1304/1404 L28, p1

Review Session

Electricity

$q_1 \circ \xrightarrow{\vec{F}_{12}} \circ q_2$

Coulomb's Law

$$\boxed{\vec{F}_{12} = k\frac{q_1 q_2}{r^2}\hat{r}}$$

P23.7 sort of

q_1 60° 0.5m q_2, q_3 — equilateral Δ

what is F on q_3?

$q_1 = q_2$

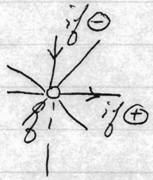
$$\vec{F}_{TOT} = \vec{F}_{13} + \vec{F}_{23} = kq_3\left[\frac{q_1 \sin 60}{(0.5m)^2} + \frac{q_2 \sin 60}{(0.5m)^2}\right]$$

$$= \frac{kq_3}{0.25m^2}\frac{\sqrt{3}}{2}\left[q_1 + q_2\right]$$

$$= 2\sqrt{3}\,kq_3\left[q_1 + q_2\right] \quad \text{down}$$

Electric field + flux

→ strength of electric force per a test charge q_2



$$\boxed{\vec{E} = kq/r^2\ \hat{r}}$$

$(d\vec{E} = kdq/r^2\ \hat{r})$ for charge distrib.

→ field lines a device to help us think about AMOUNT of field

$|E| \propto$ # field lines

- flux → a sort of "flow" of E field

→ amount of field "passing thru" a surface

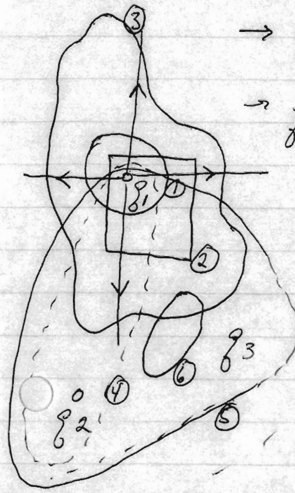
$$\Phi_E = \int \vec{E} \cdot d\vec{A}$$

1304/1404 L28, p2

Review Session

Gauss's Law

$$\boxed{\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}}$$



→ flux independent of shape of surface

→ flux $\propto q_{in}$ inside surface

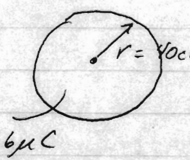
→ same for ①, ②, ③

$\Phi_1 = \Phi_2 = \Phi_3 = q_1/\epsilon_0$

$\Phi_4 = (q_1 + q_2)/\epsilon_0$, $\Phi_6 = 0$

$\Phi_5 = (q_1 + q_2 + q_3)/\epsilon_0$

*** 24.10
24.11
24.13
24.24



what is E @ r = 0, 10, 40cm?

* have spherical symmetry w $\vec{E} \parallel d\vec{A}$

* $\oint \vec{E} \cdot d\vec{A} \rightarrow EA_\odot = \frac{q_{in}}{\epsilon_0}$

$$E = k\frac{Q}{a^3}r \quad \text{for } a < r$$

$$E = k\frac{Q}{r^2} \quad \text{for } a > r$$

$\vec{E}$ is radially outward

all that matters is how much charge inside radius

1304/1404 L28, p3

Review Session

Electric Potential (not potential Energy!)
→ takes work to move charge in a E-field → $W = q\Delta V$

$\Delta V = -\int_A^B \vec{E}\cdot d\vec{s}$ → not depend. on path taken


- radial E lines
- circular equipotential lines

$\Delta V = kq\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$

$V = kq/r$ (define $V_B \to 0$ @ $r\to\infty$)

P 25.17

$|E| = 500\,V/m$, $V = -3\,kV$

$V = kq/r$ $\quad |E| = kq/r^2$

$kq = Vr = |E|r^2$

a) $V = Er \rightarrow \underline{r} = \frac{V}{|E|} = \frac{3000\,V}{500\,V/m} = \underline{6m}$

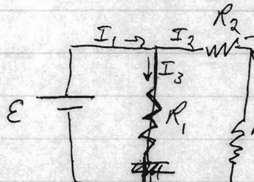
b) $kq = Vr \rightarrow q = Vr/k = \underline{-2\mu C}$

Look @ 26.16

$\boxed{V = IR}$ → resistors (caps in series)

Kirchhoff's Rules
- $\boxed{\sum I_{in} = \sum I_{out}}$ (junction rule)
- $\boxed{\sum_{\text{closed loop}} \Delta V = 0}$ (loop rule)

*** look @ 28.21, 25, 26, 29, 30



* $I_1 = I_2 + I_3$
* $\mathcal{E} + I_3R_1 = 0$
* $I_3R_1 + I_2R_2 + I_2R_3 = 0$

1304/1404 L28, p4

Review Session
Magnetism

Force Eq. $\boxed{\vec{F}_B = q\vec{v}\times\vec{B}}$ use right-hand rule

P29.7

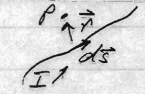
proton, $|v| = 4\times10^6\,m/s$

$B = 1.7T$ $\quad F = 8.2\times10^{-13}N$

$F = |q|vB\sin\theta \Rightarrow \theta = \sin^{-1}\left(\frac{F}{qvB}\right)$

$\theta = \sin^{-1}\left(\frac{8.2\times10^{-13}N}{(6.8\times10^6\,Tm/s)(1.6\times10^{-19}C)}\right) = \underline{49^\circ}$

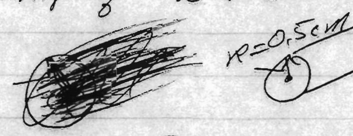
Biot-Savart Law $\boxed{d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{s}\times\hat{r}}{r^2}}$ P30.2



Ampére's Law $\boxed{\oint \vec{B}\cdot d\vec{s} = \mu_0 I}$

→ relationship of B + current, I

*** P30.23, .25, .26



$R = 0.5cm$ $\quad 100\times 2A$

$a = 0.2cm$

a) ~~$\oint \vec{B}\cdot d\vec{s} = B\,2\pi a$~~ $\quad a<r;\ B = \frac{\mu_0 I}{2\pi R^2}a$

$B = \frac{\mu_0 I r}{2\pi R^2} = \frac{(4\pi\times10^{-7}Tm/A)(99)(2A)(0.2\times10^{-2}m)}{2\pi(0.5\times10^{-2}m)^2} = 3.2mT$

$\hat{B}$ tangent to circle w/ $r = 0.2cm$

$F_B = I\,l\,B = \frac{\mu_0 l I^2}{\ldots}$

$\vec{F} = I\vec{l}\times\vec{B}$ (radially inward)

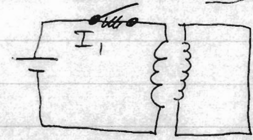
$\boxed{F/l = IB\sin\theta = 6.3\times10^{-3}\,N/m}$

b) $B \propto r$ + $F \propto B$ → greatest at outer surface

** Gauss's Law for B field: $\boxed{\oint \vec{B}\cdot d\vec{A} = 0}$

Review Session

Faraday's Law $\oint \vec{E} \cdot d\vec{s}\ (= \mathcal{E}) = -(N)\frac{d\Phi_B}{dt}$



→ I_2 in 2ndary circuit

I_1 sets up B field in coil, which is transfered to 2ndary

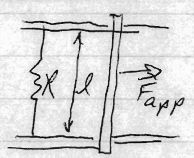
→ occurs when Φ_B is changing when close circuit

~~P31.20~~

Lenz's Law

→ I_2 in direction creates B field opposing $\Delta\Phi_B$ thru area enclosed by loop

**P31.20



$\mathcal{E} = IR \Rightarrow I = \mathcal{E}/R = \frac{Blv}{R}$

$v = IR/Bl = 1\,m/s$

LC circuits: $\omega = 1/\sqrt{LC}$ $\boxed{P32.50}$

Transformers: $\Delta V_2 = \frac{N_2}{N_1}\Delta V_1$ ~~P33.44~~

$I_1 \Delta V_1 = I_2 \Delta V_2$

$\boxed{P33.44}$ $N_2/N_1 = 1/13$; $I_1 = 0.35A$; $\Delta V_1 = 120V$

a) $\Delta V_2 = \frac{1}{13}(120V) = 9V$

b) $I_2 = \frac{\Delta V_1}{\Delta V_2} I_1 = 13 \cdot 0.35A = \underline{4.5A}$

c) $P = I_2 \Delta V_2 = \underline{41W}$

Review Session - Optics

Poynting Vector: rate E flows thru unit surface area ⊥ to dir. of wave propagation

→ power per unit area (J/s m², W/m²)

$\boxed{\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}}$

units J/s/m² $S = \frac{E^2}{\mu_0 c} = \frac{c}{\mu_0}B^2$

$\boxed{P34.4}$ EM wave: $E = 220\,V/m$ what is B?

$\frac{1}{2}\epsilon_0 E_{max}^2 = \frac{B_{max}^2}{2\mu_0}$

$B_{max}^2 = \epsilon_0 \mu_0 E_{max}^2 \Rightarrow \boxed{B_{max} = \frac{E_{max}}{c}} = \underline{7.3 \times 10^{-7}\,T}$

Law of Reflection: $\theta_{in} = \theta_{out}$

Snell's Law: $\boxed{n_1 \sin\theta_1 = n_2 \sin\theta_2}$ ***$\boxed{35.13, 36, 37}$

Mirror/thin lens Eq.: $\boxed{\frac{1}{p} + \frac{1}{q} = \frac{1}{f};\ M = -\frac{q}{p}}$ $\boxed{36.28, 30}$

2 slit Interf. & Diffraction: **$\boxed{P38.10}$

→ $\boxed{d \sin\theta_{dark} = (m + \frac{1}{2})\lambda}$ $m = 0, \pm1 \ldots$

$\boxed{\sin\theta_{dark} = m\frac{\lambda}{a}}$ $(m = \pm1, 2\ldots)$

Rayleigh's criterion: $\boxed{\lambda/a = \theta_{min}}$

$1.22\lambda/D = \theta_{min}$