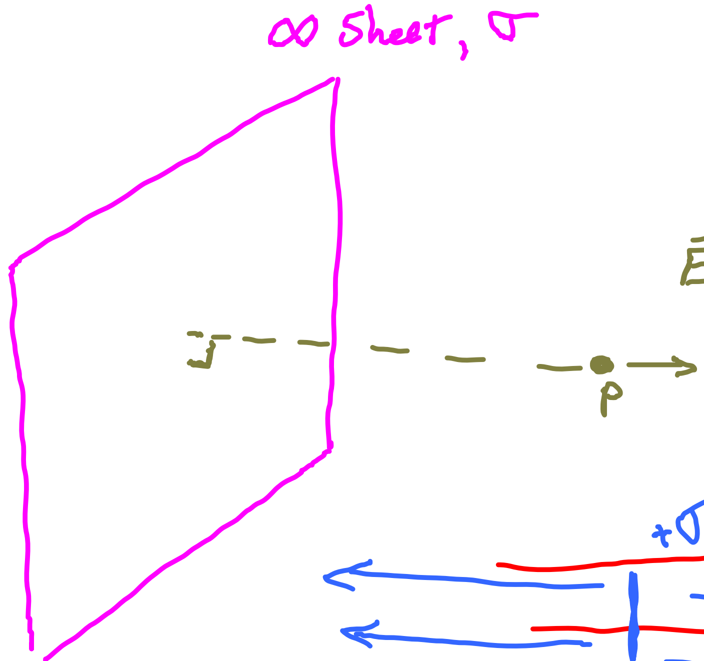
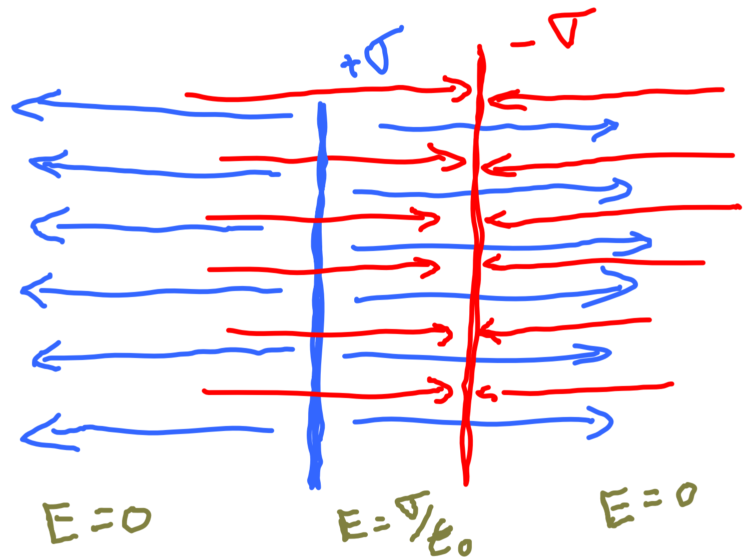
Physics 142 - September 30, 2014

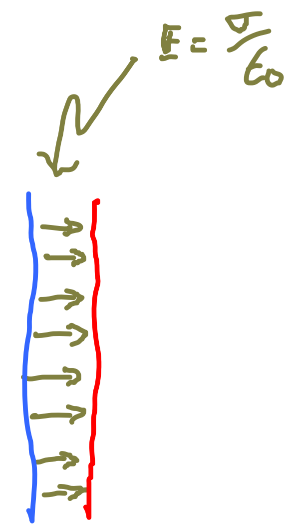
- I'm moving locally over the weekend
  Apologies if email response cryptic (using phone) or slow
- Exam in 1 week ... here
- Scheduling Q+A session on Monday
  Please Fill out Doodle Poll ASAP

Last Time



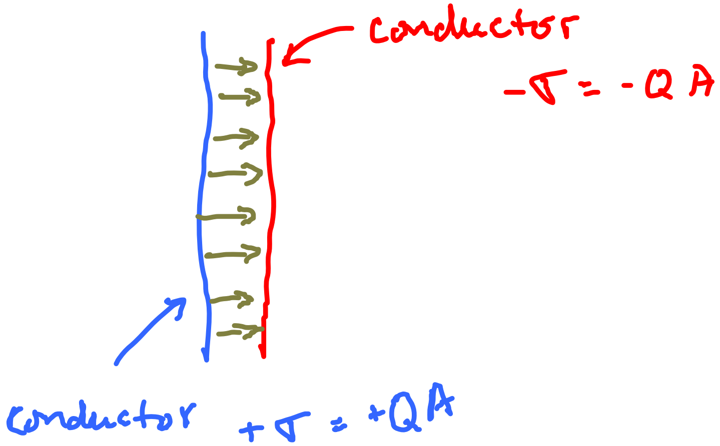
$\vec{E} = \frac{\sigma}{2\epsilon_0}$ Away from sheet





parallel plates

Capacitance



Example of capacitor

"Packages" $\vec{E}$

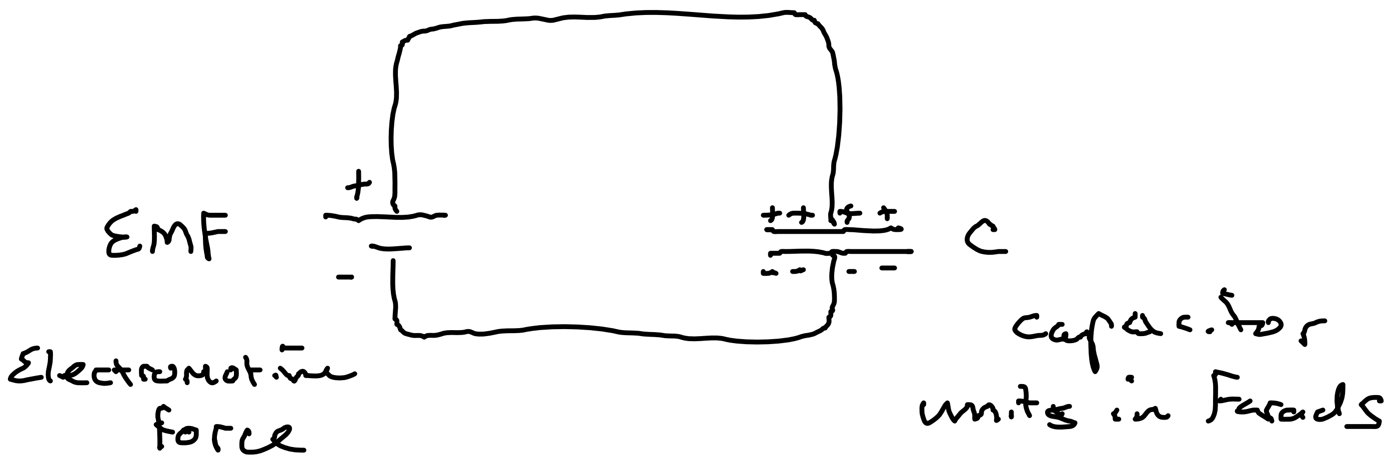
Stores charge

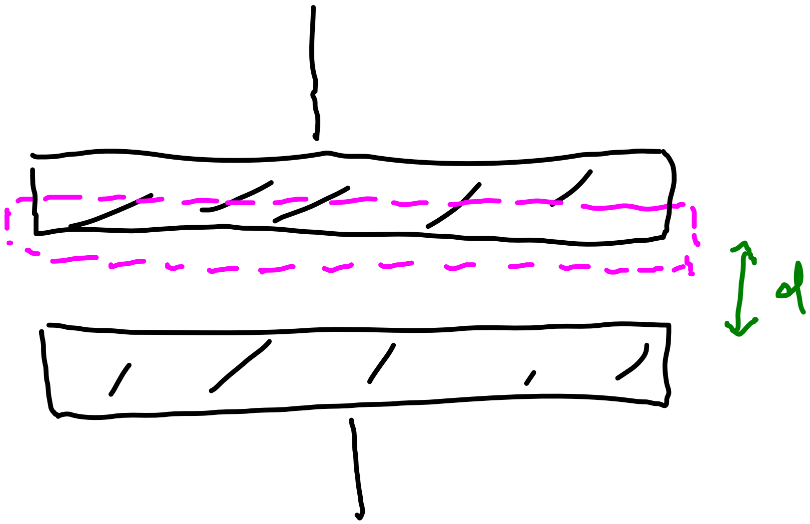
$$Q = C V$$

Q: charge on each conductor
Total is zero

V: potential difference between conductors

C: Capacitance depends on geometry of system


EMF
Electromotive force
C
capacitor
units in Farads



$$\oint \vec{E} \cdot d\vec{A} = |E| A$$

$$= \frac{Q_{encl}}{\epsilon_0} = \frac{\sigma A}{\epsilon_0}$$

$$|E| A = \sigma A / \epsilon_0 \qquad |E| = \sigma / \epsilon_0$$

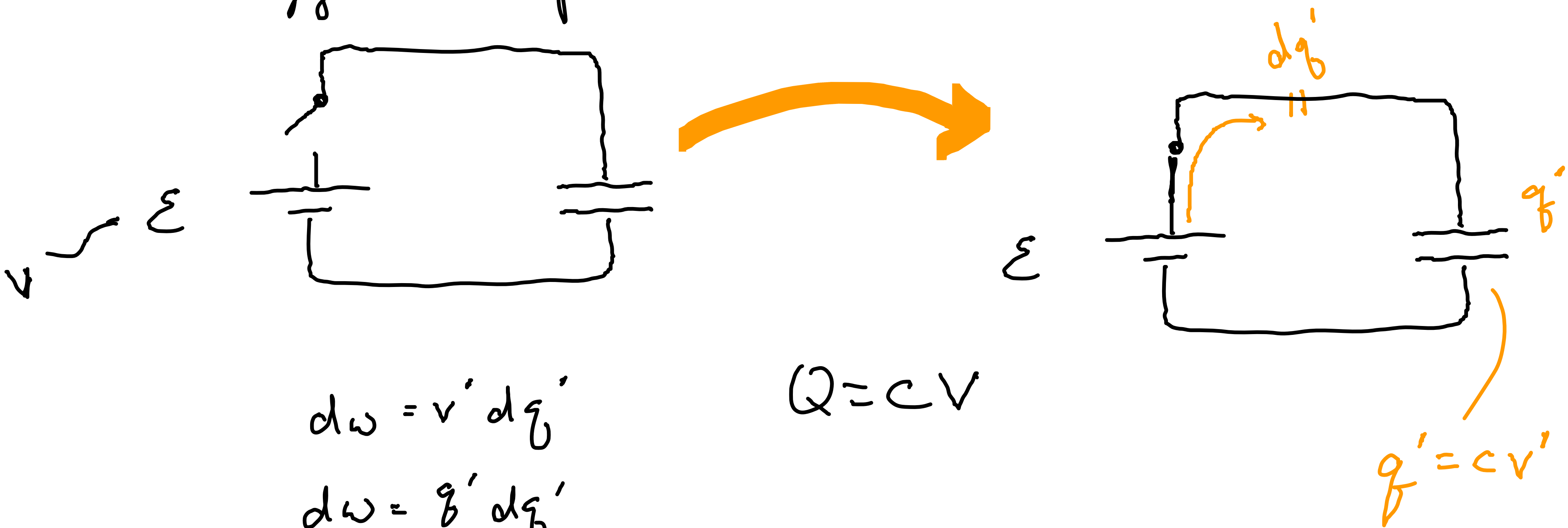
$$V = E d$$

$$Q = C V$$

$$C = \frac{Q}{V} = \frac{\sigma A}{E d} = \frac{\sigma A}{\sigma/\epsilon_0 \, d} = \frac{\epsilon_0 A}{d}$$

Depends only on Geometry

Energy and Capacitors



$$Q = CV$$

$$dW = V' \, dq'$$

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

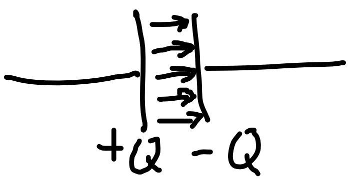
$$W = \int dW = \int_0^Q \frac{q'}{C} \, dq' = \frac{1}{C} \frac{Q^2}{2} = \frac{1}{C} \frac{C^2 V^2}{2} = \frac{1}{2} C V^2$$

Energy it takes to charge capacitor $\equiv U = \frac{1}{2}CV^2$

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

Energy Stored in capacitor

Energy density in Electric Field



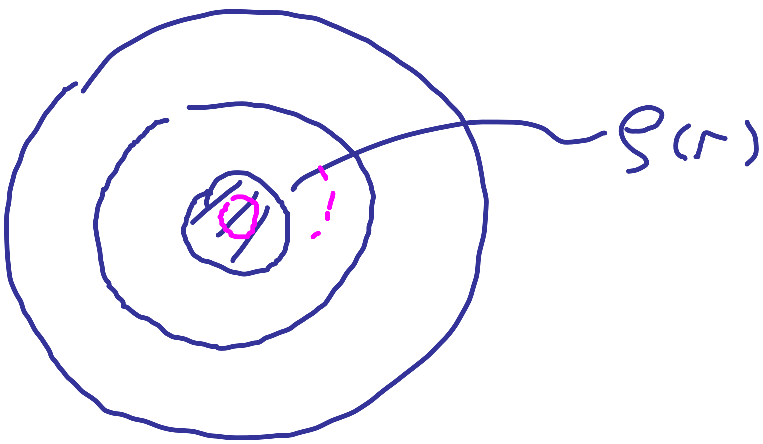
$$\equiv u_E = \frac{U_{\text{TOTAL Energy}}}{\text{Vol. Bet. plates}} = \frac{\frac{1}{2}CV^2}{dA}$$

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

$$u_E = \frac{1}{2}\frac{A\epsilon_0}{d}\frac{|E|^2 d^2}{dA} = \frac{\epsilon_0}{2}|E|^2$$

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

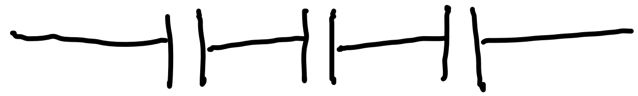
general result!



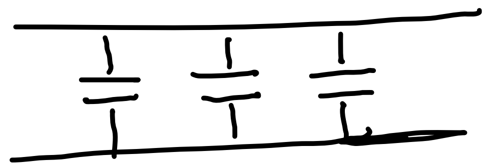
$$U_{\text{TOTAL}} = \int_{\text{vol}} u_E \, dv$$

TOTAL Energy of System

Back to capacitance

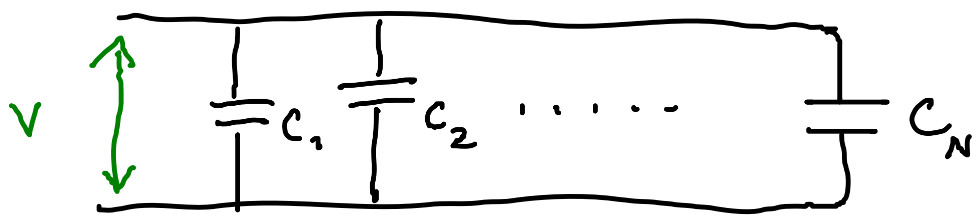


Series



parallel

What is capacitance of system of capacitors



$Q_1 = C_1 V$ $Q_2 = C_2 V$ $Q_N = C_N V$

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

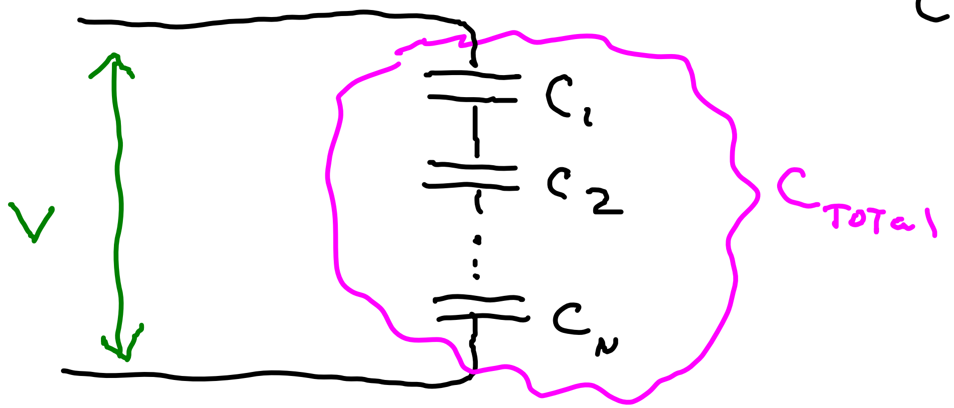
$$C_{TOT} V = C_1 V + C_2 V + \cdots + C_N V$$

$$C_{Total} = C_1 + C_2 + \cdots + C_N = \sum_i C_i$$

$$\boxed{C_{Total} = \sum_i C_i}$$

capacitors in parallel

Capacitors in Series



$$Q_{TOTAL} = C_{TOTAL} V$$

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

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

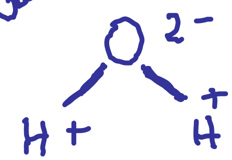
$$\frac{1}{C_{TOTAL}} = \sum_i \frac{1}{C_i}$$

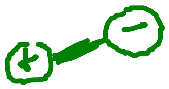
$\vec{E}$ in Materials - noncondutors

dielectric

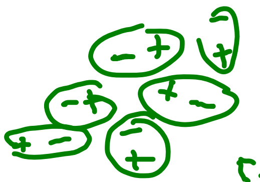
Polar

water



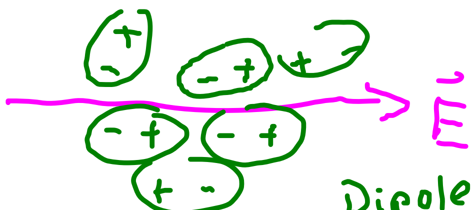


inherent dipole



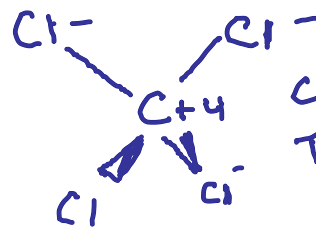
E=0

random orientations

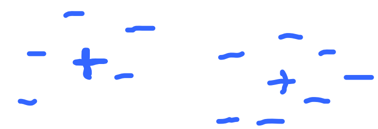


Dipoles Align w/ field

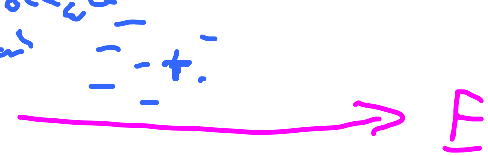
nonpolar



carbon Tetrachloride

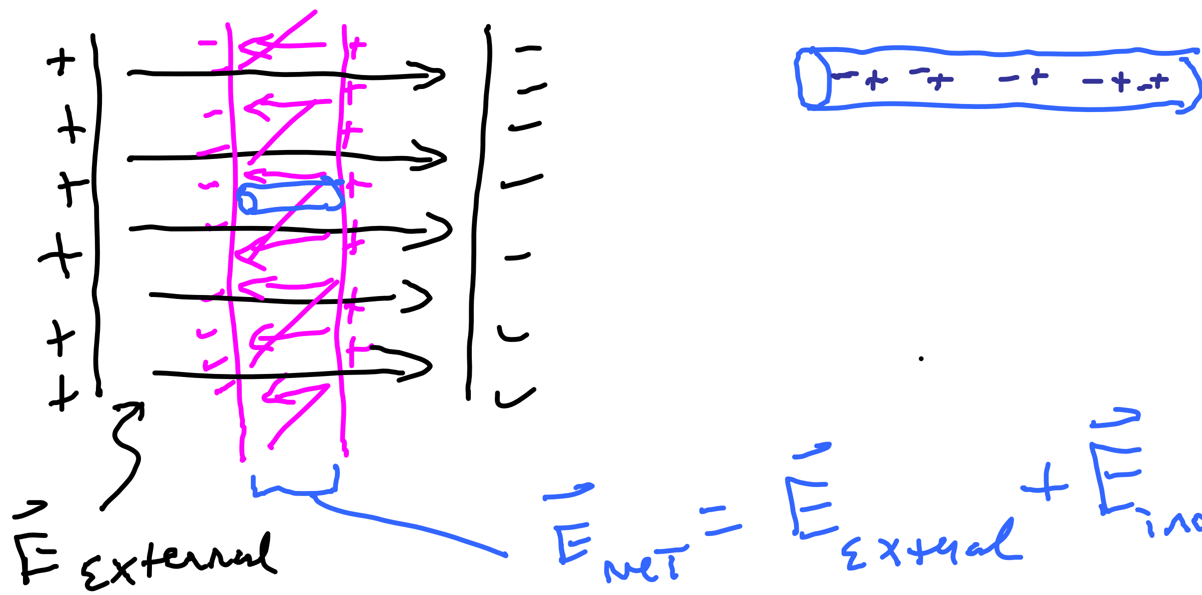


E can induce a dipole element in materials



dipoles Aligned $\propto |E|$

"linear dielectric"



$\vec{E}_{net} = \vec{E}_{external} + \vec{E}_{induced}$