Lecture 9

Fri: Physics Seminar

Mon: Warm Up 4 by 9am D2L

Tues: Discussion/quiz

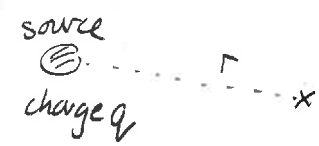
Supp 34, 35, 36, 37, 39

Ch 21 Probs 27, 32

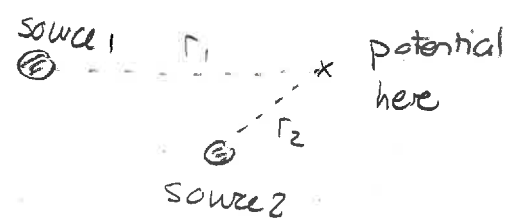
Electrostatic potential produced by multiple point sources

The electric potential produced by a single point source is

$$V = k\frac{q}{r}$$



Now suppose that there are multiple sources. These will also produce an electric potential which can be computed from the potentials produced individually by each source:



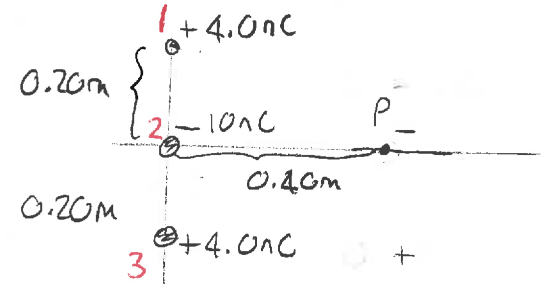
$$V = V_1 + V_2 + \cdots$$

where $V_i = k\, q_i / r_i$.

Quiz 1 70% → 95%

Quiz 2 30% → 70%

Example: Three source charges are as illustrated. An electron is located at point P. The electron is released from rest and moves right. Determine its speed when it is infinitely far from the sources.



Answer: Strategy

Energy conservation ⇒ Potential energy converted into kinetic

↳ Use $\Delta K + q\Delta V = 0$ → Get ΔV from sources

→ Get ΔK → Get v_f

Then initial = release
final = infinitely far

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

$$\Rightarrow \quad \Delta K = -q\Delta V$$

$$K_f - K_i = -q\Delta V$$

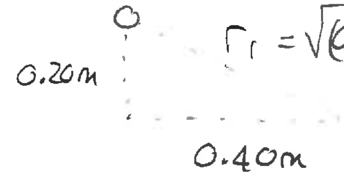
$$\tfrac{1}{2}mv_f^2 - \cancel{\tfrac{1}{2}mv_i^2} = -q(V_f - V_i)$$

Now we need the potentials. First consider V_i

$$V_i = V_1 + V_2 + V_3$$

Then

$$V_1 = k\,\frac{q_1}{r_1}$$



$$r_1 = \sqrt{(0.20m)^2 + (0.40m)^2} = 0.45m$$

$$= 8.99\times10^{9}\,\frac{Nm^2}{C^2}\;\frac{4\times10^{-9}C}{0.45m}$$

$$= 80V$$

Similarly $V_3 = 80V$

Then $V_2 = k\,\frac{q_2}{r_2} = 8.99\times10^{9}\,\frac{Nm^2}{C^2}\;\frac{-10\times10^{-9}C}{0.40m} = -225\,V$

So

$$V_i = 80V - 225V + 80V = -65V$$

Now we need V_f. Here

$$V_1 = k\,\frac{q_1}{r_1 \leftarrow \infty} = 0$$

$$V_2 = k\,\frac{q_2}{r_2 \leftarrow \infty} = 0$$

$$V_3 = k\,\frac{q_3}{r_3} = 0$$

$\Rightarrow V_f = 0$

So

$$\frac{1}{2} m v_f^2 = -q(-V_i) = qV_i$$

$$\Rightarrow \frac{1}{2}\, 9.11\times10^{-31}kg\; v_f^2 = (-1.6\times10^{-19}C)(-45V)$$

$$\Rightarrow v_f^2 = 1.58\times10^{13}\,m^2/s^2$$

$$\Rightarrow v_f = \sqrt{1.58\times10^{13}\,m^2/s^2} = \boxed{4.0\times10^{6}\,m/s}$$

Quiz3 40% -100%

Quiz4 30% -30%

Quiz5

In all cases we use

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

Then

$$\underset{V_f=0}{\Delta K = \cancel{K_f}^{\,0} - \cancel{K_i}^{\,0}}_{\text{at rest}} \Rightarrow -q\,\Delta V = 0 \Rightarrow \Delta V = 0$$

Electrostatic potential energy

Consider two point charges near to each other. The electric potential energy of 2 (as a probe) in the vicinity of 1 (as a source) is

$$U_{elec} = q_2 V_1 = q_2\, k\frac{q_1}{r} = k\frac{q_1 q_2}{r}$$

It is clear that if we reverse the idea of source/probe then we get the same U_{elec}. Thus

> The electric potential energy of two point charges in the illustration is
>
> $$U_{elec} = k\frac{q_1 q_2}{r}$$

When the charges are infinitely far apart then $U_{elec}=0$. Thus U_{elec} is the energy that must be supplied (if $U_{elec}>0$) or is produced ($U_{elec}<0$) when the charges are assembled from infinitely far apart

Quiz6