Lecture: 17 (iq15)

Lecture Demo:

- Assorted capacitors, discharging a capacitor
- Magnetic field around a long wire

1. Capacitance: Computer keyboard button
2. Energy stored in a capacitor. **Clicker 16-2**
3. Capacitor: E, V and C, and U
4. Capacitor filled with dielectric medium: K: E', V', C' and U'. **Clicker16-5, 16-6**
5. Two problems in h3.
   a. Comment on **Ch17-h3, 005**
   b. A modified problem based on Ch17, **h3, 010-011**.
6. Biot Savart law, RHR1 and RHR2.

Announcement:

- My office hour: 9:15 to 10:15.
- You may setup may set up an appointment to meet with me to discuss your midterm1 performance. (Bring your redo midterm1 work when you come.)

ig 15

1. Capacitance : $C = \frac{Q}{V}$

$$C = \frac{Q}{Ed} = \frac{Q}{\left(\frac{Q/A}{\epsilon_0}\right)d} = \frac{\epsilon_0 A}{d}$$

Units: $\frac{\text{Coul.}}{\text{vol.}} = \text{farad}$

Computer Key button — Estimate C

$A \sim 1\,cm^2$

$d \sim 1\,mm$

$\epsilon_0 = \frac{1}{4\pi k} \sim 8.85 \times 10^{-12} \sim 10^{-11}$.

#1 Find: C $10^{-10}f$ $10^{-11}f$ $10^{-12}f$

Ans $10^{-12}f = 1pf$.

2. Energy stored in a capacitor, Q, A, d.

$$U = F^{ext} d = Q E_Q^{1\,plate} d$$

$$= Q\left(\frac{Q/A}{2\epsilon_0}\right)d$$

#2 clicker 16-2 $$= \frac{Q^2}{2} \cdot \frac{1}{\frac{\epsilon_0 A}{d}} = \frac{Q^2}{2C}$$

In terms E :-

$$E = \frac{Q/A}{\epsilon_0}, \quad Q = \epsilon_0 E A$$

$$\therefore U = \frac{(\epsilon_0 E A)^2}{2} \cdot \frac{1}{\epsilon_0 A} = \left(\frac{\epsilon_0 E^2}{2}\right)(Ad), \quad u = \frac{\epsilon_0 E^2}{2}$$

volume

whenever there is E there is electric energy

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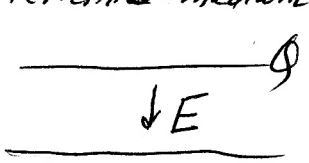
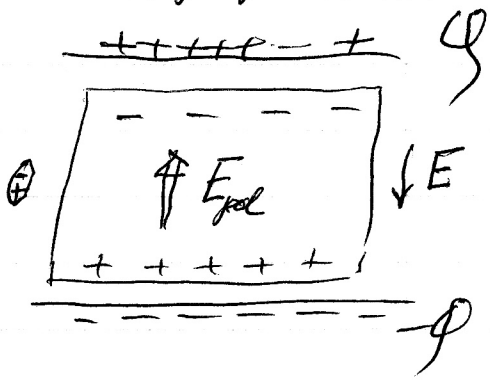
3. Dielectric medium —



$E' = \frac{E}{K}$

Medium in Gap	K
vac	1
Air	1.0006
typical plastic	5
Water	80
Semi-cond	~300
Conductor	∞

Microscopic picture —



$E' = E - E_{pol} = E/K$

$$\frac{Q/A}{\epsilon_0} - \frac{Q_{pol}/A}{\epsilon_0} = \frac{Q/A}{K\epsilon_0}, \quad Q - Q_{pol} = \frac{Q}{K},$$

$$Q_{pol} = Q\left[1 - \frac{1}{K}\right]$$

2 limits: vac $K=1 \Rightarrow Q_{pol} = Q\left[1 - \frac{1}{1}\right] = 0$

metal: $K=\infty \Rightarrow Q_{pol} = Q\left[1 - \frac{1}{\infty}\right] = Q$

General K: $1 < K < \infty$, $E' = \frac{E}{K}$, $V' = \frac{V}{K}$

$C = \frac{Q}{V}$, $C' = \frac{Q}{V'} = KC$, $U = \frac{Q^2}{2C}$, $U' = \frac{Q^2}{2C'}$

clicker 16-5

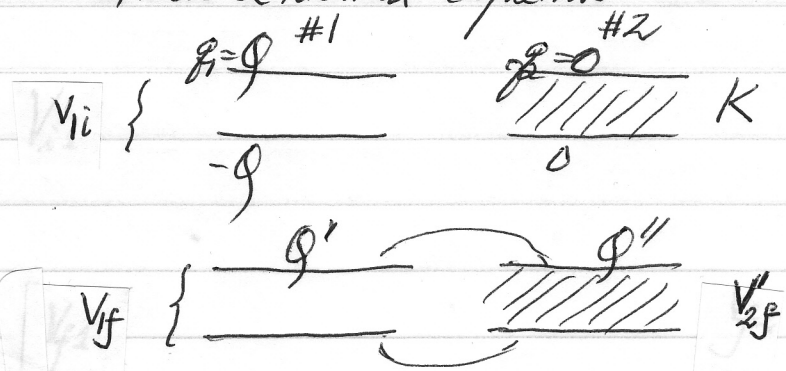
clicker 16-6: $U' = U/K$.

Capacitor: $C' = KC$

#3

4. Hint on Ch17-h3:005

Given 2 identical capacitors



Find: $\frac{V_{1f}}{V_{1i}}$

Hint: $\frac{V_{1f}}{V_{1i}} = \frac{E_{1f}\,d}{E_{1i}\,d} = \frac{\frac{Q'/A}{\epsilon_0}}{\frac{Q/A}{\epsilon_0}} = \frac{Q'}{Q'+Q''} = \frac{1}{1+\frac{Q''}{Q'}}$

#4 Clicker: Ch17-h3:005

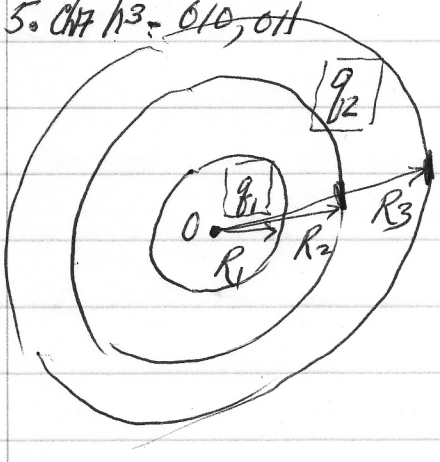
Compare V_{1f} + V'_{2f}:

1) $V_{1f} > V'_{2f}$
2) $V_{1f} = V'_{2f}$
3) $V_{1f} < V'_{2f}$

$V_{1f} = V'_{2f} \Rightarrow E_{1f} = E'_{2f} \Rightarrow \frac{Q'/A}{\epsilon_0} = \frac{Q''/A}{K\epsilon_0}$.

Solve for Q''/Q'.

5. Ch 17 h3: 010, 011



Find: V at O.

$$V_0 = V_0^{shell\,1} + V_0^{shell\,2} + V_0^{shell\,3}$$

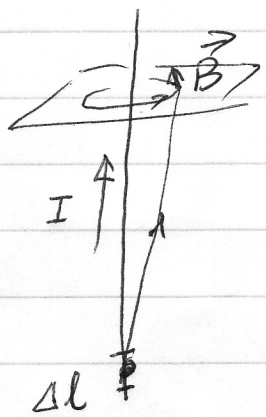
where charges are at surfaces of 3 shells.

with charges q', q', q''

radius: R_1, R_2, R_3

#5 Determine Sign of 3 terms : Ans = 1.

Demo: Magnetic field due to a long wire Previous of Ch 18



$$\Delta\vec{B} = \frac{\mu_0}{4\pi}\frac{I\Delta\vec{l}\times\hat{r}}{r^2}$$