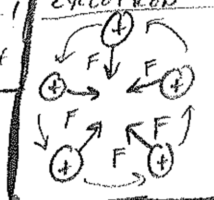
LENSES:	(+)	(−)
Focal length	Converging	Diverging
Image Distance	Real Image	Virtual
Radius	Convex toward object	Concave toward object
MIRRORS:		
Radius	Concave toward object	Convex toward object
Focal length	Concave " "	Convex " "
Image Distance	Real	Virtual

* $\vec{E}$ and $\vec{V}$ from another object!
U_E and $\vec{F}$ on another object

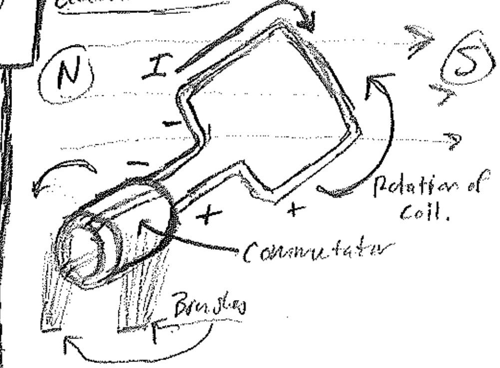
ΔV CAUSES $\vec{E}$
$\vec{E}$ CAUSES $I \Rightarrow \sigma A E$
I DETERMINED BY $\frac{V}{R}$
"IDEAL WIRE" $\Rightarrow R = \emptyset$

CYCLOTRON



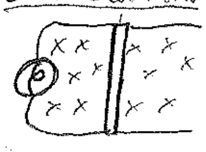
Two wires carrying I in SAME DIRECTION: ATTRACT!

Electric motor:

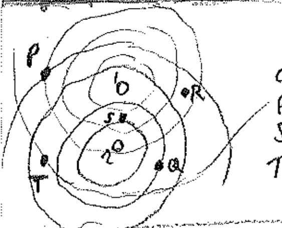


$l = 10cm$

Desert Generator: Bulb $R = 6\Omega$ in $.1T$ field
Need $.5A$ to get Full Brightness.
What $\vec{V}$ needed to pull wire?

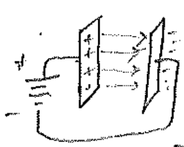


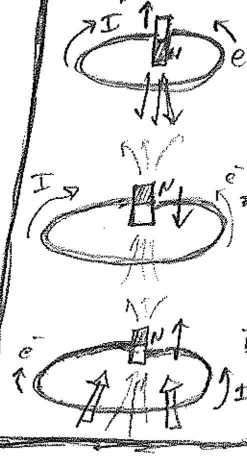
$\vec{V} = \frac{RI}{lB} \Rightarrow \frac{3}{(.1m)(.1T)} \Rightarrow 300\ m/s$



P = Constr.
Q = Destr.
R = Constr.
S = Const.
T = Destr.

PARALLEL PLATE CAPACITOR:
2 Plates seperated by insulator.
Battery creates opposite charges on each plate; current flows when discharged.



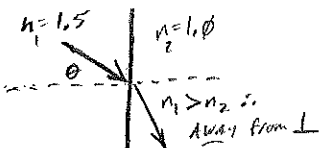


Decreasing Φ, Downward $\vec{B}$ to counter $I \to CW$
Magnet moving ↑

"Increasing Φ ∴ Downward $\vec{B}$ ∴ $I \Rightarrow CW$

Decreasing Φ ∴ Upward $\vec{B}$ ∴ $I = CCW$

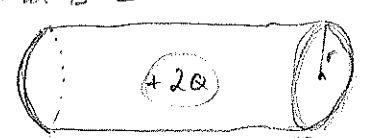
At $d = 5m$, jackhammer has an intensity 10x greater than a tornado siren. If siren's intensity is 120 dB, what is intensity of jackhammer?
$\Rightarrow 130 dB$ $\beta = 10\,db \cdot \log_{10}\left(\frac{I_1}{I_2}\right)$



$n_1 > n_2$ ∴ Away from ⊥

In double-slit interference experiment, which of the following actions would cause fringe spacing to increase?
Increase Distance to View Screen.
Increase the λ of light
Decrease? → Increase slit spacing or Put it in H_2O!

What is Φ thru Gaussian Surface in terms of Q?



$\ominus$ −Q

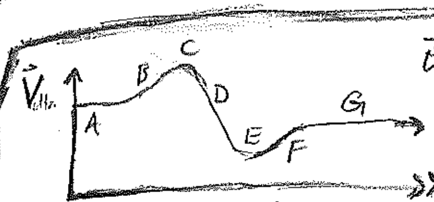
$\phi = \frac{\partial q}{\varepsilon_0}$

Yang can focus on objects 150cm away w/ relaxed eye, W/full accommodation, she can focus on objects 20cm away. After corrected for distance vision, what will her near point be while wearing glasses?

$1/f = \frac{1}{s} + \frac{1}{s'} = \left(\frac{1}{.20}\right) + \left(\frac{-1}{1.5m}\right) = -.67D.$

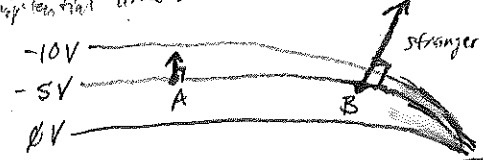
∴ $s' = -20cm$; $f = -150cm$ ∴ new near point $s = fs'/s'-f = 23cm.$

$\vec{E} = \frac{V}{d}$

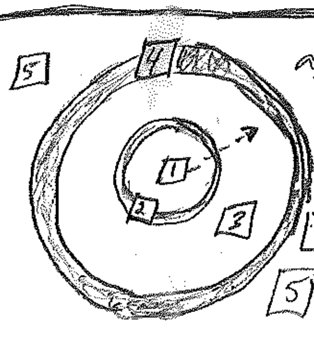


a.) where is largest $\vec{E}$? D
b.) where will $\vec{E}$ point Left? B, F.
c) where does e^- have largest U_e? E.
d) where is p^+ acceleration greatest? D.

Equipotential lines. $\vec{E}$ fields @ pts. A and B,



e^- experiencing
a in +x direction (to Right) due to $\vec{E}$.
a) $\vec{E}$ direction = LEFT
b) Potential is greater RIGHT
c) E^- U_e greater LEFT
d) e^- moving? CAN'T TELL



a) $\boxed{1}$ $\vec{E} = \emptyset$
$\boxed{2}$ $\vec{E} = \emptyset$
$\boxed{3}$ $\vec{E} = K \cdot \frac{2\lambda}{r}$
$\boxed{4}$ same as 2!
$\boxed{5} \Rightarrow \vec{E} = \frac{\lambda_1 + \lambda_2}{2\pi r \varepsilon_0}$

$V = \lambda f$

Index of Refraction : $n = \frac{c}{v}$

$V = \sqrt{\frac{T}{\mu}}$; T: Tension ; μ = String density

$\Delta\phi = \frac{2\pi \Delta x}{\lambda}$

Intensity of Light $= \frac{Power}{Area}$

K = Phase Constant $\Rightarrow \frac{2\pi}{\lambda}$

R + -propagating wave : $D = \sin(kx - \omega t)$

L + - " " : $D = \sin(kx + \omega t)$

$\phi = Kr - \omega t + \phi_0$; ϕ_0 = Initial Phase

Amplitude $\Rightarrow 2a\cos\left(\frac{\Delta\phi}{2}\right)$

$\Rightarrow 2a\cos\left(\frac{\pi \cdot \Delta r}{\lambda}\right)$

$n_1 > n_2$ Leads away from ⊥

V_1

Harmonics / MODE PATTERNS

String	open-open	open-open	Closed-open
1^{st}	$\lambda = 2L$, $f = V/2L$	$\lambda = 2L$, $f = V/2L$	$\lambda = 4L$, $f = \frac{V}{4L}$
2^{nd}	$\lambda = L$, $f = \frac{V}{L}$	$\lambda = L$, $f = \frac{V}{L}$	$\lambda = 4/3\,L$, $f = 3/4\,\frac{V}{L}$
3^{rd}	$\lambda = 2/3\,L$, $f = 3/2\,\frac{V}{L}$	$\lambda = 2/3\,L$, $f = 3/2\,\frac{V}{L}$	$\lambda = \frac{4L}{5}$, $f = \frac{5}{4}\frac{V}{L}$
MODE :	$\lambda = \frac{2L}{m}$	$\lambda = \frac{2L}{m}$	$\lambda = \frac{4L}{m}$; m = odd

m = # Anti-nodes !

Double-Slit Constructive Interference : $\Delta r = d\sin\theta = m\lambda$ ← Spectroscopy!

Bright Fringes @ angles : $\theta_m = m\left(\frac{\lambda}{d}\right)$; $m = 0, 1, 2, 3, \ldots$

REFLECTION : $\theta I = \theta R$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{S_0} + \frac{1}{S_i} = \frac{1}{f}$

$f = \frac{R}{2}$

Total Internal Reflection : $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

Magnification $= \frac{h_i}{h_o} = \frac{-S_i}{S_o}$

* If $m = (+)$, IMAGE IS UPRIGHT !!

$S_i = \left(\frac{n_2}{n_1}\right) S_0$

Diopter (D) $= \frac{1}{f}\ m^{-1}$

TOTAL MAGNIFICATION $= (M_1)(M_2)\ldots$

Diffraction Limit : $W = \frac{2.44\lambda(f)}{D}$

Resolution : $\theta_{min} = \frac{1.22\lambda}{D}$; Human eye focuses Diverging Rays!

d = spacing b/t slits ⇒ 1mm / # slits

Fringe Spacing : $\Delta y = \frac{\lambda L}{d}$

Fringe Position : Height above center of screen: $y_m = L\tan\theta_m$; m = # fringes or $y_m = \frac{m\lambda L}{d}$

Fiber optics : $n_{cladding} < n_{core}$

OPTICAL INSTRUMENTS : (> 1 lenses combined) - Image of 1^{st} → object of 2^{nd}

$\vec{F} = q\vec{E}$

$\vec{F} = K\frac{|q_1||q_2|}{r^2}$

$\vec{E} = k\frac{q}{r^2}\hat{r}$ (point charges)

If Diopter (Rx) = (−) : myopia ! If (+), Hyperopia!

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

Linear charge Density $\lambda = \frac{Q}{L}$

Area Charge Density $\eta = \frac{Q}{A}$

Volume charge Density $\rho = \frac{Q}{V}$

Ring of Charge : $\vec{E} = \frac{KzQ}{(z^2+R^2)^{3/2}}$; z = height above ring

Line of charge : $\vec{E} = \frac{KQ}{r\sqrt{r^2 + \left(\frac{L}{2}\right)^2}}$

Infinite Line of Charge : $\vec{E} = \frac{K2\lambda}{r}$

Disk of charge : $\eta = \frac{Q}{\pi R^2}$; $\vec{E} = \frac{\eta}{2\varepsilon_0}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)$

Plane of Charge : $|\vec{E}| = \frac{\eta}{2\varepsilon_0}$

Sphere of charge : (r from center) $\vec{E} = \frac{kQ}{r^2}$

Dipole Moment : $p = qs$

$\tau = p \times \vec{E}$

Velocity $= \sqrt{\frac{2 \cdot KE}{mass}}$

Dielectric constant (Polarizability) $K_{appa} = \varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$

Velocity of sound $= 343\ m/s$

$6.022 \times 10^{23} = 1\ mol$

$KE = \frac{1}{2}mv^2$; $U_c = mgh$

$U_E = qV$

$\Delta U_E = \Delta KE$

$\varepsilon_0 = \frac{C^2}{Nm^2}$

$V = \mathcal{E}$

$\varepsilon_0 = 8.85 \times 10^{-12}$

$\mu_0 = 4\pi \times 10^{-7}$

$\int dA \Rightarrow$ Volume! Sphere Vol $= \frac{4}{3}\pi r^3$; Cylinder $= \pi r^2 h$

$K = 9 \times 10^9\ \frac{Nm^2}{C^2}$

$C = 3 \times 10^8\ m/s$

$\bar{e} = 1.6 \times 10^{-19}\ C$; $9.11 \times 10^{-31}\ kg$

$p^+ = 1.67 \times 10^{-27}\ kg$

Capacitor : $\vec{E} = \frac{Q}{\varepsilon_0 A}$; $\eta = \frac{Q}{A}$

$\vec{a} = \left(\frac{q}{mass}\right)\vec{E}$

$\Phi = \vec{E} \cdot \vec{A}\cos\theta$

KINEMATICS !!!

$V_{f_y} = V_{i_y} + a_y \Delta t$

$V = V_0 + at$

$\Delta x = V_0 t + \frac{1}{2}at^2$

$V^2 = V_0^2 + 2a\Delta x$

$S_f = S_i + V_i t - \frac{1}{2}at^2$

Voltage $= -\vec{E} \cdot d$; $\vec{E} = \frac{-V}{d}$

$\Phi = \frac{Q_{in}}{\varepsilon_0}$

Q = Coulomb

$\Phi = Nm^2/C$

$\vec{E} = N/C$

$\vec{E} = \frac{\rho r}{3\varepsilon_0}$

$\vec{F} = \frac{Kq_1q_2}{r^2}$

$\vec{E} = \frac{Kq}{r^2}$

$V_{d} = \frac{J}{C}$

$V = \frac{Kq}{r}$

$U = \frac{Kq_1q_2}{r^2}$

$U_c = \frac{Q^2}{2C}$ (Joules)

$Q = C_{apacitance} \cdot \Delta V$

τ = mean-time b/t collisions

$\Delta V_c = \frac{Q}{\varepsilon_0 A} \cdot d$

Parallel Plate Capacitor : $\frac{\varepsilon_0 A}{d}$ = Farads

i_e = "electrons per second" $\Rightarrow n_e \cdot A \cdot V_d$

n_e = e^- # per unit volume

$C = \varepsilon_r \cdot C_0$

$\left(\varepsilon_r = \frac{\varepsilon_r}{\varepsilon_0}\right)$

I = current $\left(\frac{C}{second}\right)$

$I = i_e \cdot e$

J = Current density $\Rightarrow \frac{I}{A}$

DRIFT VELOCITY = $V_d = \frac{e\tau}{m}(\vec{E})$; e = e^- charge! m = e^- mass!

CONDUCTIVITY σ : $\left(\frac{n_e \cdot e^2 \cdot \tau}{m}\right)\vec{E}$

$J = \sigma E$

$\rho = \frac{1}{\sigma}$ "Resistivity"

R = Resistance : $\frac{\rho L}{A}$

• = toward ; × = away

$\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\frac{q\vec{V} \times \hat{r}}{r^2}$

$\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\frac{qV\sin\theta}{r^2}$

$\vec{B}$ = Teslas

$\vec{B}_{wire} = \frac{\mu_0 I}{2\pi d}$

SOLENOID : $\vec{B} = \left(\frac{\mu_0}{2}\right)\frac{NI}{R}$; N = # wire turns ; R = loop radius.

RHR CURRENT : Thumb = I direction ; Fingers Curl in direction of $\vec{B}$!!!

Right Hand Rule : Thumb = $\vec{V}$; Index = $\hat{r}$; middle = $\vec{B}$

Dipole moment ($\vec{B}$) $\vec{\mu} = A \cdot I$

INSIDE LOOP ↑ OUTSIDE LOOP ↓

If charge (−), flip !! ↑

Frequency (cyc) : $\frac{qB}{2\pi m}$

$\vec{B} = \left(\frac{\mu_0}{4\pi}\right)\frac{2\vec{\mu}}{z^3}$

MRI : $\vec{B} = \mu_0 \frac{NI}{Length}$

RHR - $\vec{B}$ Force : Thumb = $\vec{V}$; INDEX = $\vec{B}$; MIDDLE = $\vec{F}$; * FLIP $\vec{F}$ if (−) charge !!

wire : $\vec{F} = I\vec{l} \times \vec{B}$

z = distance from dipole center

$\vec{F} = q\vec{V} \times \vec{B} \Rightarrow |\vec{F}| = qVB$

INDUCTION : $E = VB$ ∴

CYCLOTRON : $r = \frac{mV}{qB}$

$\Phi_B = BA\cos\theta$

INDUCTOR : $\vec{B} = \frac{\mu_0 \cdot N \cdot I}{l}$

$\Delta V = \mathcal{E} = VBl$ ∴

$\Phi = \omega t$

INDUCTANCE : $L = \frac{\Phi_m}{I}$

$I = \frac{\mathcal{E}}{R} \Rightarrow \frac{VlB}{R}$ ∴

$\Phi_m = \left(\frac{\mu_0 \cdot N^2 \cdot A}{l}\right) \cdot I$

$F = \frac{Vl^2B^2}{R}$