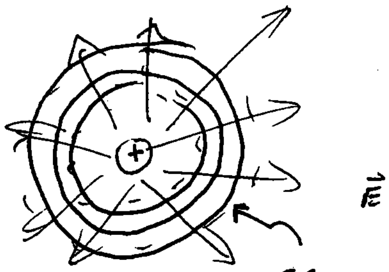
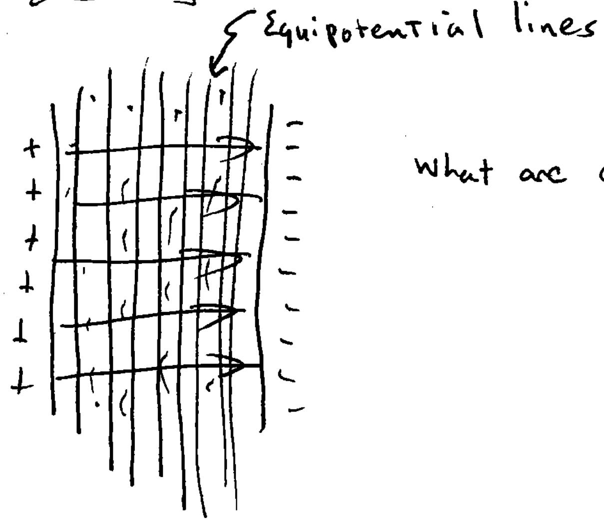
∴ $\vec{E}$ is ⊥ to equipotential surfaces at all points



What are equipotential surfaces for point charge

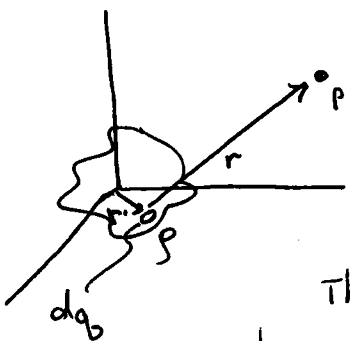


What are equipotential surfaces for ∞ plane, // charged plates ?

So

V can be used to get $\vec{E}$

V is a scalar $\quad V_p = \int_{\text{Volume}} \frac{k\,dq}{r}$



↖ $\vec{E}$ sometimes hard to calculate

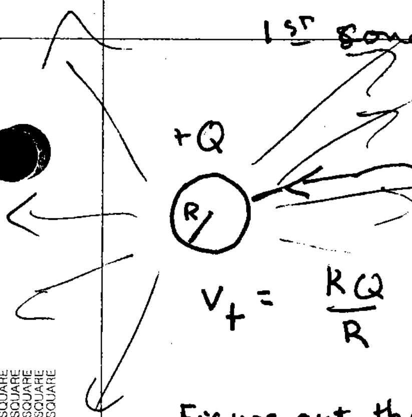
V sometimes easier

Then get $\vec{E}$

There are some special techniques beyond the scope of this course for calculating V.

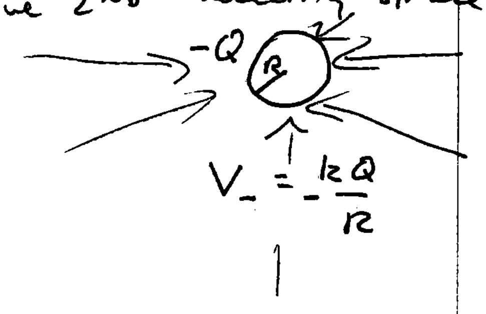
CAPACITANCE

1st conducting Sphere — $+q_0$



$V_+ = \frac{kQ}{R}$

Far FROM 1st sphere
Have 2ND conducting sphere



$V_- = -\frac{kQ}{R}$

Figure out the potential of a charge
on sphere w/ ∞ as "Zero"
of potential

Conducting sphere .... ⇒ all at same potential

$\Delta V_{+-} = V_+ - V_- = \frac{2kQ}{R}$

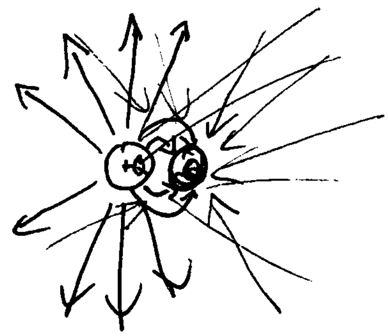
capacitance of 2 sphere systems $C = Q/V_{+-}$

$Q = C_+ V_+$ ←
$Q/V_+ = C_+$

$V_+ \propto Q$ $\quad$ $V_- \propto Q$ → $Q = C_- V_-$

$C \equiv$ capacitance

Now move two spheres close to each other



Use Two Transparencies
To show lines of force ~ cancelling out

but of course get dipole field
Lines of force do NOT cross

$V_+ \rightarrow V_+'$ $\quad$ $V_+' < V_+$ and $V_+' > 0$

$V_- \rightarrow V_-'$ $\quad$ $V_-' > V_-$ and $V_-' < 0$

NOW
ΔV_{+-} is Reduced, Q has NOT changed

$C = \frac{Q}{V_{+-}}$ ← defined this way

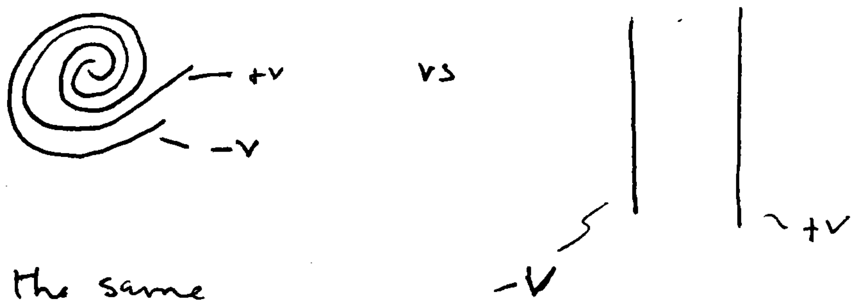
Capacitance has gotten much larger

Capacitance is the amount of charge held in a system ÷ by the potential ~~differen~~ difference between the parts of the system — or if system is one conductor — The other "part" of the system is at ∞ w/ "zero" potential

$$C = \frac{q}{\Delta V} \quad \text{in coul/volt} \equiv 1 \text{ farad}$$

in honor of Michael Faraday

Capacitance depends only on geometry
(sizes, shapes, separations of conductors)



ΔV is the same

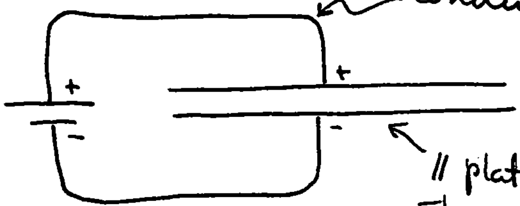
which would hold more charge? i.e., have higher capacitance?

Capacitors

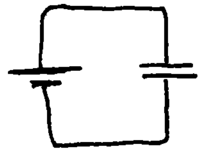
act as resevoirs of charge in electric circuits
implications of this to be covered later
can be used to store energy — which can be released
very quickly

The most common capacitor for us is

The Parallel plate capacitor

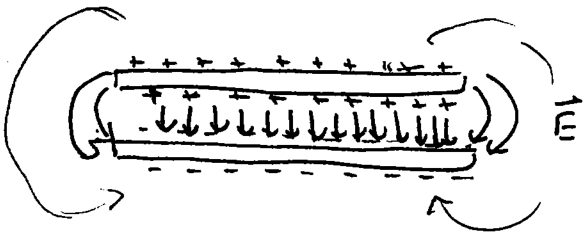


or

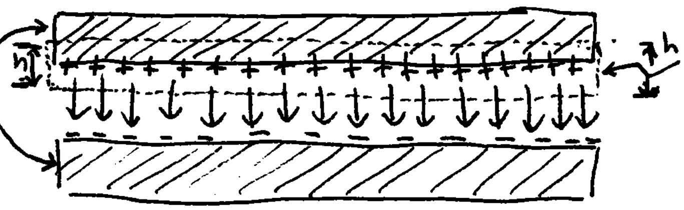


Battery ≡ Device which Maintains a constant Potential Difference between its terminals

Your first circuit diagram!



we will neglect edge effects



Capacitor plates w/ charge $+Q$ and $-Q$, Area A, Separation d

Gauss's Law

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

in integral only the surface between the plates gets a contribution because either $\vec{E}=0$ or $\vec{E}\cdot d\vec{A}=0$

So

$$|\vec{E}|A = \frac{Q}{\epsilon_0} \Rightarrow Q = \epsilon_0 |\vec{E}| A$$

The work to carry a charge q_0 from one plate to the other is Vq_0 or $q_0|\vec{E}|d$

$$\int q_0 \vec{F} \cdot d\vec{s}$$

$\therefore$

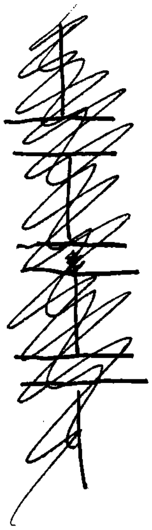
$$V = |\vec{E}|d$$

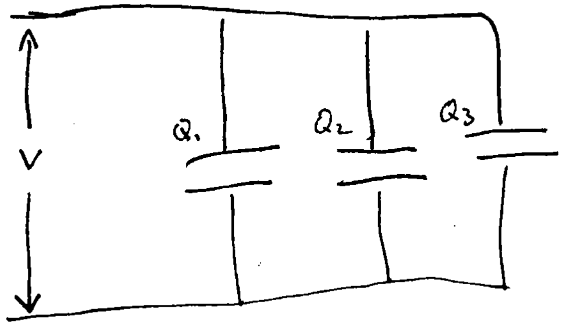
Now $$C = \frac{Q}{V} = \frac{\epsilon_0 |\vec{E}| A}{|\vec{E}|d} = \frac{\epsilon_0 A}{d}$$

Depends only on geometry ... As promised !!

Combinations of Capacitors

in Parallel //





TOTAL $Q = Q_1 + Q_2 + Q_3$

but $Q_1 = C_1 V$

$Q_2 = C_2 V$

$Q_3 = C_3 V$

$$Q_{TOTAL} = V(C_1 + C_2 + C_3)$$

$\therefore$

$$C_{\text{cap in } //} = C_1 + C_2 + C_3$$