TEST TWO Thursday Evening April 1 7:30- 9:30 pm. The Friday class immediately following is canceled because of the evening exam.

What We Expect From You On The Exam

1. An understanding of the properties of conductors.

2. An understanding of capacitors. You will not need to know about the effects of dielectrics.

3. An understanding of current flow in a resistive material, e.g. how J is related to *I*, how E is related to J, how resistance is related to resistivity, and how to calculate it.

4. An understanding of simple circuits. For example, you should be able to set up the equations for multi-loop circuits, using Kirchhoff's Laws. You should be able to derive and guess the solution to differential equations for RC circuits, and should understand the meaning of time constants ($\tau = RC$).

5. A conceptual understanding of how to determine the direction of magnetic fields of moving charges or current elements using the Biot-Savart law, e.g.

$$\vec{\mathbf{B}} = \frac{\mu_o}{4\pi}\frac{q\,\vec{\mathbf{v}} \times \hat{\mathbf{r}}}{r^2} \qquad d\vec{\mathbf{B}} = \frac{\mu_o}{4\pi}\frac{I\,d\vec{\mathbf{s}} \times \hat{\mathbf{r}}}{r^2}.$$

You will not need to calculate any integrals using Biot-Savart Law.

6. An understanding of how to calculate the force on a current element in an external magnetic field or on a charged particle moving in an external magnetic field or in both magnetic and electric fields, including the characteristics of cyclotron motion. That is, to understand and be able to apply the equations

$$q\vec{\mathbf{v}} \times \vec{\mathbf{B}} = m\vec{\mathbf{a}} \qquad q(\vec{\mathbf{E}} + \vec{\mathbf{v}} \times \vec{\mathbf{B}}) = m\vec{\mathbf{a}} \qquad d\vec{\mathbf{F}} = I d\vec{\mathbf{s}} \times \vec{\mathbf{B}}$$

7. An understanding of the magnetic moment vector of a current loop. A conceptual understanding of how the torque exerted on a magnetic dipole in an external field arises, ($\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{\mu}} \times \vec{\mathbf{B}}$).

To study for this exam we suggest that you review your problem sets, in-class problems, Friday problem solving sessions, PRS in-class questions, and relevant parts of the study guide and class notes.

Summary of Class 21

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

8.02 Spring 2010

Exam Two Equation Sheet

Force Law: $\vec{\mathbf{F}} = q(\vec{\mathbf{E}}_{ext} + \vec{\mathbf{v}} \times \vec{\mathbf{B}}_{ext})$

Source Equations:

$$d\vec{\mathbf{E}} = \frac{1}{4\pi\varepsilon_o}\frac{dq}{r^2}\hat{\mathbf{r}} = \frac{dq}{4\pi\varepsilon_o r^3}\vec{\mathbf{r}}$$

$$d\vec{\mathbf{B}} = \frac{\mu_o}{4\pi}\frac{Id\vec{\mathbf{s}} \times \hat{\mathbf{r}}}{r^2} = \frac{\mu_o}{4\pi}\frac{Id\vec{\mathbf{s}} \times \vec{\mathbf{r}}}{r^3}$$

$\hat{\mathbf{r}} = \dfrac{\vec{\mathbf{r}}}{r}$ points from source to field point

Current Density and Current:

$$I = \iint_{\text{open surface}} \vec{\mathbf{J}} \cdot d\vec{\mathbf{a}}$$

Gauss's Law:

$$\iint_{\text{closed surface}} \vec{\mathbf{E}} \cdot d\vec{\mathbf{A}} = Q_{\text{inside}} / \varepsilon_o$$

Gauss's Law for Magnetism:

$$\iint_{\substack{closed\\surface}} \vec{\mathbf{B}} \cdot d\vec{\mathbf{A}} = 0$$

Electric Potential Difference:

$$\Delta V = V_b - V_a \equiv -\int_a^b \vec{\mathbf{E}} \cdot d\vec{\mathbf{s}}$$

$$\vec{\mathbf{E}} = -\vec{\nabla} V$$

Potential Energy:
$\Delta U = q\Delta V$

Capacitance:

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

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}C\Delta V^2$$

Capacitors in Parallel: $C_{eq} = C_1 + C_2 + \cdots$

Capacitors in Series: $\dfrac{1}{C_{eq}} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \cdots$

Ohm's Law: $\Delta V = I\,R$

$\vec{\mathbf{J}} = \sigma_c \vec{\mathbf{E}}$ where σ_c is the conductivity

$\vec{\mathbf{E}} = \rho_r \vec{\mathbf{J}}$ where ρ_r is the resistivity

Resistors in Parallel: $\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \cdots$

Resistors in Series: $R_{eq} = R_1 + R_2 + \cdots$

Power Loss in Resistor:
$P_{\text{Joule}} = I\Delta V = I^2 R = \Delta V^2 / R$

Magnetic Dipole: $\vec{\boldsymbol{\mu}} = I\,A\,\hat{\mathbf{n}}$

Torque on Magnetic Dipole: $\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{\mu}} \times \vec{\mathbf{B}}$

Constants:

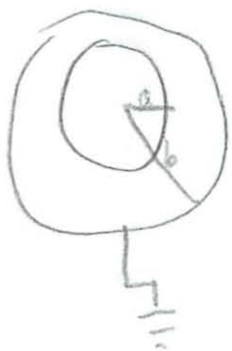
$k_e = 1/4\pi\varepsilon_0 = 9 \times 10^9\ \mathrm{N \cdot m^2 \cdot C^{-2}}$

$\mu_0 / 4\pi = 10^{-7}\ \mathrm{T \cdot m \cdot A^{-1}}$

Exam Review

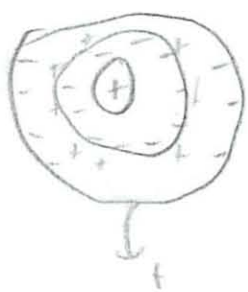
3/26

Conductors + Capicators



spheres Faraday ice pail

1. Put ⊕ at center



2. Touch ~~so~~ together
   - the ⊕ on outer ring go to ground
   - the ⊖ go to inner ring
3. Remove touch
4. Remove charge inside
   - so just ⊖ charges in inner ring evenly distributed

Find Q, E, V + C

(2)

Remember $\boxed{\oint\!\!\oint E \cdot dA = \frac{q_{inc}}{\varepsilon_0}}$

What surface are we doing this for

$E = \frac{-kQ}{r^2}\,\hat{r}$

* Review Guass' Law from last test

$\cancel{V = \frac{-kQ}{r}}$

$Q = -q$

$$\boxed{\begin{gathered} E(4\pi r^2) = \frac{-Q}{\varepsilon_0} \\ E = \frac{-Q}{4\pi\varepsilon_0 r^2} = \frac{-kQ}{r^2} \end{gathered}}$$

* Total charge enclosed by any closed conductor = 0

$\oint\!\!\oint E \cdot dA = 0 = \frac{Q_{enc}}{\varepsilon_0}$ <u>sheilding</u> inside of it

(review a little bit)

total charge must be 0

(3)

$V \rightarrow$ must integrate from B to A

(3) $\Delta V = \frac{Q}{4\pi \epsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right)$

(1) $\Delta V = -\int E\, dr$

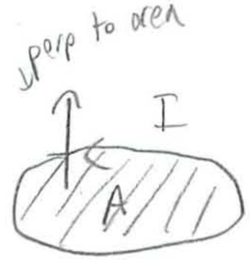
(2) $\Delta V = -\int_a^b \frac{Q}{4\pi \epsilon_0}\, dr$

* perfect exam problem

Office Hrs

3/29

Diapoles + Torque



$\vec{\mu} = I\vec{A}$ diapole moment

Put diapole in field
- Feels a torque

$\vec{\tau} = -\vec{\mu} \times \vec{B}$

direction for torque
- screwdriver
- thumb towards torque
- fingers how to point

Be able to do right rule
$A \times B = C$
$F = V \times B$
Dir created field (B)
infinite wire
thumb towards current

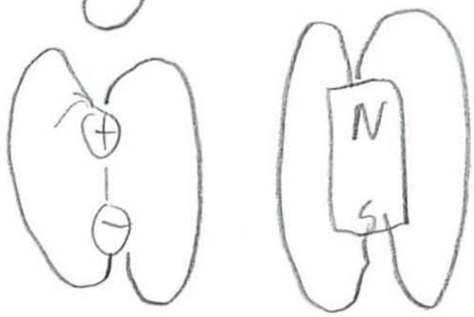
Torque $= \mu \times B$
↑ dir of vector
Dir $\vec{\mu}$

here dir into board rotates

μ is like p
"moment"
charge or mass <u>distributed</u> in a certain way/shape

 no diapole moment

 now has shape → diapole moment



how big diapole moment =
how big of a diapole moment

bar maget

Everything is a diapole

μ is how strong is it / how much does it look like

Diapole moments want to line up w/ field

- wants to lower energy

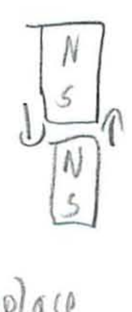
$$U = -\mu \cdot \vec{B}$$

wants as big a θ ~~TT~~ as possible

$$-\mu B \cos\theta$$

↑ if aligned $\cos\theta \doteq 1$

then will go to biggest B field



want to stick together
- field strongest

~~ϕ~~ So replace diapole w/ bar magnet and think of that

wants to line up w/ field

wire loop = diapole

* magnetic fields never accelerate charges

-not true for currents

$I = \frac{\varepsilon}{2R}$ ← $V = IR$

Close B

now differential time varring

have parallel aspect

(I should review this)

"instant" - treat capacitator as wire online

$$I = \frac{2\varepsilon}{3R}$$

* Avoid kirkoff at all costs

3/30

Review Dormaskin

9-10:30 PM

know what is on test

Properties of Conductors

Capicators + Capitance

- no dielectrics

Current, Resistance, Circuits

- no solving differential circuit :)

- know graphically

Magnetism

- forces, torques current loops

- no Ampere's law

- B-S only conceptual

Old tests cover different things

Capitance

$Q = C\Delta V$

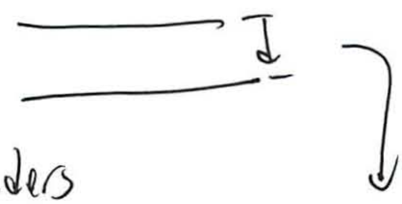
↑ charge appears when voltage diff applied

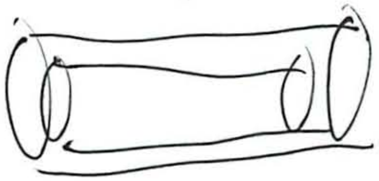
Calculate $C = \frac{Q}{|\Delta V|}$

1. How $|\Delta V|$? → $\int \vec{E} \cdot ds$ (gauss' law) to find E

(2)

3 types of capicators

- shells  (conducting)
- parallel plates  Area A
- concentric syllanders

 → infinite lenght or neglect edge effects

lenght l

charges flow away from 1 plate to other when voltage diff aplied

Q is where (+) charge is

$$C = \frac{Q}{|\Delta V|} = \frac{Q}{|\int \vec{E} \cdot d\vec{s}|}$$

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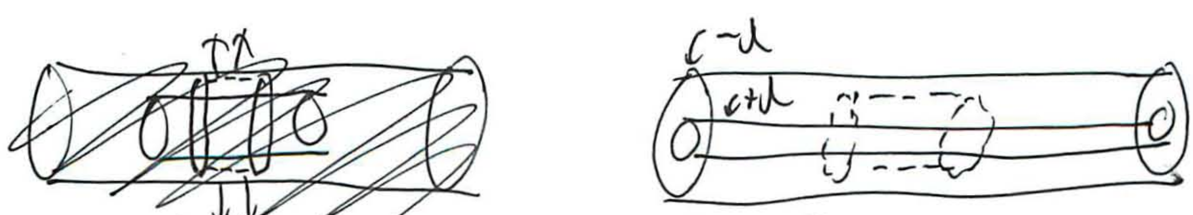
ex coaxial conducting cylinders

need to assume they are charged up
- will cancle out later



lenght l radius r

3)

$\oiint \vec{E} \cdot d\vec{a}$	$\frac{q_{enc}}{\varepsilon_0}$
$E \cdot \text{area}$	$= \frac{\lambda \ell}{\varepsilon_0}$
$E \cdot 2\pi r \ell$	$=$

$$\boxed{\vec{E} = \frac{\lambda}{2\pi\varepsilon_0} \frac{1}{r} \hat{r} \quad a < r < b}$$

* Conductor so all charge on surface

← need to be able to do (from last test) → I need to look over + review

* Also ~~know~~ remember what pitfalls are

$$C = \frac{Q}{|\int \vec{E} \cdot d\vec{s}|}$$

$$\hookrightarrow \int_{r=a}^{r=b} \vec{E} \cdot d\vec{s}$$

potential diff decreasing from inner to outer so - but abs value so does not matter

$$= -\int_a^b \frac{\lambda}{2\pi\varepsilon_0} \frac{1}{r} \, dr$$

$$= -\frac{\lambda}{2\pi\varepsilon_0} \ln\left(\frac{b}{a}\right)$$

← know the rule

$$C = \frac{Q}{\frac{\lambda}{2\pi\varepsilon_0} \ln\left(\frac{b}{a}\right)}$$

but what is Q?

↳ should cancel

↳ $\lambda = \frac{Q}{L}$ ← known

$$C = \frac{\lambda L}{\frac{1}{2\pi\epsilon_0}\lambda \ln(b/a)} = \frac{L}{\frac{\ln(b/a)}{2\pi\epsilon_0}} = \boxed{\frac{2\pi\epsilon_0 L}{\ln(b/a)}}$$

Energy Stored in a Capicator

$$U_c = \frac{Q^2}{2C} \quad \leftarrow \text{memorize}$$

$$Q = C|\Delta V|$$

$$= \frac{1}{2} C |\Delta V|^2$$

$$= \frac{Q^2}{2\left(\frac{2\pi\epsilon_0 L}{\ln(b/a)}\right)} \quad \text{in this example}$$

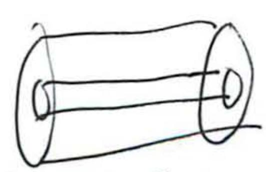
Or if have voltage

$$= \frac{1}{2}\left(\frac{2\pi\epsilon_0 L}{\ln(b/a)}\right)\Delta V^2$$

also

$$= \frac{1}{2}\epsilon_0 \iiint E^2 \, dV$$

$$= \frac{1}{2}\epsilon_0 \int_a^b \left(\frac{\lambda}{2\pi\epsilon_0}\frac{1}{r}\right)^2$$



$dV = L\,2\pi r\,dr$

cylindrical shell

will get same result

5

Try for all 3 cases (sphere, cylinder, plates)

know → if E non constant, must do integral

What are the electric fields

? must know figured out for last test

Circuit Theory

Current + Resistance

$$I = \iint \vec{J} \cdot d\vec{a}$$ how much J through an area

Ohm's Law

$$\Delta V_{element} = RI$$

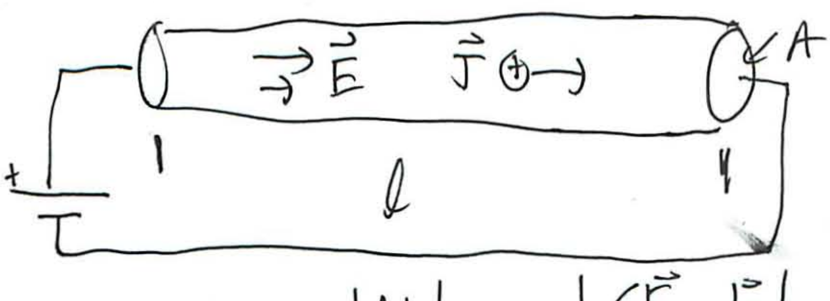
$$R = \frac{|\Delta V_{element}|}{|I|} = \frac{|\int \vec{E} \cdot d\vec{s}|}{|\iint \vec{J} \cdot d\vec{a}|}$$

Resistivity (ρ_r)

$$\vec{E} = \rho_r \vec{J} \qquad \sigma_c = \frac{1}{\rho_r} = \text{conductivity}$$

$$\vec{J} = \sigma_c \vec{E}$$

(*) know



a wire

$$R = \frac{|\Delta V|}{|I|} = \frac{|\int \vec{E} \cdot d\vec{s}|}{|\iint \vec{J} \cdot d\vec{a}|}$$

6

$$\boxed{E = \frac{\rho_c \cancel{A} J l}{J A} = \frac{\rho_c L}{A}}$$

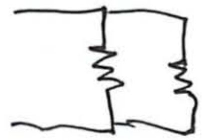
← do not know at all, study

Circuits

Resistors ~~Parallel~~ ~~Series~~

Series 

- same current through each
- voltage drops add
- replace w/ R_{eq}

Parallel 

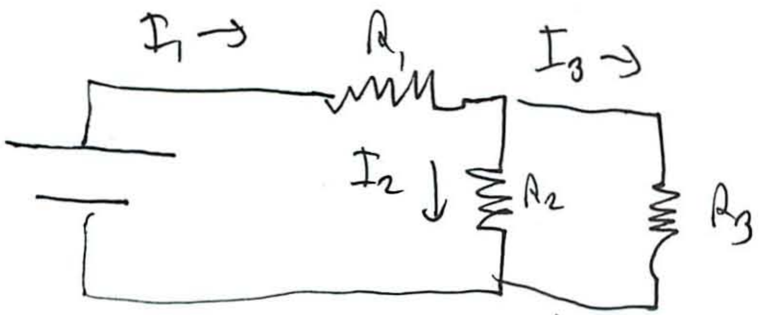
- same voltage across them
- current added
- more doors to leave theater

$\boxed{\text{Can make things far simpler}}$

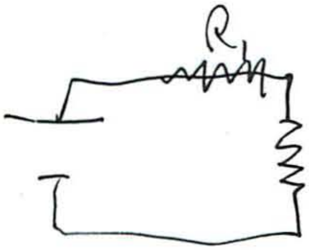
$\Delta V = I R_1$

$\Delta V = I R_2$

$$\frac{\Delta V}{R_{eq}} = \frac{\Delta V}{R_1} + \frac{\Delta V}{R_2}$$



2 in parallel which together are in series is 1



$$\frac{1}{R_{eq'}} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$R_{eq} = \frac{R_2 R_3}{R_2 + R_3}$$ ← know

7

$$Req = R_1 + Req$$

$$I_1 = \frac{\Delta V}{Req}$$

to find I_2 or I_3

$$I_1 = I_2 + I_3$$

↑ Just found

know ΔV 2 and 3 =

so $I_2 R_2 = I_3 R_3$

$$I_2 = \frac{I_3 R_3}{R_2}$$

$$I_1 = \frac{I_3 R_3}{R_2} + I_3 = \frac{\Delta V}{Req}$$

$$I_1 = I_3 \left(\frac{R_3}{R_2} + 1 \right)$$

$$I_2 = I_3 \frac{R_3}{R_2}$$

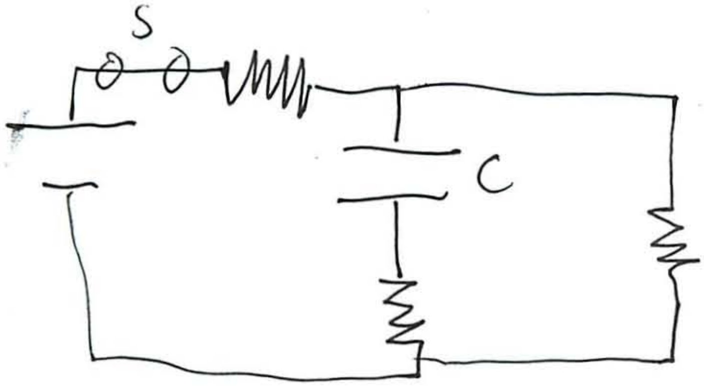
far better w/ algebra now thanks to Physics + problem solving

"solve a circuit" → find current in every branch

So what happens when you add a capicator

⟶

(8)



time dependent circuit
need loop laws + differential eqs to get full time dependence

but they just ask
- switch just closed
- closed for really long time
- etc

$t=0$, close S → Capicator uncharged (like a wire)

$R_{eq}' = \frac{R}{2}$

$R_{eq} = \frac{3R}{2}$

$I = \frac{\Delta V}{\frac{3R}{2}}$

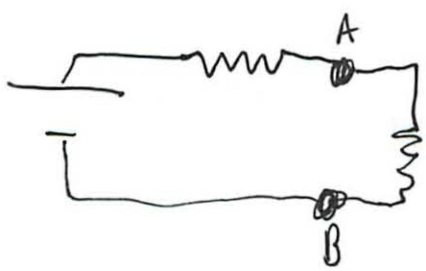
find I_2, I_3

$t=$ long time after S closed

Capicator fully charged

$I_2 = $ zero

$V_f = ?$



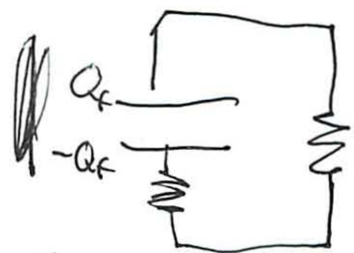
$= I_{1,\,final} \cdot R$

$= \frac{\Delta V R}{2R} = \frac{\Delta V}{2}$ half the voltage of the battery

4

Now open switch ~~dig~~

-discharge capicator



if solving differential equation

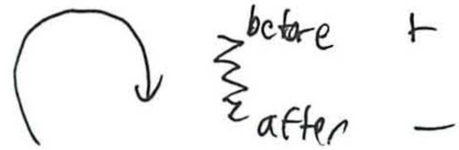
$$\Delta V = V_{after} - V_{befor}$$

choice of current dir $\neq$ choice circulation dir

↑ what after + before means

if going

So ~~the~~ voltages are



$$\Delta V = IR$$

$$0 = -I_2 R - I_1 R + \frac{Q}{C}$$

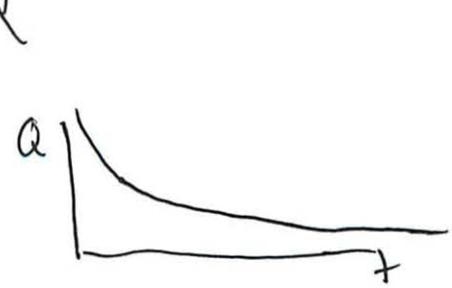
↑ since going from ⊖ → ⊕ plate

$$\frac{Q}{C} = 2 I_2 R$$

$$I_2 = -\frac{dQ}{dt} \text{ discharging}$$

$$\frac{Q}{C} = -2 \frac{dQ}{dt} R$$

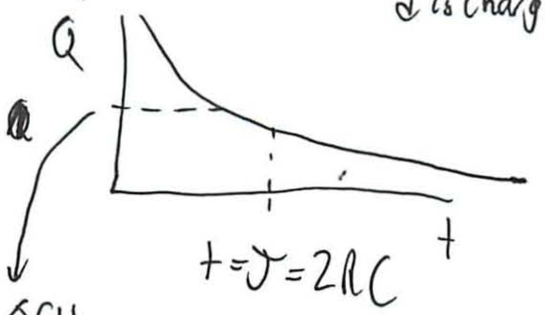
$$\frac{Q}{-2RC} = \frac{dQ}{dt}$$



(10)

$$\frac{dQ}{Q} = \frac{dt}{2RC}$$

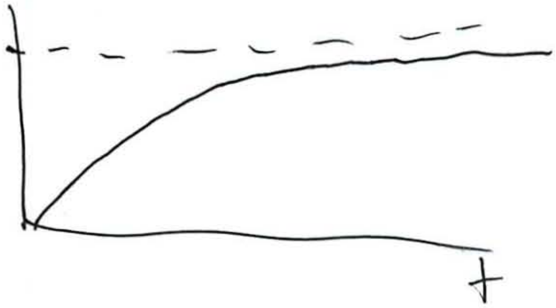
discharging



$Q(t) = Q_0 e^{-1}$

charging

- bit more complicated



didn't do capicators in parallel

- do a bit more w/ graphs - like that lab

Magtism

- currents or moving charges produce magnetic fields

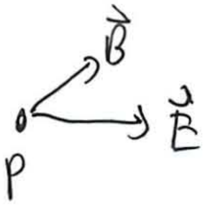
$$\vec{B} = \frac{\mu_0}{4\pi}\int \frac{I\, d\vec{s} \times \hat{r}}{r^2}$$ - come from sources

- 2 special cases
  - ring w/ field at center
  - ring w/ field some height z

- otherwise won't use B-S much

(1) Given a $\vec{B}$ field + $\vec{E}$ field

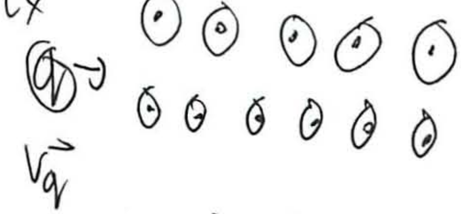
$\uparrow$ moving charges   + charges



$$F = q(\vec{E}_{ext} + \vec{V}_q \times \vec{B}_{ext})$$

Place q at p

ex



$\vec{E} = 0$

$\vec{F}$	$= m_q \vec{a}_q$
$q(\vec{V_q} \times \vec{B})$	

$\uparrow$ Cross product perpendicular to either vector
- velocity only change dir
"do no work"

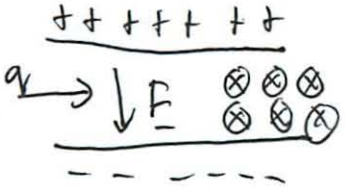
If $\vec{B}$ is uniform
- uniform force
- will get circular motion
  - of radius r

$$\boxed{VqB = \frac{mv^2}{R}}$$

← memorize
"cyclotron"

$$T = \frac{2\pi R}{V_q}$$

2)



q > 0

$$F = m\vec{a}$$

$$q(\underline{E} + \vec{v} \times \vec{B}) = m\vec{a}$$

where it goes is up to the relative strenghts

~~both~~ straight → they cancle

if its not straight now force points a diff direction

So the problem has gotten a lot harder

Current loops in magnetic fields

$$\vec{F}_{wire} = \int_{wire} I\, d\vec{s} \times \vec{B}$$

$$dF = dq\,\vec{v} \times \vec{B}$$

add that up over the wire → integrate

If $\vec{B}$ is uniform, ~~then~~ then ~~the force on the wire~~

↳ can pull out B

$$\vec{F}_{wire} = \left(\int I \cdot ds\right) \times B$$

If wire is straight just use lenght

$$\vec{F}_{wire} = I\left(\int d\vec{s}\right) \times B = I\vec{L} \times B$$

If wire is a loop (closed path) in uniform $\vec{B}$ field

$$F_{wire} = 0 = \left(I \oint d\vec{s}\right) \times \vec{B}$$

(13)

~~Br~~ ~~...~~

Torque is easy to calculate

- Use concept of magnetic moment

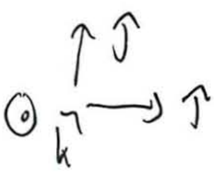
$$\vec{\mu} = I A \hat{n}_{RHR}$$

$\odot$ $\hat{n}_{RHR}$ $\odot$ $\vec{\mu}$

↑ "screwdriver"

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

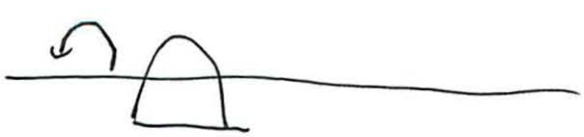
Write some unit vectors



$$\tau = I A \hat{k} \times B \hat{j}$$

$$\tau = I A B (-\hat{\imath})$$

- causes object to rotate
- points along ~~the~~ axis of rotation



at this instant

- magnetic moment changing di

(14)

Another problem "current in adj objects"

- 2 wires
  - parallel currents attract
  - antiparallel " repel
- current loops
  - same

Did not do much conductors

Think this test far better off
- then review session 1 where I learned a lot
- only real ~~new~~ thing I did not remember was Guass' Law
- and some formulas to memorize (but know how to use)

8.02 Test 2 Review

4/1

2:30 - exausted - not tired but exausted
- like long day of travelling

from Math test before and long race all weekend

- need some fun
  - bubbles today (first time having fun in a while)

Well test at 7 first

Lets start w/ reviwing last test + then Gauss' Law

* remember opposets attract

flux is dependent on charge inc
- if it is net 0, no net flux

systems always want to ↓ PE

$E = -\nabla V$

Remember V comes from outside in

add each region

separately

$\Delta V = -\int E \cdot ds = V(P) - V(\infty)$

$\int_P^\infty$ scalar

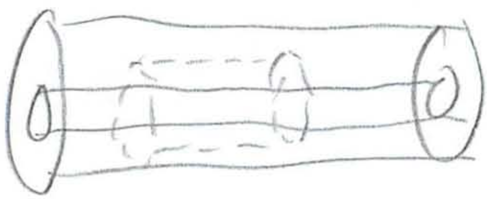
Pill box of what is enclosed

Riew Gaussian shapes

Remember cylinders only outwards 

(2) Look at Dormashkin's Review

- Shells
- parallel plates
- Concentric sylinders of ∞ lenght



If did outside it would be 0, I am pretty sure of

For capicator define what is $\pm \lambda$

Then $\int \vec{E} \cdot da = \frac{Q_{inc}}{\epsilon_0}$

$E \cdot 2\pi r l$

integrate if non uniform
did I have any problems like that ??

$= \frac{\lambda l}{\epsilon_0}$

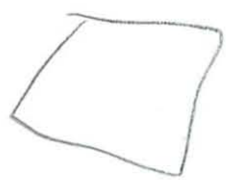
$E = \frac{\lambda}{2\pi \epsilon_0} \frac{1}{r}$

③ If other shape

Rod - kinda the same - but no radius on the rod

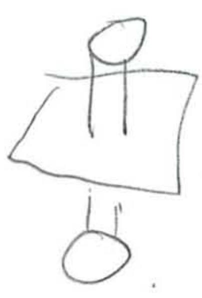
$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$ ← same ans actualy!

One ∞ large plane



σ = charge density

pill box over the shape



- only escapes on top & bottom
  - Sides don't matter

$$\Phi = \iint E \cdot dA$$

$$E_1 A_1 + E_2 A_2$$

$$= (E_1 + E_2) A$$

one + one → right

$$= 2EA$$

(4) Now typical

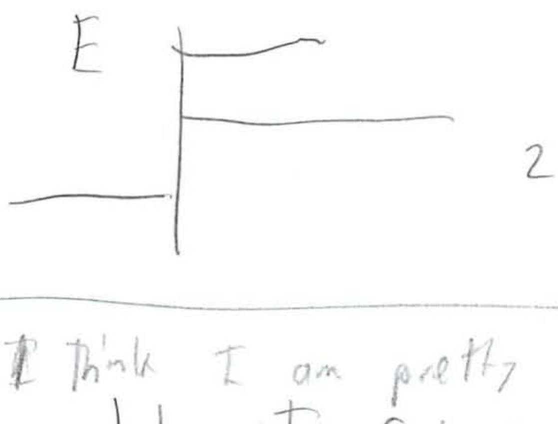
$$2EA = \frac{q_{inc}}{\epsilon_0} = \frac{\sigma A}{\epsilon_0}$$

$$E = \frac{\sigma \cancel{A}}{\epsilon_0 2\cancel{A}} = \frac{\sigma}{\epsilon_0 2}$$

then have to split

$$\frac{\sigma}{2\epsilon_0} \quad z > 0$$

$$-\frac{\sigma}{2\epsilon_0} \quad z < 0$$



I pretty much remember this

I think I am pretty good (better than Math) — but I feel that I have to se time studying

$r \leq a$

all 0 since charges on shell

$r \geq a$ (beyond shell)

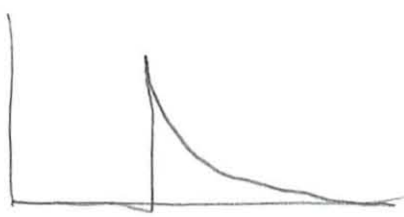
$Q_{inc} = Q$

$E \cdot 4\pi r^2$

$$\vec{E} = \frac{Q}{4\varepsilon_0 r^2} = \frac{k_e Q}{r^2}$$

oh that is where that comes from

$\vec{E}$ or electric field



Non conduction solid shell

$$\rho = \frac{Q}{V} = \frac{Q}{4/3 \pi a^3}$$

$r \leq a$

$\Phi = E\, 4\pi r^2$

$$q_{inc} = \int_V \rho\, dV = \rho V = \rho \frac{4}{3}\pi r^3 = Q \frac{r^3}{a^3}$$

(6)

$$E(4\pi r^2) = \frac{\rho}{\epsilon_0}\left(\frac{4}{3}\pi r^3\right)$$

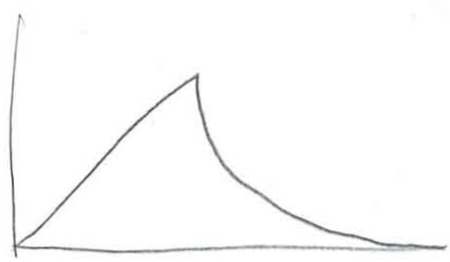
E = can solve

When $r \geq a$

$k\frac{Q}{r^2}$ be just looking from outside

Now where is it that you have to $\int$ integrate

(perhaps should take nap before test)



Conductors

— net charge ~~0 inside~~ all on surface

$\vec{E}$ field 0 inside conductor

$$C = \frac{Q}{|\int E\cdot ds|}$$ ~~= study~~

~~study~~ know the formulas now since had to learn them

7 Here is where have to actually integrate

$\Delta V = -\int E \cdot ds$

$\int_a^b \frac{\lambda}{2\pi\epsilon_0} \frac{1}{r}$

Know $\int_a^b \frac{1}{r} = \ln(r) = \cancel{\left(\frac{1}{b} - \frac{1}{a}\right)}$

$\ln\left(\frac{b}{a}\right)$

know that was on last test's formula sheet

there was anoter special one

or it was written on board not on this formula sheet

Oh $\int_a^b \frac{1}{r^2} = \left(\frac{1}{a} - \frac{1}{b}\right)$

note order not what I thought

Know that $\lambda = \frac{Q}{L}$

So it will cancle

λ = charge density

$\sigma = \frac{Q}{A}$ I think

8 So E stored in a capicator

$$\boxed{U = \frac{Q^2}{2C}}$$ ← know

Can plug in now for C

then can just leave

So think I can figure out splere & cylinder

If just remember splere $A = 4\pi r^2$

$V = \frac{4}{3}\pi r^3$

$$I = \iint \vec{J} \cdot d\vec{a}$$

$$V = RI = IR$$

$$R = \frac{|V|}{|I|} = \frac{\int E \cdot ds}{\int \vec{J}\, da}$$ ← never saw it written like that

resistivity all on here

Should prob switch to pratice test

Well first ring

created magnetic field from current loop

$\vec{B}(P) = ?$

– but this is B-S law which is not on here – except perhaps this basic case

(10) Ok Sample Test 1 Spring 08

- I so dont feel like this
- Half hrs to go till German
- wasted lsh half hr too
- So only 1 hr of work → 8 pages

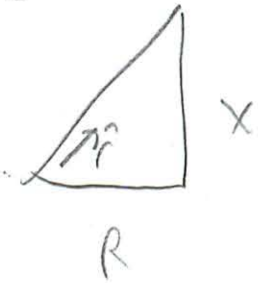
Perhaps I will think through - not write

So burnt out for all this

- need to recover on test

Pratice test making me feel less good - but not concentrating

(9)



$$r = \sqrt{R^2 + x^2}$$

$$d\vec{s} \times \vec{r}$$

$$ds = R\, d\theta$$

$$= |d\vec{s}|$$ don't really ~~get~~ get

$$\int \frac{\mu_0}{4\pi} \left(-R\, d\theta\, \hat{k} \times \frac{R(-\hat{\imath}) \times x\hat{\jmath}}{\sqrt{R^2 + x^2}} \right)$$

- all the horiz cancle
  and the vert add up

$$\frac{I R\, d\theta (-\hat{k}) \times (\hat{r}_{horiz} + \hat{r}_{vertical})}{R^2 + x^2}$$

$$d\vec{s} = R\, d\theta\, (-\hat{k})$$

$$r_{horiz} = \hat{r} \cos\theta$$

$$= \hat{r} \frac{R}{(R^2 + x^2)^{1/2}}$$

$$\text{dir}(-\hat{k} \times \hat{r}_{horiz}) = \text{dir}\ \hat{\jmath}$$

$\hat{r}_{vert}$

$\otimes$ $d\vec{s}$ Skip - we don't have to know this complex ...