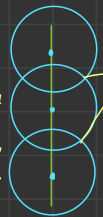
Chapter 2: Physical Optics

Huygen's Principle

↳ each point on a wave front act as a secondary point source emitting secondary waves known as wavelets



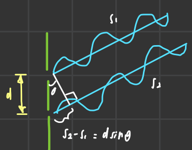
Coherent Source

↳ sources that have
- same frequency
- maintain a constant phase

in-phase
- same frequency,
- zero-phase difference

anti-phase
- same frequency
- π / 180° phase difference

Path difference (PD)



Phase difference, ϕ

↳ if there is path difference, there is phase difference.

* if PD = λ, ϕ = 180° / π

$$\frac{\phi}{2\pi} = \frac{PD}{\lambda}$$

Interference of

2 inphase

m	$\Delta\phi$	PD
2	4π	2λ
1	3π	$\frac{3\lambda}{2}$
1	2π	λ
0	π	$\frac{\lambda}{2}$
0	0	0
0	π	$\frac{\lambda}{2}$
1	2π	λ
1	3π	$\frac{3\lambda}{2}$
2	4π	2λ

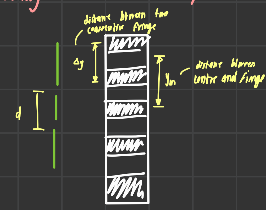
Constructive (bright)	Destructive (dark)
PD = mλ	PD = $(m + \frac{\lambda}{2})$
ϕ = 2mλ	$\phi = (2m+1)\pi$

2 anti-phase

m	$\Delta\phi$	PD
2	5π	2λ
1	4π	$\frac{3\lambda}{2}$
1	3π	λ
0	2π	$\frac{\lambda}{2}$
0	π	0
0	2π	$\frac{\lambda}{2}$
1	3π	λ
1	4π	$\frac{3\lambda}{2}$
2	5π	2λ

Constructive (bright)	Destructive (dark)
PD = $(m + \frac{\lambda}{2})$	PD = mλ
$\phi = (2m+1)\pi$	ϕ = 2mλ

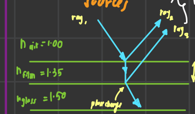
Young's double-slit experiment



condition	eqn
central — bright fringe	$y_m = \frac{m\lambda D}{d}$
central – dark fringe	$y_m = \frac{(m+\frac{1}{2})\lambda D}{d}$

Interference on thin film.

in-phase coherent sources



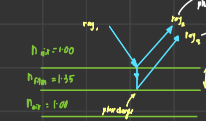
both experience π rad phase change as they move from dense → less dense medium = in-phase

constructive, $2nt = m\lambda$

destructive, $2nt = (m + 1/2)\lambda$

$t > 0$, $m_{bright} = 1$, $m_{dark} = 0$

anti-phase coherent source



constructive, $2nt = (m + 1/2)\lambda$

destructive, $2nt = m\lambda$

$t > 0$, $m_{bright} = 0$, $m_{dark} = 1$

① Air wedge

anti-phase coherent source

constructive, $2nt = (m + 1/2)\lambda$

destructive, $2nt = m\lambda$

1st bright, m = 0

1st dark, m = 0

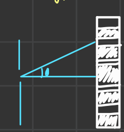
② Newton's rings

anti-phase coherent source

	In-phase	anti-phase
Center	Bright	Dark
Formula	constructive, $2nt = m\lambda$ destructive, $2nt = (m+1/2)\lambda$	constructive, $2nt = (m+1/2)\lambda$ destructive $2nt = m\lambda$
m	1st bright, m = 1 1st dark, m = 0	1st bright, m = 0 1st dark, m = 1

③ Single slit diffraction

destructive (minima)	$\sin\theta = \frac{m\lambda}{a}$ m = ±1, ±2, ... * to calc max no of orders observed, θ = 90°
m^{th} order minima — central max	$\tan\theta = \frac{y_m}{D}$
width of central max	$2y_1$



④ Diffraction Gratin

constructive	$d\sin\theta = m\lambda$
separation distance between slits, d	$d = \frac{1}{N}$ lines/mm

Chapter 3: Electrostatics

Electric Charges, $Q = ne$

e: 1.602×10^{-19} C

Coulomb's Law

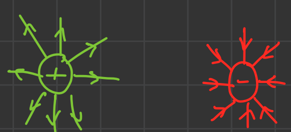
$$F_c = \frac{Kq_1q_2}{r^2} \; N$$

K: $9.0 \times 10^9 \, Nm^2C^{-2}$ (coulomb constant)

$$F_{12} = F_{21} = \frac{Kq_1q_2}{r^2}$$

Electric Field

(region around a charged particle where any electric charge in the region will experience an electric force



Electric Field Strength, $E = \frac{F}{q_0} = \frac{kq}{r^2}$ NC^{-1}

q: point charge

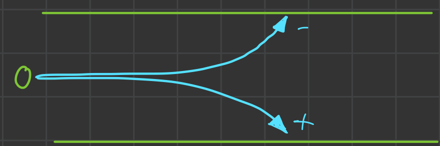
q_0: test charge ($\hat{q}$ nk diguna[kan])

q_0:
- +ve : F & E same direction
- −ve : F & E opposite direction

Electric Field Produced by Parallel Plates, $E = \frac{\Delta V}{d}$ Vm^{-1}

ΔV: potential difference between parallel plates

d: distance between parallel plates



x-component	y-component
$a_x = 0$	$a_y = \frac{qE}{m}$
$u_x = u$	$u_y = 0$
$v_x = u_x = u$	$v_y = +\frac{qE}{m}t$ - moves upward $v_y = -\frac{qE}{m}t$ - moves downward
$s_x = ut$	$s_y = +\frac{1}{2}\frac{qE}{m}t^2$ - moves upward $s_y = -\frac{1}{2}\frac{qE}{m}t^2$ - moves downward
	$v_y = \sqrt{2\frac{qE}{m}s_y}$

Electric Potential, $V = \frac{kq}{r}$

Potential Difference, $\Delta V = \frac{W_{AB}}{q_0}$

W_{AB}: work done to move charge from point A to B

ΔV terbalik: $\boxed{V_{BA} = V_B - V_A}$

- +ve, work done by external force
- −ve, work done by electric force
- in uniform electric field : $\Delta V = E \cdot d$

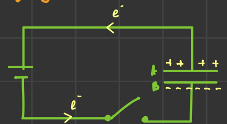
Electric Potential Energy, $U = \frac{kqq_0}{r}$

$$\Delta U = U_f - U_i$$

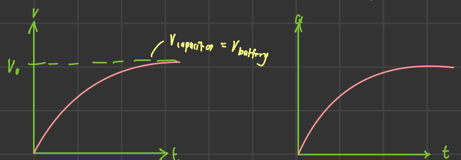
Chapter 4: Capacitors

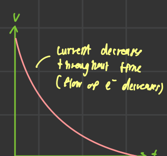
Charging, discharging of capacitor

Charging

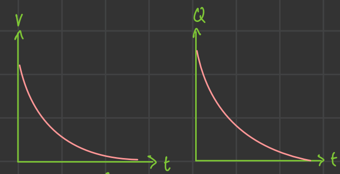


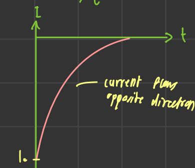
- when the switch is closed, electron flows and accumulate on the plate B
- then electrons 'll flow to the +ve terminal of battery, making plate A positively -charged.





Discharging

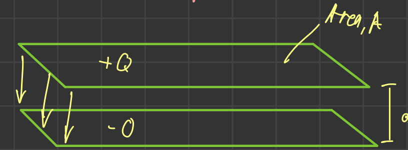




Potential Difference, $\Delta V = Ed$

Capacitance, $C = \dfrac{Q}{V}$ (CV^{-1} or F (farads))

Parallel Plate Capacitors



$C_0 = \dfrac{\varepsilon_0 A}{d}$ — if separated by air

ε_0: permittivity of free space (air) $= 8.85 \times 10^{-12}\ C^2 N^{-1} m^{-2}$

$C = \dfrac{\varepsilon A}{d}$ — if separated by a $\boxed{\text{dielectric}}$ material

dielectric: poor conductor of electricity, efficient supporter of electrostatic field

dielectric constant, $k = \dfrac{C}{C_0} = \dfrac{\varepsilon}{\varepsilon_0} = \dfrac{V_0}{V} = \dfrac{E_0}{E}$

Effect of inserting dielectric materials

Bat3 is connected	Bat3 is disconnected
C↑	C↑
V =	V↓
Q↑	Q =
E =	E↓

Capacitors in series

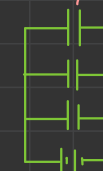
$Q_1 = Q_2 = Q_3$

$V = V_1 + V_2 + V_3$

$\dfrac{1}{C_{eq}} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$

$C_{eq} < C$

Capacitors in parallel



$V = V_1 = V_2 = V_3$

$Q = Q_1 + Q_2 + Q_3$

$C = C_1 + C_2 + C_3$

$C_{eq} > C$

Energy stored in a capacitor

work done to separate opposite charges, and move them to two parallel plates

$U = W = \dfrac{1}{2}\dfrac{Q^2}{C}$

$= \dfrac{1}{2} CV^2$

$= \dfrac{1}{2} QV$

Chapter 5: Electric Current

Electric Current, I

↳ rate of flow of charge

$I = \frac{Q}{t}$

Drift velocity, $V_d = \frac{I}{nAe}$

e — 1.6×10^{-19} Coulomb

n — no. of electron per unit volume

↳ average velocity of electrons that drift due to electric force

Ohm's Law

↳ current is proportional to potential difference, if the temperature is constant

$V = IR$

R ↳ due to collisions between the electron and the fixed atom inside the conductor

$R = \rho\frac{L}{A}$ / $\rho = \frac{RA}{L}$

ρ — resistivity of material Ωm

$\sigma = \frac{1}{\rho}$ → inverse of resitivity, conductivity $\Omega^{-1}m^{-1}$

Electrical Energy and Power

$W = VIt$ — ①

$E = W = VIt$

$= I^2Rt$ — ②

$= \frac{V^2t}{R}$

$P = \frac{W}{t} = \frac{E}{t}$ — ③

③ → ②

$P = IV$

$P = I^2R = \frac{V^2}{R}$

Electromotive Force (emf), ε

↳ work done to move a charge through internal resistance, r and external resistance, R

internal resistance, r - due to chemical reaction in the battery

$\varepsilon = V_t + V_r$

V_t ↓ terminal voltage

V_r ↓ voltage dropped

$V_t = IR$, $V_r = Ir$

$\varepsilon = V_t + Ir$

$= I(R+r)$

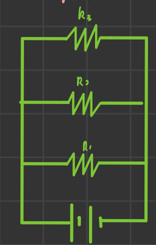
Series

$I_{eq} = I_1 = I_2 = I_3$

$V_{eq} = V_1 + V_2 + V_3$

$R_{eq} = R_1 + R_2 + R_3$

Parallel



$I_{eq} = I_1 + I_2 + I_3$

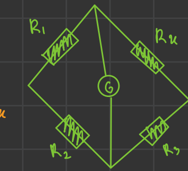
$V_{eq} = V_1 = V_2 = V_3$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Wheatstone bridge

$\frac{R_x}{R_1} = \frac{R_3}{R_2}$

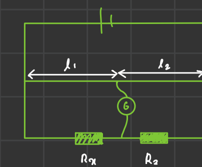
besides R_x



modified into

Slidewire bridge

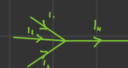
$\frac{l_1}{l_2} = \frac{R_x}{R_2}$



Kirchoff's Law

1st Law / current law

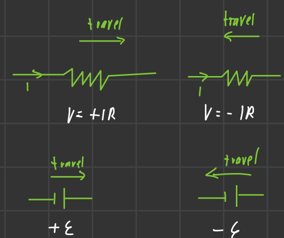
$\Sigma I_{in} = \Sigma I_{out}$



$I_1 + I_2 + I_3 = I_4$

2nd Law / voltage law

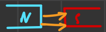
$\Sigma \varepsilon = \Sigma V = \Sigma IR$



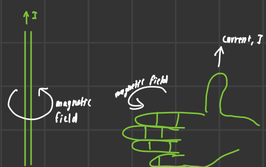
Chapter 6 : Magnetism

Magnetic field, T(tesla)

↳ region around a magnet where a magnetic force can be experienced

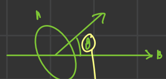


Right hand rule



→ Represents number of magnetic field lines

Magnetic Flux (Ø)



$\emptyset = BA\cos\theta$

normal to area, A

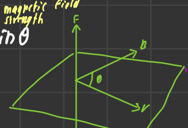
Weber (Wb)

Magnetic Force

- A moving charges produces magnetic field
- A second moving charge responds to this magnetic field experiences electric force

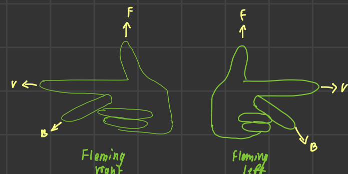
$F = qvB\sin\theta$

charge, magnetic field strength, velocity

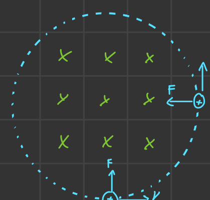


Determining direction of magnetic force

+ve charge — -ve charge



Motion of Charged Particle in a Magnetic Field



- use fleming right hand, B (magnetic field) into the paper
- F causes centripetal acceleration

$F = F$

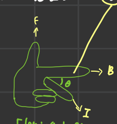
$\frac{mv^2}{r} = qvB\sin\theta$

V perpendicular to B, θ: 90°

↳ if V is not perpendicular to B, path is spiral (helix)

Magnetic Force on a Current-Carrying Conductor

$F = BIL\sin\theta$



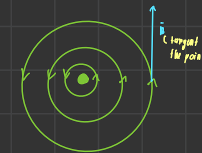
Magnetic Field

a) long, straight wire

$B = \frac{\mu_0 I}{2\pi r}$

Permeability of free space $4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$

henry



b) At the centre of a Circular Loop

$B = \frac{\mu_0 N I}{2R}$

number of turns

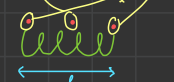
c) Inside a Solenoid

relative permeability (air = 1)

$B = \mu_r \mu_0 n I$

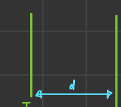
$\frac{N}{l}$

$B = \frac{1}{2}B$



Magnetic Force Between Two Parallel Conductor

a) Attractive Force (I same direction)



Force on wire 2 in the presence of field B_1

$F_{21} = B_1 I_2 l_1 = \frac{\mu_0 I_1 I_2}{2\pi d}$

b) Repulsive Force (I opposite direction)

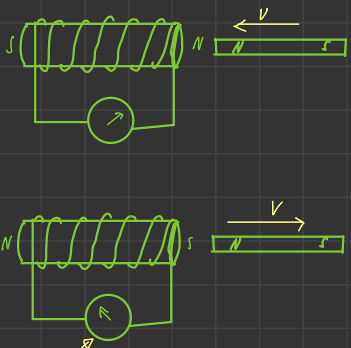
× Magnitude is the same as attractive force, but opposite direction

Chapter 7: Electromagnetic Induction

Electromagnetic Induction

↳ Production of an electric potential difference / Voltage (e.m.f) across a conductor situated in a changing flux

Faraday's Law



- solenoid tends to keep it magnetic force
- will oppose changes

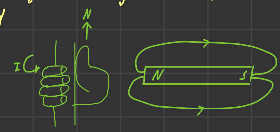
deflection ∝ speed

Faraday's Law of Induction, $\varepsilon = -N \dfrac{d\varnothing_B}{dt}$

change of magnetic flux

Lenz's Law

↳ direction of the induced current is always opposite direction of the original change in magnetic field



Ohm's law, $\varepsilon = IR$

Induced e.m.f

① change in B or A

$$\varepsilon = -N \frac{d(\varnothing_f - \varnothing_i)}{dt}$$

θ is constant

A is constant

$$\varepsilon = -N \frac{d(\varnothing_f - \varnothing_i)}{dt} = \frac{-N(B_f - B_i)A\cos\theta}{dt}$$

B is constant

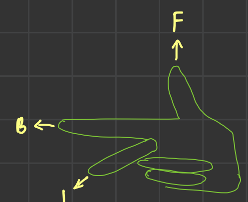
$$= \frac{-N(A_f - A_i)B\cos\theta}{dt}$$

θ varies (rotating)

$\varepsilon = NBA\omega\sin\omega t$

ε is max when $\omega t = \theta = 90°$

Induced E.M.F in a moving conductor



$|\varepsilon| = Blv\sin\theta$

Self induction

↳ a phenomenon when a solenoid experience changing of flux due to change in the magnetic field

self induced emf, $\varepsilon = -L \dfrac{dI}{dt}$

self inductance, H (henry)

Current ↑
- ε = -ve
- induced current opposite direction

Current ↓
- ε = +ve
- induced current same direction

It'll try to oppose the change in current

$$L = \frac{N\varnothing}{I}$$

$$L = \frac{\mu_0 N^2 A}{l}$$

Energy stored in a conductor

$$U = \frac{1}{2}LI^2$$

Chapter 8: Atomic Structure And Nuclear Physics

29/05/2022

Energy of an Electron, $E = E_k + E_v$

V at certain point from a point charg $V = \frac{+e}{4\pi\varepsilon_0 r}$

To bring a test charge from infinity to a point, $W = -q^V$ or $-eV$

Work done is converted to potential energy owned by the electron $V = \frac{-e^2}{4\pi\varepsilon_0 r}$

Kinetic Energy $E_k = \frac{e^2}{8\pi\varepsilon_0 r}$

Total Energy $E = \frac{-ze^2}{8\pi\varepsilon_0 r}$

Bohr's postulate of H atom

① e^- can only moves in an allowed circular orbits without emitting energy, called stationary orbit

② Angular momentum, $L = \frac{nh}{2\pi}$ (n: quantum no, h: planck constant)

③ e^- can make a transition from
- lower energy state → higher energy state (absorbs energy)
- higher energy state → lower energy state (release energy)

Bohr atomic radius

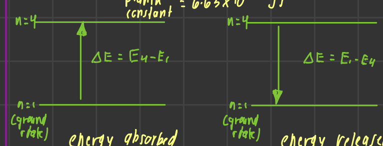
$$r = \frac{n^2 h^2 \varepsilon_0}{\pi (2e)^2 m}$$

2e — total charge

Energy Level Diagram

$\Delta E = E_f - E_i = hf$ $\quad f = \frac{c}{\lambda}$ (c: speed of light 3×10^8 m/s)

h: planck constant $= 6.63\times10^{-34}$ Js



Ground state
A condition where energy of atom is minimum (stable)

Excited state
the electron is situated at higher energy level (not stable)

Energy state for H atom, $E_n = -\frac{E_1}{n^2}$

E_1: ground state energy (13.59 eV)

$* 1\text{ eV} = 1.6\times10^{-19}$ Joule

Energy
- **Excitation Energy**: energy needed by an electron in inner orbit to jump to a higher orbit
- **Ionization Energy**: energy required by an inner orbit electron to be completely free from the atom

Electron transition

↳ electron in an excited state is unstable, and will fall back to the ground state } photons emitted

energy of the photons are equal to ΔE

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

R_H: Rydberg constant $= 1.097\times10^7\ m^{-1}$

Principle of Energy-Mass Equivalence

$E = mc^2$

Electron Volt (eV)
$1\text{ MeV} = 1.6\times10^{-13}$ J

Unified Mass Unit (u)
↳ unit of mass that equals to mass of one 12-C

$1u = 1.66\times10^{-27}$ kg

$1u = 1.49\times10^{-10}$ J

$1u = \frac{931.5\text{ MeV}}{c^2}$

Mass Defect

↳ $M_{nucleus} < (\Sigma m_{proton} + \Sigma m_{neutron})$

↳ there is loss of mass when the nucleus is formed

$\Delta m = (Zm_p + Zm_n) - M_n$

Δm: converted into energy

Binding Energy

↳ energy required to separate nucleons into protons and neutrons

$E = \Delta mc^2$

Spontaneous Decay

↳ process which the nucleus of an unstable atom loses energy by emitting radiation or particles.

$\Delta m = \Sigma m_{before} - \Sigma m_{after}$

Radioactive decay
- **Alpha, α**
  - emits ${}^4_2He$
  - ${}^{A-4}_{Z-2}X$
- **Beta, β**
  - emits ${}^0_{-1}\beta$
  - ${}^{A}_{Z+1}X$
- **Gamma, γ**
  - emits photons (gamma rays)
  - nucleus changes from high level energy state → low level energy state
  - electromagnetic radiation of very short λ, high penetrating power

Nuclear Reaction

Nuclear Fission ("Fi split")
- heavy molecules split into smaller nuclei, by bombarding it with neutron / proton / beta / alpha } particle

Nuclear Fusion
- two nuclei combine to form a heavier nucleus
- energy released (thermonuclear energy)