Midterm 1 Review

Tuesday, February 12, 2019 6:31 PM

1. Coulomb's Law

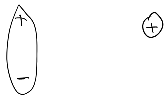
Likes attract opposites $\boxed{\text{repel}}$

$\ast$ $K = \frac{1}{4\pi\varepsilon_0} = 9\cdot10^9 \frac{Nm^2}{C^2}$

$\vec{F}[N] = \frac{K\,|Q\cdot q|}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{|Q\cdot q|}{r^2}$

$\varepsilon_0 = 8.85\cdot10^{-12}\frac{C^2}{Nm^2}$

2. Dipole vs. Monopole



3. Newton's 2nd Law

$F = ma$ ← Solve for acceleration

← Use Coulomb's law to find force

$\ast$ Might need to use radial acceleration to solve for V where $a = \frac{v^2}{r}$

4. Field due to a charge

$\vec{E}\left[\frac{N}{C}\right] = K\frac{Q}{r^2}\cdot\hat{r}$ ← unit radial vector

or → $\left[\frac{V}{m}\right]$

$\ast$ Don't forget about magnitude AND direction

Drawing Field lines
- closer when $\vec{E}$ is larger
- can NEVER cross
- arrows indicate where a $\underbrace{\text{positive test charge}}_{q>0}$ would accelerate

Calculating Electric Fields

$\mathbb{R}$	$\mathbb{R}^2$	$\mathbb{R}^3$
$\lambda = \frac{\text{charge}}{\text{length}}$	$\sigma = \frac{\text{charge}}{\text{area}}$	$\rho = \frac{\text{charge}}{\text{volume}}$

↑ Not only for lines of charge, can also be used in rings when length $= 2\pi r$ etc

How to integrate

$\vec{E} = \int dE \qquad dE = K\frac{dq}{r^2}$

$\ast$ Might need to consider an angle (in sin/cos form or as ratios) when integrating dE.

dq

$\mathbb{R}$

$= R\cdot\lambda\cdot d\theta$ circles, rings etc

$= \lambda\, dx$ lines of charge

$\mathbb{R}^2$

$= \sigma\, dA \Rightarrow dA = 2\pi x\, dx$

5. Motion of Particles in a Constant field

$\sum\vec{F} = q\vec{E} = \text{constant}$

$\therefore\ \vec{a} = \frac{q\vec{E}}{m}$ due to Newton's 2nd Law $\Longrightarrow$ Use this to use Lori Kinematics equations

"like projectile motion" just instead of g as your acceleration you have $\vec{a} = \frac{q\vec{E}}{m}$

$\sum\tau = |\vec{p}\cdot|\vec{E}|\sin\phi = \vec{p}\times\vec{E}$

angle from horizontal

Potential Energy $= -\vec{p}\cdot\vec{E}$

6. Gauss' Law

- Flux of charge through a surface

SA of a Sphere $= 4\pi r^2$

$\oint E\,d\vec{A} = \frac{1}{\varepsilon_0}Q_{enc}$

$\Downarrow$

$E(r)\cdot A$

$\Downarrow$ ω

$E(r) \cdot A$

total area

$E \cdot d\vec{A} \Rightarrow |E|\,|dA| \cos\phi$

$\therefore$ if E and dA ⊥ Flux = 0

| | | ↑↑ | = EdA

| | | ↑↓ | = −EdA

7. Insulators Vs Conductors

Insulators: Charge always remains fixed in place

Conductors: Some charges are free to move / spread out $\Longrightarrow$ Q = 0 inside material $\therefore$ $\vec{E} = 0$ inside material

Ex) charges must develop for a ring on the outside/inside to keep the $\vec{E} = 0$ in the middle when doing Gauss' law problems

8. Potential Energy, U

$$\Delta U = -W = -\int_{r_1}^{r_2} \vec{F} \cdot d\vec{l}$$

ΔU: change in potential energy; $-W$: negative work

If $\vec{F}$ is constant, $= -F_0 (r_2 - r_1)$

$$F = \frac{KqQ}{r^2}$$

$$\therefore \Delta U = -\int_{r_a}^{r_b} \frac{KqQ}{r^2} = KqQ\left(\frac{1}{r_b} - \frac{1}{r_a}\right)$$

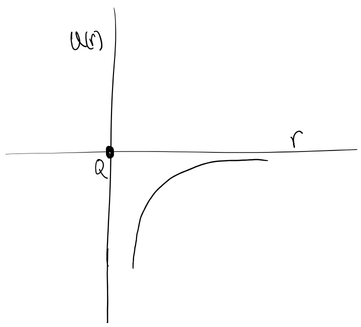
✱ Same potential energy as Q due to q

Conservation of Energy:

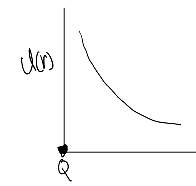
$$KE_i + U_i = KE_f + U_f$$

KE of charged particles; Potential energy from fields / other charges

Attractive Charges



Repulsive Ch



U due to multiple charges acting on a particle:

$$U = \sum U \Rightarrow U_1 + U_2 + \dots + U_n = \frac{KqQ_1}{r_1} + \frac{KqQ_2}{r_2} \dots + \frac{KqQ_N}{r_N}$$

9. Potential, V

$$\Delta V = \frac{\Delta U}{q}$$

ΔV: change in "potential"; ΔU: change in potential energy

$\therefore$ Potential is independent of q, $\underbrace{\text{solely property of } \vec{E}}_{\text{Field } (E(r))}$

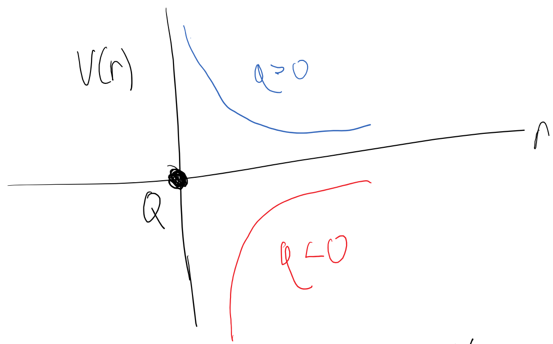
Units $V = \left[\frac{J}{C}\right] = [V]$ ← Volts

Can give E new Units, $E = \left[\frac{N}{C}\right] = \left[\frac{V}{m}\right]$ ← Volts per meter

Always wants to reach lower potential energy BUT if

(+) → wants to go to lower "potential"

(−) → wants to go to higher "potential"



Calculating Potential: $V = \frac{KQ}{r}$ Can also calculate U via V since $U = q \cdot V$ $= -W$

also equals negative work

10. General Test Tips

What to expect on exam

- last page is formula sheet
- cover sheet is the same
- 3 multipart questions
  - point charge
  - continuous distribution
  - Gauss' Law

  } Somewhere along some motion

Don't Forget

- Specify magnitude <u>and</u> direction