Phys 112 2019

Lecture 7

Tues: Discussion / quiz

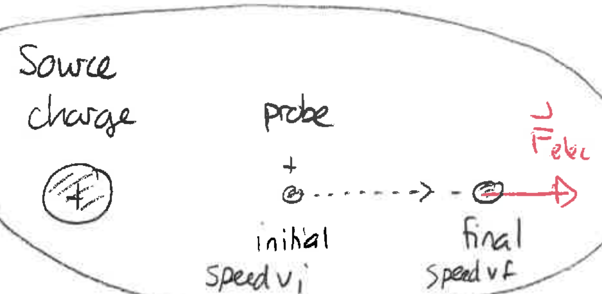
Supp Ex 25, 26, 27, 28

Ch 21 Prob 7, 73

Weds: Class Mtg.

Energy conservation

We can consider aspects of a charged particle's motion using energy conservation.



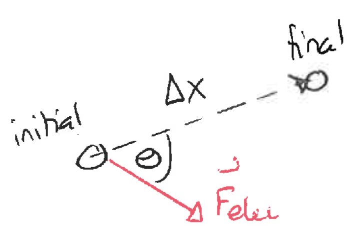
Describe kinetic energy change

$$\Delta K = K_f - K_i$$

where $K_f = \frac{1}{2} m v_f^2$

$K_i = \frac{1}{2} m v_i^2$

Work done by electric force (assume constant)



$$W_{elec} = F_{elec} \Delta x \cos\theta$$

Work kinetic energy theorem

$$\Delta K = W_{elec}$$

where W_{elec} is the work done by the electric force

Quiz 1

~~Warm Up~~

A detailed mathematical analysis shows that there exists an electric potential energy U_{elec} so that

$$W_{elec} = -\Delta U_{elec} \quad \text{and} \quad \Delta U_{elec} = U_{elec\,f} - U_{elec\,i}$$

Thus:

$$\Delta K = -\Delta U_{elec}$$

which implies that the energy is conserved or:

$$\boxed{\Delta K + \Delta U_{elec} = 0}$$

CONSERVATION OF ENERGY

An alternative statement of this is:

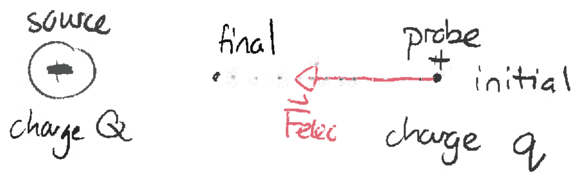
$$K_f - K_i + U_{elec\,f} - U_{elec\,i} = 0 \Rightarrow \boxed{K_f + U_{elec\,f} = K_i + U_{elec\,i}}$$

Warm Up 1

What we need are methods for computing the electric potential energy in situations such as those of warm up 1. Before we do this we will explore a general feature of the electric potential energy that allows for a slightly different calculation

Electric potential

Consider how the work done on the probe depends on the magnitude of the probe charge. Consider an example:



Here $W = F_{elec} \Delta x \cos\theta$ and

$$F_{elec} = k \frac{q Q}{r^2}$$ probe

Quiz 2

We see that

> In any electrostatic situation the work done on a probe is proportional to the probe charge

It follows that the change in electric potential energy is proportional to the probe charge. Specifically

> The electric potential energy of a probe in the presence of fixed sources is:
>
> 
>
>
> $$U_{elec} = qV$$
>
> where V is the electric potential produced by the sources alone

We see that the units of electric potential are J/C. These are called Volts. (V). So

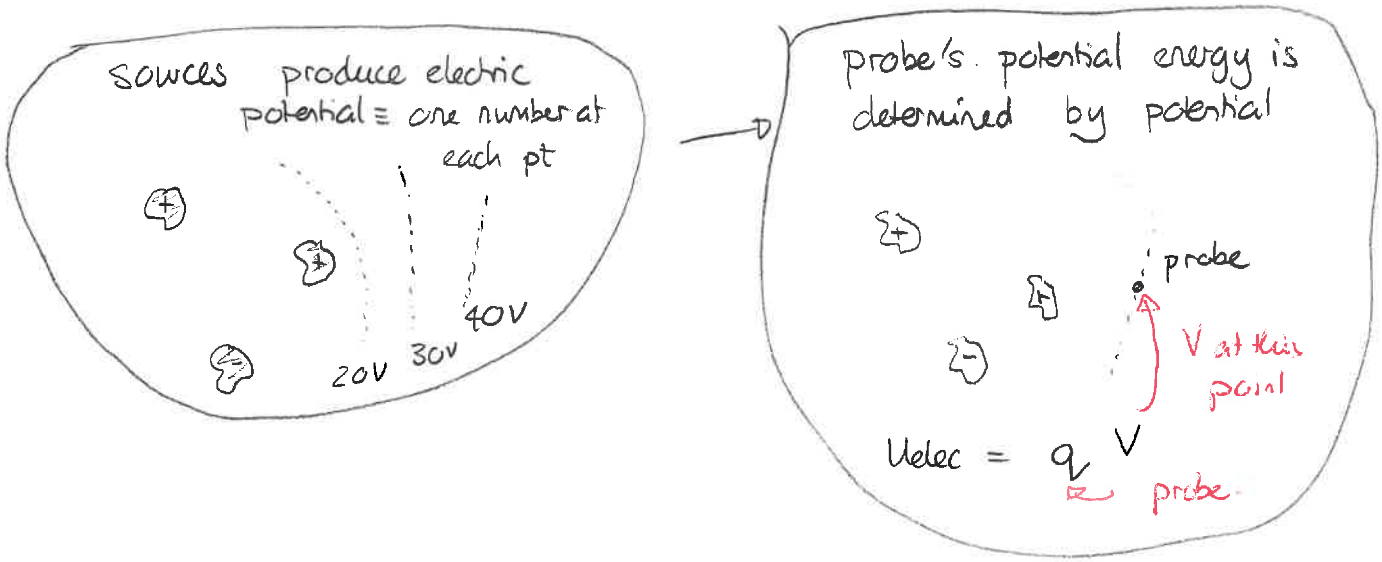
$$V = J/C$$

Warm Up 2

Then it follows that

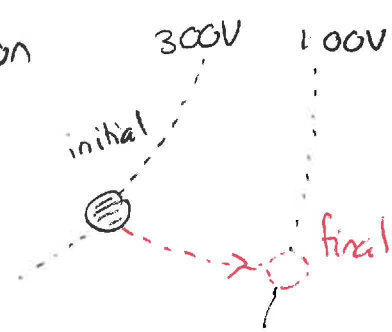
$$\boxed{\Delta U_{elec} = q\,\Delta V}$$

Note that the source charges produce a potential:



mass 5.8×10^{-26} kg

Example: A chlorine ion has one extra electron and thus charge $-1.6\times10^{-19}C$. It passes an initial location with speed 4.0×10^{4} m/s and travels as illustrated. Determine its speed at the final location



Answer: $\Delta K + \Delta U_{elec} = 0$ and $\Delta U_{elec} = q\,\Delta V$

$$\Rightarrow \quad \Delta K + q\,\Delta V = 0$$

$$\Rightarrow \quad \Delta K = -q\,\Delta V = -q\,(V_f - V_i)$$

We can get

$$q\,\Delta V = -(-1.6\times10^{-19}C)(100V - 300V)$$

$$= -3.2\times10^{-17}\,J$$

So $\qquad \Delta K = -3.2\times10^{-17}\,J$.

$$\Rightarrow \quad K_f - K_i = -3.2\times10^{-17}\,J$$

$$\Rightarrow \quad K_f = K_i - 3.2\times10^{-17}\,J$$

Now $\quad K_i = \frac{1}{2} m v_i^2 = \frac{1}{2}(5.8\times10^{-26}\,kg)(4.0\times10^{4}\,m/s)^2$

$$= 4.6\times10^{-17}\,J.$$

$$\Rightarrow \quad K_f = 4.6\times10^{-17}\,J - 3.2\times10^{-17}\,J = 1.4\times10^{-17}\,J$$

So $\qquad \frac{1}{2} m v_f^2 = 1.4\times10^{-17}\,J$

$$\Rightarrow \quad \frac{1}{2}\,5.8\times10^{-26}\,kg\;v_f^2 = 1.4\times10^{-17}\,J$$

$$\Rightarrow \quad v_f^2 = 4.8\times10^{8}\,m^2/s^2$$

$$\Rightarrow \quad v_f = 2.2\times10^{4}\,m/s$$