Physics 114 – February 19, 2015

- Exam 1 is graded
- Solns + Distribution on class website
- Will hand back + discuss toward end of class today
- Look Through/understand Solutions
  Look Through/understand what you did

Why?

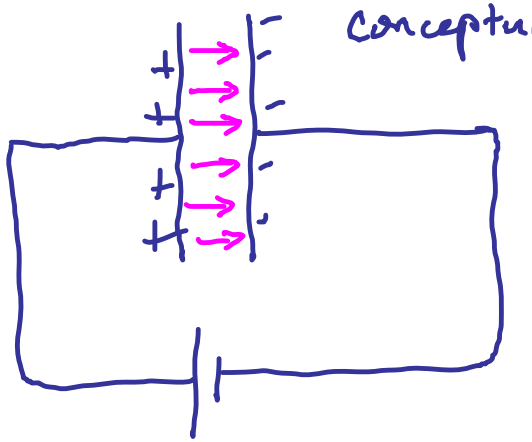
Learn
Catch grading errors
Best diagnostic for improvement

- Regrade Policy
- Troubleshooting guide
- Me  Bring your Exam

Do not wait until you see grade for Exam 2

Last Time

Capacitance



conceptually

$Q = CV$

C → Capacitance (Farads, MKS)

For // plate capacitor (// my shorthand for "parallel"; use "⊥" for perpindicular)

$$C = \frac{\epsilon_0 A}{d}$$

Depends only on geometry

Last Time — $V \propto Q$

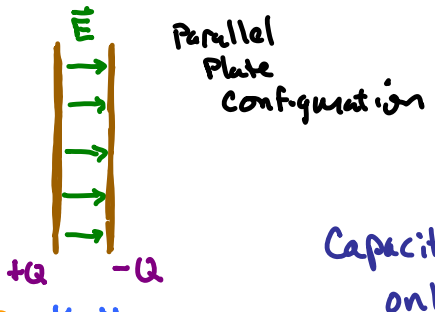
Define Capacitance as CONSTANT of Proportionality

$Q = CV$

$\equiv$ Capacitance

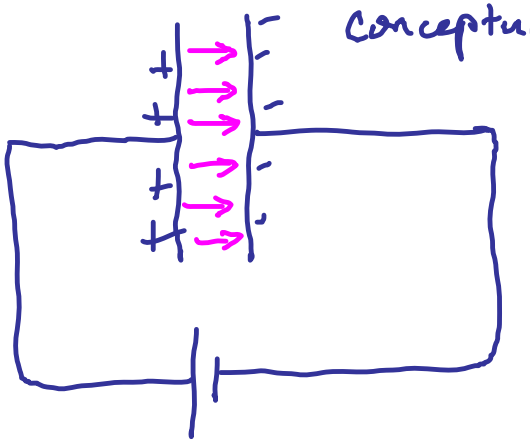
Units $= \frac{Coul}{NM/Coul} = \frac{Coul^2}{Nm}$

$\equiv$ Farad



Parallel Plate Configuration

Capacitance Depends only on geometry



Conceptually

For example:

For // plate geometry we found

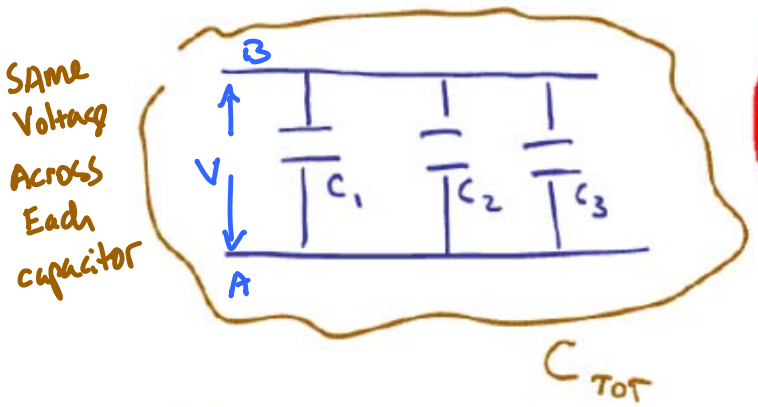
$C = \frac{\epsilon_0 A}{d}$ ← area of plates; ← Geometry only

d ↑ distance bet plates

SM shorthand for Parallel

used for perpendicular

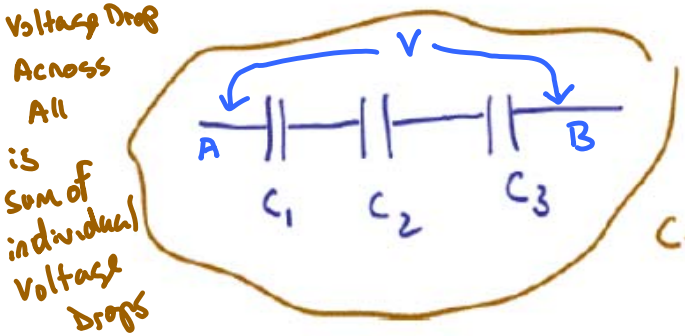
For Capacitors in parallel



$$C_{TOT} = \sum_i C_i$$

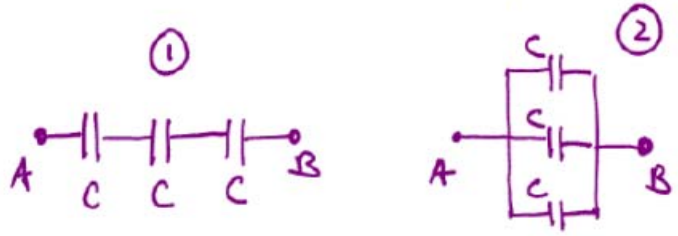
Useful

For Capacitors in Series



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

3 identical capacitors are connected in two different configurations



A voltage is applied between pts A + B

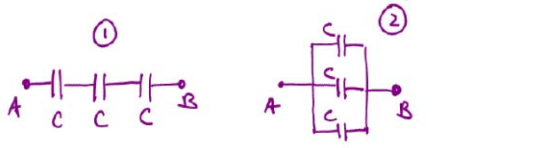
Some time passes

V_{AB}

how does the Amount of charge Stored in the LH config. compare to that on the right ?

(A) $Q_1 > Q_2$ (B) $Q_1 < Q_2$ (C) $Q_1 = Q_2$

3 identical capacitors are connected in two different configurations



A voltage is applied between pts A + B

Some time passes

V_{A-B}

how does the Amount of charge Stored in the LH config. compare to that on the right ?

(A) $Q_1 > Q_2$ (B) $Q_1 < Q_2$ (C) $Q_1 = Q_2$

$Q = CV$

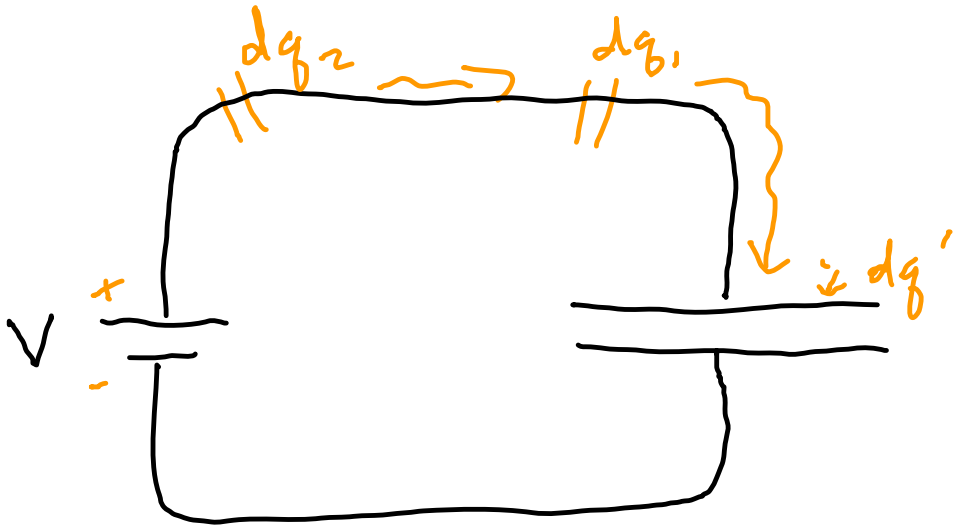
$\frac{1}{C_{TOT}} = \frac{\Sigma 1}{C_i} = \frac{3}{C}$

$C_{TOT} = \frac{C}{3}$

$C_{TOT} = \Sigma C_i$

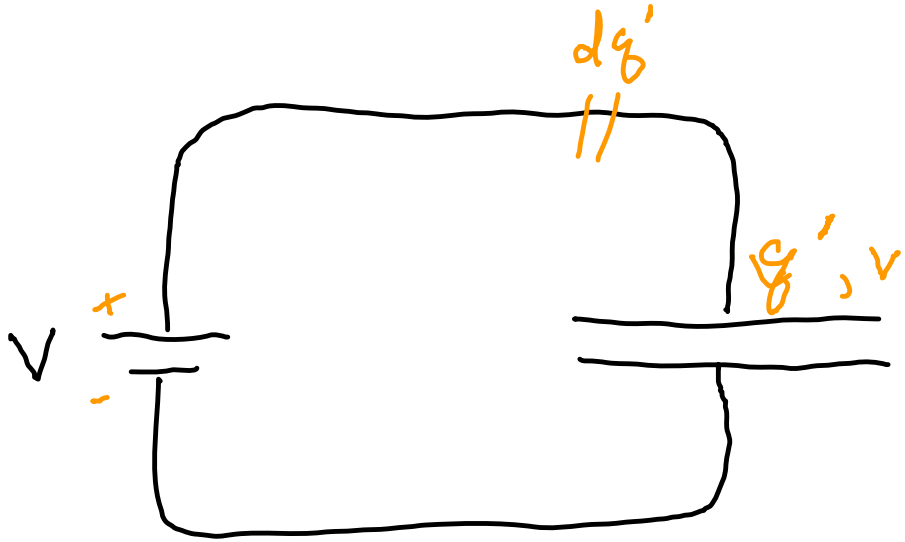
$C_{TOT} = 3C$

How much work (or Energy) does it take to charge a capacitor?



$t = 0$

$t = t_1 \cdots$



$q' = C v'$

$v' = dw / dq'$

$dw = v' dq'$

$dw = \frac{q'}{C} dq'$

$W = \int dw = \int_0^Q \frac{q'}{C} dq$

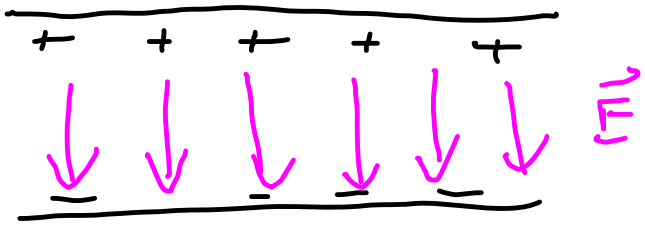
$$W = \frac{1}{C}\left.\frac{q^2}{2}\right|_0^Q = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}\frac{C^2V^2}{C} = \frac{1}{2}CV^2$$

$Q = CV$

$$\frac{1}{2}\frac{Q^2}{Q}V = \frac{1}{2}QV$$

Energy it takes to charge a capacitor

↳ Stored in the capacitor $\equiv U \equiv \frac{1}{2}CV^2 \equiv \frac{Q^2}{2C} \equiv \frac{1}{2}QV$



Energy is stored in $\vec{E}$

$$u_E \equiv \frac{U}{\text{Volume bet // plates}} \equiv \text{Energy density of Electric field}$$

$$\mathcal{U} = \frac{U}{\text{Vol bet plates}} = \frac{\frac{1}{2}CV^2}{A\,d}$$

Area of plate ↑ dist bet plates ↑

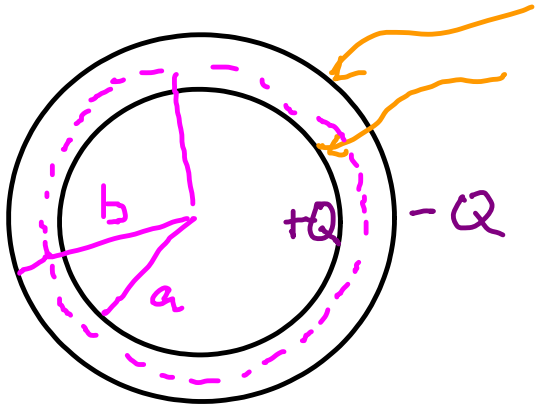
$$C_{\parallel \text{plate}} = \frac{\epsilon_0 A}{d}$$

$$\mathcal{U} = \frac{\frac{1}{2}\frac{\epsilon_0 A}{d}V^2}{A\,d} = \frac{1}{2}\epsilon_0\frac{V^2}{d^2} = \frac{1}{2}\epsilon_0|\vec{E}|^2$$

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

$$E = \frac{V}{d}$$

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



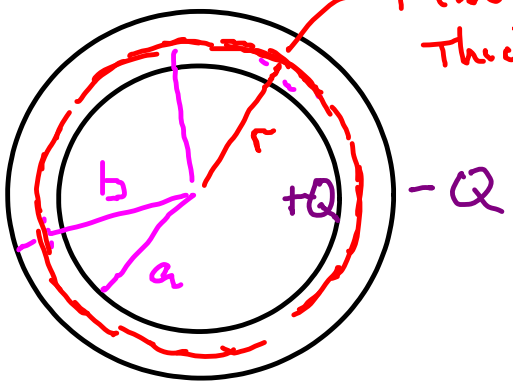
What is total energy stored in this system?

for $r<a$ $E=0$ (no charge encl)

For $r>B$ $E=0$ (NET charge encl $=0$)

For $a<r<b$ $\oint E \cdot dA = \frac{Q_{encl}}{\epsilon_0}$

$$|\vec{E}| 4\pi r^2 = \frac{+Q}{\epsilon_0} \rightsquigarrow |\vec{E}| = \frac{Q}{4\pi\epsilon_0 r^2}$$



To get Energy (total)

$$(u_E)(\text{vol}) = E$$

↑ problem dep on r

$$dU = 4\pi r^2 dr\, u_E = u_E\, 4\pi r^2 dr$$

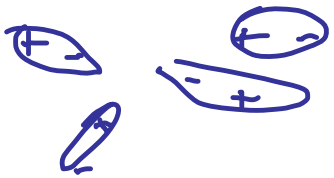
$$dU = \underbrace{\left(\frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\right)^2 \frac{\epsilon_0}{2}}_{u_E} 4\pi r^2 dr$$

$$U = \frac{1}{(4\pi\epsilon_0)^2}\frac{Q^2}{2}\epsilon_0 4\pi \int_a^b \frac{1}{r^2}\,dr = \frac{Q^2}{2}\left[-\frac{1}{r}\right]_a^b$$

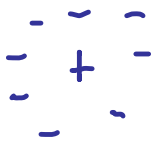
$$\boxed{U = \frac{1}{4\pi\epsilon_0}\frac{Q^2}{2}\left(\frac{1}{a} - \frac{1}{b}\right)}$$

Electric fields in Materials

Polar



Non polar



Mean = 60

Median = 59

Here is the takeaway ⇒

Do not ask me to tell you if you are an A or an A- or a contact etc. on This Exam

Seeing some pretty serious holes - vector addition...

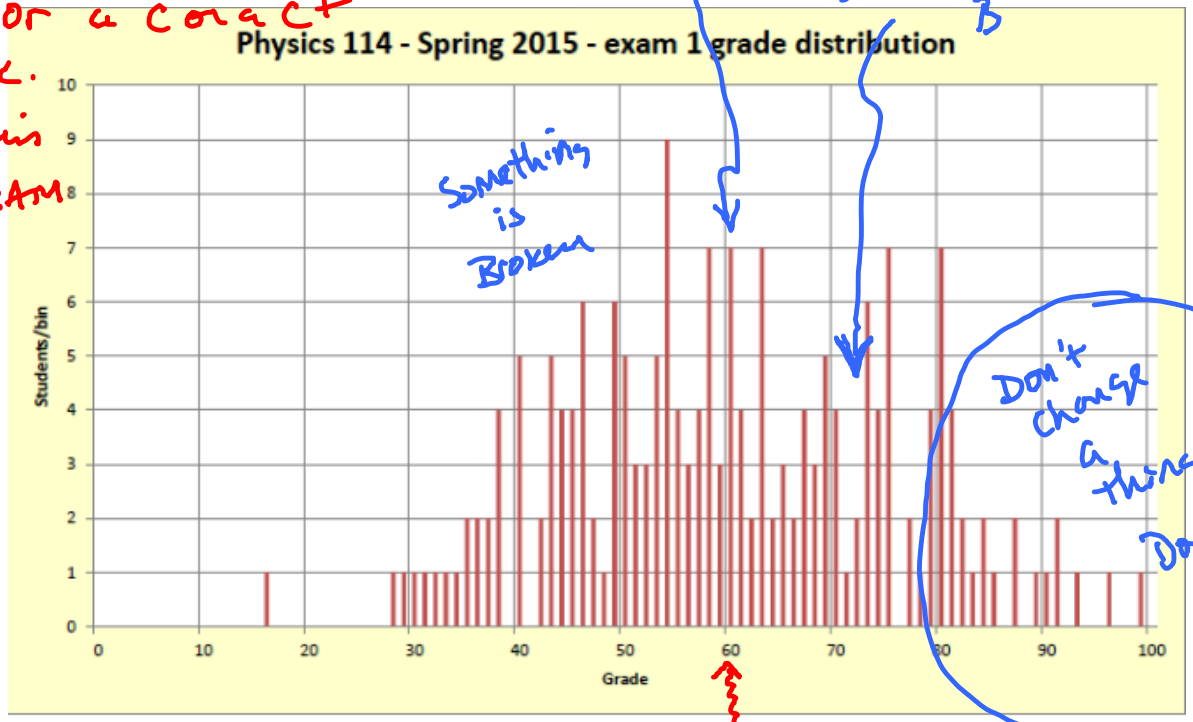
Some holes

Some mistakes

doing okay

B

B-



Something is Broken

Don't change a thing

Don't let up

Mean