cdots + C_N = \sum C_i$$

$$\boxed{C = \sum C_i \quad \text{capacitors in parallel}}$$



capacitors in series

$$C_{TOT} V = Q_{TOT}$$



chg induced

$$C_1 V_1 = Q_{TOT}$$

$$C_2 V_2 = Q_{TOT}$$

$$C_N V_N = Q_{TOT}$$

$$V = V_1 + V_2 + \cdots + V_N$$

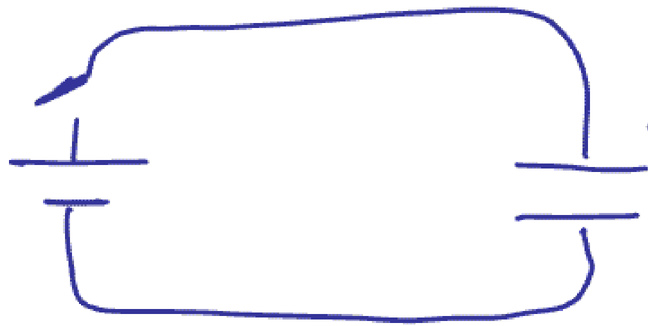
$$C_{TOT} V = Q_{TOT}$$

$$\frac{Q_{TOT}}{C_{TOT}} = \frac{Q_{TOT}}{C_1} + \frac{Q_{TOT}}{C_2} + \cdots \frac{Q_{TOT}}{C_N}$$

$$\frac{1}{C_{TOT}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_N}$$

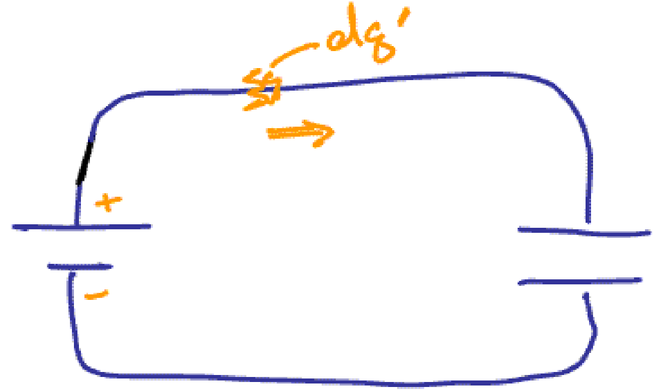
$$\boxed{\frac{1}{C} = \sum_i \frac{1}{C_i} \quad \text{capacitors in series}}$$

Time dependence



at moment switch is closed capacitor begins to charge

Moment later



$V = EMF$

$q' = CV'$

$$dw = v'\,dq'$$

$$q' = c\,v'$$

geometry

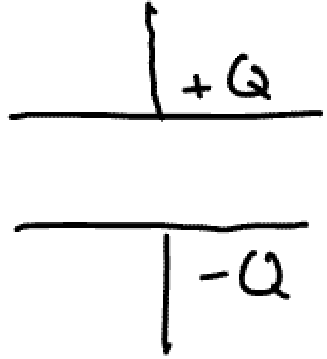
$$dw = \frac{q'}{c}\,dq' \qquad Q = CV$$

$$W = \int_0^Q \frac{q'}{c}\,dq' = \frac{1}{c}\frac{Q^2}{2} = \frac{c^2V^2}{c\,2} = \frac{1}{2}cV^2$$

Energy Stored by Capacitor

Work it takes to charge a capacitor

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



where is the energy?

$\longrightarrow$ in Electric field

Energy density of Electric field

$$u_E = \frac{U_{\text{TOT Energy}}}{\text{Vol. bet. plates}} = \frac{\frac{1}{2}CV^2}{dA} = \frac{1}{2}\frac{A\epsilon_0}{d}V^2\frac{1}{dA}$$

$$C_{\text{// plates}} = \frac{A\epsilon_0}{d}$$

$V \sim Ed$

$$u_E = \frac{\epsilon_0 V^2}{2d^2} = \epsilon_0 \frac{|E|^2 d^2}{2d^2}$$

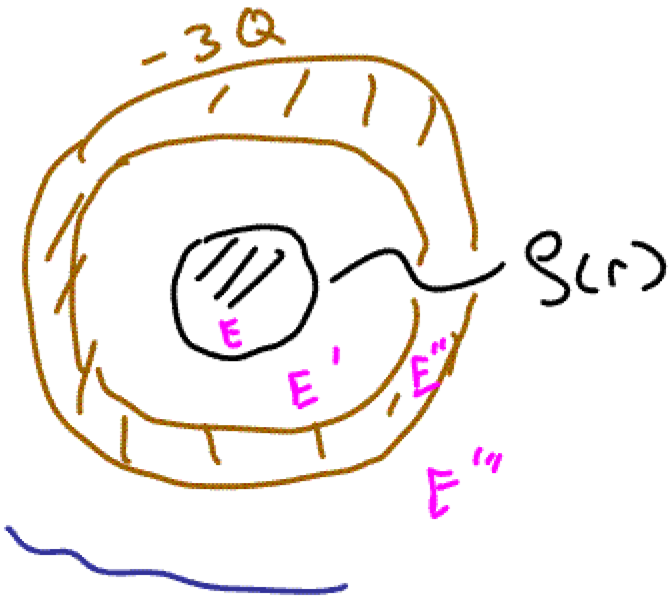
$$\boxed{u_E = \frac{\epsilon_0}{2}|E|^2} \rightarrow \text{general}$$

From a particular geometry that is easy to analyze and understand, we've found an expression for the energy density in electric field.

Final expression contains nothing specific to the particular example chosen.

$\Rightarrow$ This is a general result

Electric fields carry energy



Some "system"

Can look at any system and solve for $|\vec{E}|$.

Once you know $|\vec{E}|$ everywhere you can calculate the total energy of the system as

TOTAL Energy

$$U = \int_{vol} u_E \, dv$$