Mon: HW by 5pm

Phys 132 Ex: 70, 71, 72, 73, 75, 76, 77, 78

can use various strategies

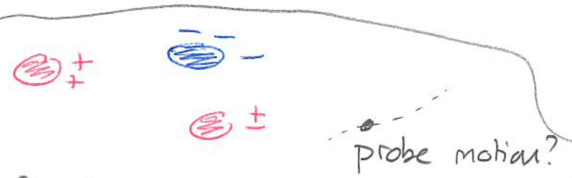
Tues: Warm Up 5

Weds: Review Exam I

Thurs: Exam I → see previous exams

Electrostatics framework

The framework for electrostatics is



fixed sources act on probe

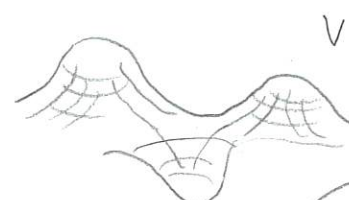
Sources produce electric field

Field exerts force on probe:

$$\vec{F} = q_{probe}\vec{E}$$

$$F_{net} = m\vec{a}$$

Sources produce electric potential



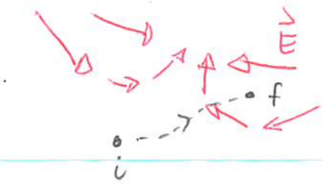
Electric potential energy of probe

$$U_{elec} = qV$$

Energy conservation $\Delta K + q\Delta V = 0$

The two methods are related via:

Given electric field $\vec{E}$



path from i to f

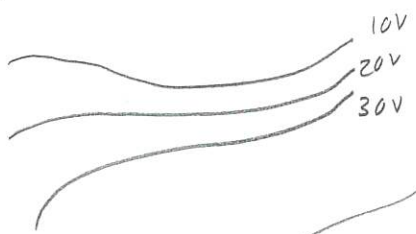
$\longrightarrow$

Electric potential difference

$\Delta V = V_f - V_i$

$= -\sum_{\substack{\text{path} \\ \text{segments}}} \vec{E} \cdot \Delta \vec{r} = -\int \vec{E} \cdot d\vec{r}$

Given electric potential, V



$\longrightarrow$

Obtain electric field via

* direction: perpendicular to equipotentials / downhill

* $E_x = -\frac{dV}{dx}$

  $E_y = -\frac{dV}{dy}$ etc...

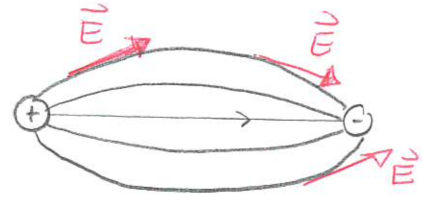
Quiz1 30% – 100%

Electric field lines

It is often less convenient to represent electric fields via vectors than lines, called electric field lines.

An electric field line is a line such that the electric field vectors are tangent to the line.

The strength of the electric field can be represented via the density of the lines.



Demo: Falstad – Electric fields

– Field Lines – dipole

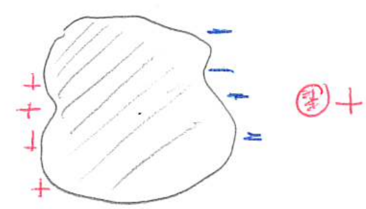
Conductors in equilibrium

In a perfect conductor charges flow without impediment and always arrange so that:

> In an electrostatic situation:
>
> * the field inside a conductor is zero
>
> * excess charge resides on the surface of the conductor.

Now consider the implications of this for the electric potential inside and on the conductor.

Could the potential vary from one location to another? If so what would it imply



Quiz 2 30% - 90%

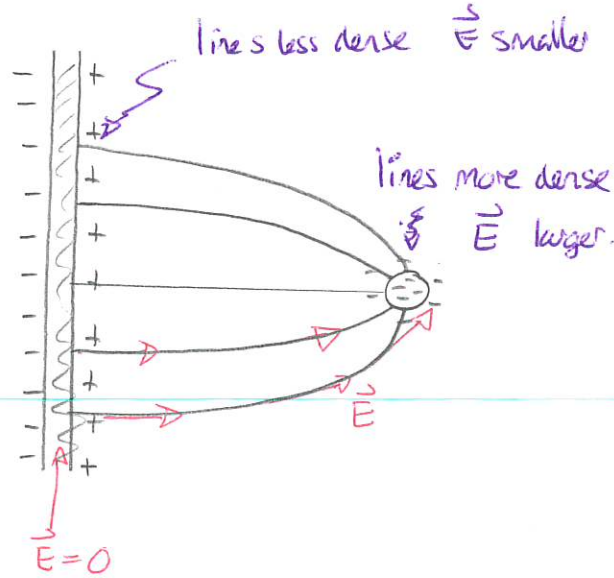
If the potential varied anywhere within the conductor, then the electric field would be non-zero at some locations. This is impossible. Thus:

> The electric potential everywhere inside a conductor takes the same value. The entire conductor is a single equipotential

This means that when describing conductors we can often use electric potential and we only need to state the value of the electric potential on the conductor.

Warm Up 1

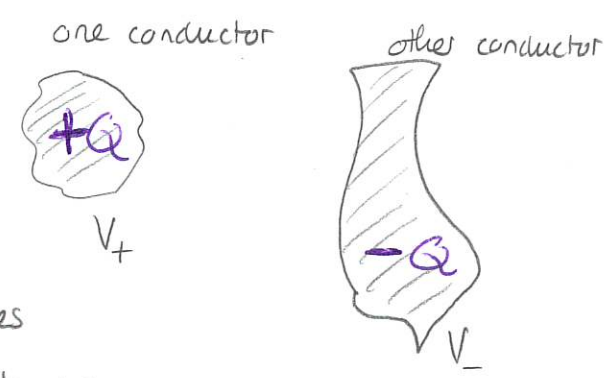
We can use this to establish basic facts about fields since at the edge of the conductor the fields are perpendicular (it's an equipotential). For example consider a point charge near an infinite sheet. Then the fact that the field lines are perpendicular gives a notion of the field direction and strength



For an infinite sheet and a point charge there is an exact technique that establishes exact expressions for the electric potential, the electric field and the charge density at each point.

Capacitors

A capacitor in its simplest construction consists of two conductors that carry charges that are equal in magnitude and opposite in sign. Each conductor is an equipotential. Thus on conductor 1 the potential is the same everywhere, and takes value V_+. On conductor 2 the potential is the same everywhere and takes value V_- (usually $\neq V_+$). These potentials are established by the excess charges on the conductors. The potential difference $\Delta V = V_+ - V_-$ will depend on:



1) the configuration of the conductors. (i.e. their size, positions...)

2) the charge placed on each.

Provided that the charges are exactly opposite, the potential difference will be proportional to Q. Thus

$$\Delta V = \text{const} \times Q.$$

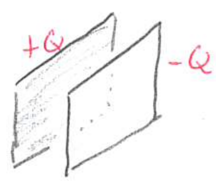
Inverting gives:

$$\boxed{Q = C\Delta V}$$

where C is a constant called the capacitance. The capacitance depends on the geometrical arrangement of the capacitors. Common examples are:

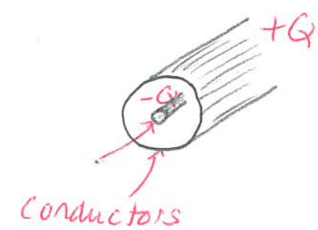
Unit: Farad $F = C/V$

Parallel plate capacitor



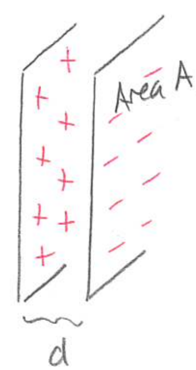
two plane sheets that are parallel

Coaxial cylindrical capacitor



Parallel plate capacitor

Consider two parallel plates, each with area A, separated by distance d. Assume that the plates are closely enough spaced that they are effectively infinite. Then we have



$$\Delta V_c = \frac{\eta}{\epsilon_0} \Delta x$$

and across the gap $\Delta x = d$.

Also $\eta = Q/A$. These give

$$\Delta V_c = \frac{Q}{A\epsilon_0} d \Rightarrow Q = \frac{A\epsilon_0}{d}\Delta V_c \Rightarrow \boxed{C = \frac{A\epsilon_0}{d}}$$

parallel plate capacitor

Warm Up 2