Charge + Feilds

Culombs $F_E = k\frac{q_1 q_2}{r^2}$

$E = \frac{F_{on}}{q}$

Efeild from point charge $E = k\frac{Q}{r^2}\hat{r}$

Efeilds add up

Efeild => $\int k \frac{dQ}{r^2}$ $dQ = \lambda dx$ or σdA or ρdV

Flux => $\Phi = E \cdot A$ or $\int E \cdot da$

Guasses Law

$\oint E \cdot dA$ => $\frac{Q_{enclosed}}{\varepsilon_0}$ → 8.87×10^{-12} F/m

E inside uniform charged shell = 0

outside acts like point charge

E of infinite plane = $\frac{\sigma}{2\varepsilon_0}$

Metals

E=0 inside

net inside = 0

E ⊥ to surface

E outside => $\frac{\sigma}{\varepsilon_0}$

polarization

$k = 9E9$ Nm^2/C^2

$e = 1.602\times10^{-19}$ C

VOLTAGE

$\Delta V = \frac{\Delta U_{of\,q}}{q} = -\int_a^b E \cdot dr$ (electric potential)

V = - Work

E=0, V>0

less voltage

voltage = 0, Electric ≠ 0

$V_{point\ charge} = \frac{kQ}{r}$

conducting shell: internal charge position no effect on lines

Compaciters

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

$C = \frac{\varepsilon_0 A}{d}$

in series $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$ in perllel $C = C_1 + C_2$

$U = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{V}$

Energy per volume = $u = \frac{U}{volume} = \frac{1}{2}\varepsilon_0 E^2$

add dialectric $C = \frac{k\varepsilon_0 A}{d}$

adding dialectic

E↓ V↓ C↑

as d increases and q=q

E = E

ΔV ↑

C ↓

U ↑

Current

$I = \frac{dQ}{dt}$ $J = \frac{I}{A} = nqv_d$ (# charges, drift speed)

Circuits

$P = IV$ $P = I^2R$

$V = IR$ $R = \frac{L}{\sigma A}$

$I_{peak}/\sqrt{2} = I_{rms}$ same as V

$R = \frac{mv}{qB}$

Farradays Law

FL: Emf caused by changing magnetic flux

$\mathcal{E}_{N\,loops} = -N\frac{d\Phi}{dt}$ $\Phi = \int \vec{B}\cdot d\vec{a}$

$\Phi = Tm^2$

$\mathcal{E}_{around\ 1\ loop} = \oint \vec{E}\cdot d\vec{l}$

Lenzs Law: $I_{induced}$ creats $B_{induced}$ in direction oppesit to changing flux

Sources of Magnetic Feilds

Biot-Savart law: $dB = \frac{\mu_0 I}{4\pi}\cdot\frac{d\vec{l}\times\hat{r}}{r^2}$

$\mu_0 = 4\pi\times10^{-7}\frac{T\cdot m}{A}$

$\tau = \mu_0 \times B$

Amperes Law: $\oint_L \vec{B}\cdot d\vec{l} = \mu_0 I_{enclosed}$ or $\mu_0 I_{thru}$

- $B_{outside}$ straight wire: $B = \frac{\mu_0 I}{2\pi r}$
- B_{inside} straight wire radius R: $B = \frac{\mu_0 I r}{2\pi R^2}$
- B_{inside} Solenoid: $B = \mu_0 n I$
- Right hand Rule: Thumb direction of current, fingers wrap around wire to make B feild
- parallel currents attract, antiparallel repell
- Gausses law applies: $\oint B \cdot da = 0$ (does not exist)
- Feild of a Solenoid = Magnet

RC Circuits

charging: $q(t) = CV_B(1-e^{-t/RC})$

$V_c = Q/C$ $P_{bat} = P_R + P_C$ $I(t) = \frac{V_B}{R}e^{-t/RC}$

uncharged compaciter = wire @ $t = 0^+$

fully charged compaciter = open switch

time constant $\tau = RC$

$t \to \infty$ $q \to CV_B$ $I \to 0$ $I(\tau) = I(37\%)$

Magnetic feilds

$F_{on\,q} = q\vec{v}\times\vec{B}$ $\mu = NI\vec{A}$ (N wires)

$F_{tot} = q\vec{E} + q\vec{v}\times\vec{B}$ => $F_{tot} = F_E + F_B$

velocity selector: $v = \frac{E}{B}$ when $F_E = -F_B$

$\omega = \frac{v^2/R}{}$, $R = \frac{mv}{qB}$

$F_{on\ wire} = I\vec{L}\times\vec{B}$ = ILBsinθ

F ⊥ I, F ⊥ B

force and torque in current loop

F_{on} closed loop = 0 stationary

Force = 0

Torque = IAB sinθ

$B = \frac{3\mu_0 I}{8R}$

current flows to the left

$\tau = \mu \times B$ (loop magnetic moment)

$\mu_B = IA$

moment x feild = direction of net torque

E or $B = \frac{\mu_0 I}{2\pi a^2}r$ for r<a

E or $B = \frac{\mu_0 I}{2\pi r}$ for r>a

$F = \frac{\mu_0 I_1 I_2 L}{2\pi r}$

B feild $= \frac{\mu_0 I}{2R}\left(\frac{1}{2} + \frac{1}{\pi}\right)$

B feild half circle $= \frac{\mu_0 I}{4R}$

magnitude of $\oint B \cdot dl = \mu_0 I = 0$

no I enclosed

Inductors => L

$\Phi_m = LI$

$\mathcal{E} = -L\frac{dI}{dt}$

circuits $\tau = L/R$

I thru L cannot change instantly

steady state I = constant, acts like a short or wire

magnetic energy density $u_m = \frac{B^2}{2\mu_0}$

magnetic energy of inductor $\frac{LI^2}{2}$

- Polarity/direction depends on increase/decrease of I
  - i) if I ↑ polarity tries to decrease I
  - ii) if I ↓ polarity tries to increase current

AC Circuits

$v(t) = V\sin(\omega t)$

transformers only work for AC

$\frac{V_{out}}{V_{in}} = \frac{V_s}{V_p} = \frac{N_s}{N_p}$

Transformers

primary N_p = # turns

secondary N_s = # turns

ratio of $\frac{V_{secondary}}{V_{primary}} = \frac{N_s}{N_p}$

$\frac{V_s}{V_p} = \frac{I_p}{I_s} = \frac{N_s}{N_p}$

$P_{avg} = I_{rms}^2 R = \frac{V_{rms}^2}{R}$

camera vs eye

f fixed; f adjustable

less bend; more bend

EM Waves

Light Elecromagnetic wave created by accelerating electric charges

$\lambda f = c$ ← speed of light (wavelength, frequency)

$I = P/A$ (intensity, power, area)

transverse

longitudinal

$v = \frac{\lambda}{T} = \lambda f$ v usually constant

$y(x,t) = A\sin\left(\left(\frac{x}{\lambda} - \frac{t}{T}\right)2\pi\right) = A\sin(kx - \omega t)$

right −, left +

period

$\omega = \frac{2\pi}{T}$ angular frequency

$k = \frac{2\pi}{\lambda}$ wave number

$n = c/v$

$c = 3\times10^8$

Optics

Snells law => $n_i\sin\theta_i = n_f\sin\theta_f$

index of refraction => $n = \frac{c}{v}$

total internal refraction @ θ_c = $n_i\sin\theta_c = n_f\sin(90) = n_f$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$ (object d_o, f, image d_i)

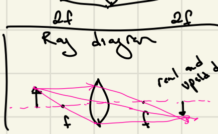
Converging: f>0

Diverging: f<0, not real image

point source: light parallel far from

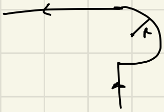
eye converging lense

source at f



$dQ = \frac{Q}{L}dx$ $E = \frac{k\,dQ}{h^2+x^2}$

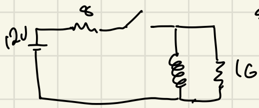
$\sin\theta = \frac{x}{\sqrt{h^2+x^2}}$ $dE_x = \frac{kx\frac{Q}{L}dx}{(h^2+x^2)^{3/2}}$



$\frac{\mu_0 I}{4R}\left(1 + \frac{1}{\pi}\right)$

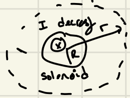
$\frac{1}{2}(E_{wire}) + \frac{1}{2}(E_{circle})$

$\Rightarrow \frac{1}{2}\left(\frac{\mu_0 I}{2\pi R} + \frac{\mu_0 I}{2R}\right)$



switch closed
curent from battery = .5
12 / 8+16
long time
12/8 = 1.5

L is opposit of C



$\oint E\,ds = -\frac{d\Phi_B}{dt}$

$\Phi_B = \pi r^2 B$

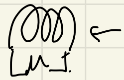
$E \cdot 2\pi r = -\pi R^2 \frac{dB}{dt}$

$E = -\frac{R^2}{2r}\frac{dB}{dt}$

N = 3 B = 2 | decreasing .2 T/s

10 Ω resister

A = .01 m²

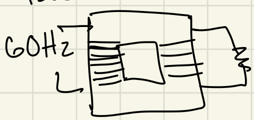


$\varepsilon = -\frac{d\phi}{dt}$

$= 3 \cdot (.01)(.2) = .006V$

$= \frac{6mV}{10\Omega}$

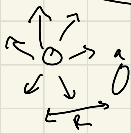
120V



$N_p = 1000 \quad N_s = 50$

$V_{out} = \frac{120}{1000/50} = 6V$

$P = \frac{V^2}{R} \quad \frac{6^2}{12} = \frac{36}{12} = $ 3W



Energy Recieved by detector

$\frac{P_0}{4\pi R^2} \cdot a \cdot t$