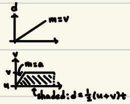
Made with Goodnotes

① Kinematics

- Velocity: $v = \frac{d}{t}$ (ms^{-1})
- acceleration: $a = \frac{v-u}{t}$ (ms^{-2})
  - → const. v: $a = 0$
  - → uniform a: const. Δv
    - → $d = \frac{1}{2}(u+v)t$
    - → $d = vt - \frac{1}{2}at^2$
    - → $d = ut + \frac{1}{2}at^2$
    - → $v = u + at$
    - → $v^2 = u^2 + 2ad$



- free fall: const. $a = g \approx 10ms^{-2}$ (on earth)
- terminal velocity: obj. in free fall fall with const. v
  - → due to air resistance

② Dynamics I: Mass & Weight

- Mass: amt. of matter (kg)
  - → const.
- Weight: force of grav. (N)
  - → $w = mg$

Gravitational field

- Grav. field: region where objs. exp. grav. force
- Grav. field strength: weight per unit mass in a grav. field
  - → $g = \frac{W}{m}$
  - → grav. field strength = grav. a

③ Dynamics II: Forces

- Resultant (net) force: ΣF
  - → $F_R = F_1 + F_2$
  - → if F_2 is in opposite direction: $F_R = F_1 - F_2$
- Balanced F: $F_R = 0$
- Unbalanced F: $F_R \neq 0$

Newton Laws

- NL1: obj. will remain in its state of motion in a str. line unless acted upon by ext. F
  - → Inertia: reluctance of obj. to change its state of motion
    - → ↑mass = ↑inertia
- NL2: Obj. of const. m will accel. in direction of F_R
  - → $F_R = ma \Rightarrow w = mg$ in free fall
- NL3: every action has an eql. but opp. reaction
- Friction: F that opposes motion between surfaces in contact

④ Moments

- Moment: turning effect of F abt. a pivot (Nm)
  - → $M = F \times d$
    - → $d \perp F$
- Principle of Moments: obj. is in equilibrium when $\Sigma CWM = \Sigma ACWM$ abt. same pivot
  - → $M_R = 0 \Rightarrow F = 0$

Centre of grav.

- COG: imaginary pt. where weight of obj. seems to act
  - → always vert. below pivot when in equilibrium
    - → $d = 0$

Stability

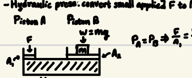
- Stability: ability of obj. to return to OG position
  - → lower COG: ↑stability
  - → base A↑: ↑stability

⑤ Pressure

- Pressure: $P = \frac{F}{A}$ ($Pa = Nm^{-2}$)
  - → ↑F or ↓A: ↑P
  - → ↓F or ↑A: ↓P
- Density: $\rho = \frac{m}{V}$ ($kg\ m^{-3}$)
  - → unaffected by g
  - → $\rho_{obj.} > \rho_\ell$: sink
  - → $\rho_{obj.} = \rho_\ell$: suspended
  - → $\rho_{obj.} < \rho_\ell$: float

Pressure in fluids

- $P = h\rho g$
- Pascal's law: P is transmitted evenly in all directions of liquid
- Hydraulic press: convert small applied F to larger F



$P_A = P_B \Rightarrow \frac{F}{A_1} = \frac{W}{A_2}$

- $P_{atm} = \frac{W}{A} = h\rho g$
  - → 1 atm = 760 mmHg
  - → altitude ↑, P_{atm}↓ & ρ↑

$P_B = h\rho g$
$P_A = P_B - h\rho g$

$P_B = P_A$ | $P_B = P_A + h\rho g$ | $P_B = P_A - h\rho g$

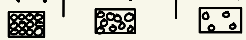
⑥ Energy

- Energy store: Energy stored in a system (J)
  - → transferred from one store to another
- KE: $E_k = \frac{1}{2}mv^2$
- GPE: $E_p = mgh$
- Principle of Conservation of Energy: Energy cannot be created or destroyed. ΣE in a system is constant
- Work done: $W = Fs$ (J)
  - → $\hat{s} = \hat{F}$
- Power = $P = \frac{W}{t} = \frac{E}{t}$ ($W = Js^{-1}$)
- Efficiency = $\frac{E_{out}}{E_{in}} \times 100\% = \frac{P_{out}}{P_{in}} \times 100\%$

⑦ Kinetic Particle Theory

- KPT: all matter is made of particles in continuous & random motion
- Diffusion: particles move from region of higher conc. to region of lower conc.
- Brownian motion: particles are in continuous & random motion because they collide with fluid molecules at diff. ∠s & diff. F

	Solid	Liquid	Gas
Arrangement	closely packed in orderly manner	more closely packed than gas but less closely packed than solid in disorderly manner	far apart in disorderly manner
Mvt.	vibrate in fixed position	slide over each other	randomly in all directions at high speeds
force of attraction	very strong	strong	very weak (negligible)



- No change state (temp ↑): thermal E → interal KE, particles vibrate more vigorously
- Change state (temp. const.): thermal E → interal PE, particles move further apart to overcome attractive forces
- When particle collides with walls, F exerted on wall by particle & reaction F applied on particle due to NL3

⑧ Thermal Processes

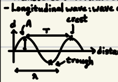
- Temperature: measure of how hot or cold smth. is ($K = °C + 274$)
- Thermal equilibrium: 2 or more objs same temp. & no net heat transfer
  - → thermal E transfers from region of higher temp. to region of lower temp. until thermal equilibrium reached
- Conduction: transfer of thermal E by vibration of particles
  - → occurs in all states except vacuum, most effective in solid
  - → Non-metals: collide with e.o. to transfer E
  - → Metal: free e^- gain thermal E, vibrate more vigorously & collide with e.o. to transfer E
- Conductors conduct heat quickly, insulators conduct heat slowly
- Convection: transfer of thermal E by convection currents of fluids (liquid & gas)
  - → due to difference in ρ
  - → cold fluid is denser & sinks to the bottom, displacing the less dense fluid causing it to rise forming a convectional current
- Radiation: transfer of thermal E by infrared waves
  - → does not require a medium
  - → ↑temp. emit, ↓temp. absorb
  - → ↑SA radiate more heat, ↓SA radient less heat
  - → dull/dark/rough good absorber/emitter, light/shiny/smooth poor absorb/emitter

⑨ Thermal Properties of Matter

- Heat capacity: $C = \frac{Q}{\Delta\theta}$ (J/K or J/°C)
  - → affects KE
  - → specific C: $c = \frac{C}{m} = \frac{Q}{m\Delta\theta}$ (J/kg·K or J/kg·°C)
    - → ↑c: substance heat up/cool down more slowly
      - → require more/less E to Δ temp. of substance
    - → ↑m: amt. of E to Δ temp. of substance
- Latent heat: E released/absorbed to Δ state of substance at const. temp (J)
  - → affect PE
  - → Latent heat of fusion: Δ (s) ⇌ (ℓ) states
    - → $L_f = \ell_f m$
  - → Latent heat of vaporisation: Δ (ℓ) ⇌ (g) states
    - → $L_v = \ell_v m$

⑩ Waves

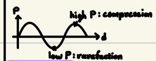
- Waves transfer E
- Transverse wave: wave direction ⊥ particle vibration
- Longitudinal wave: wave direction // particle vibration



- ↑A: ↑E
- 2 pt in phase: always in same direction
- Wavefront: imaginary line joining all adj. pts of wave in phase
  - → wave direction ⊥ wavefront
- Period (T): t for 1 oscillation (s)
- Frequency: no. of oscillation/s ($Hz = s^{-1}$)
  - → $f = \frac{1}{T}$
- Wave speed: $v = f\lambda$

⑪ Sound

- Sound: longitudinal
  - → compression: layers of air pushed tgt. (prong move outwards)
  - → rarefaction: layers of air pushed apart (prong move inwards)
  - → move via series of compression & rarefaction



Speed of sound

- $v_s > v_\ell > v_g$
- Audible range: 20Hz < f < 20kHz
  - → ultrasound: f > 20 kHz
  - → infrasound: f < 20 Hz
- $v_{sound} = 340 ms^{-1}$
  - → ↑v when same direction as wind
  - → ↑temp.: ↑v
  - → ↑humidity: ↑v
- Avg t: $\langle t \rangle = \frac{t + t'}{2}$
  - → $v = \frac{d}{\langle t \rangle}$ or $\frac{2d}{t}$
- Echo: reflected sound
- Reverberation: prolonged echo sound
- loudness↑, Amp.↑
- pitch↑, f↑

⑫ EM Wave

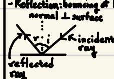
- EM waves don't carry I or Q
- EM waves follow $v = f\lambda = 3\times10^8 ms^{-1}$

- ionising wave: high f & E

↓f — radiowave → microwave → infrared → visible light → UV → X-ray → γ-ray — ↑f
↑λ — ↓λ

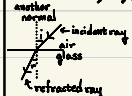
⑬ Light

- Reflection: bouncing of light rays after hitting an opaque obj.



law 1: ray_i, ray_r & normal same plane
law 2: $i = r$

- Regular reflection: smooth surface
  - → light rays //
- Diffuse reflection: rough surface
  - → diffused image
  - → light rays all directions
- Image: virtual, laterally inverted & upright
  - → same size as obj.
- Refraction: bending of light as it pass from one optical medium to another

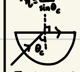


law 1: ray_i, ray_r & normal same plane
law 2: $\frac{\sin i}{\sin r}$ = const.

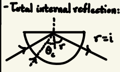
- → ↓ρ to ↑ρ: i > r
- → ↑ρ to ↓ρ: i < r
- Refractive index: measure of light ray bending
  - → $\eta = \frac{\sin i}{\sin r} = \frac{c}{v} = \frac{\text{true depth}}{\text{apparent depth}}$
- Principle of reversibility: light ray will follow the same path when reversed no matter how many times it is reflected or refracted

Critical Angle

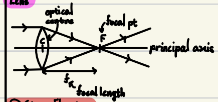
- Critical ∠ (θ_c): i when r = 90°
  - → $\eta = \frac{1}{\sin\theta_c}$



- Total internal reflection: $i > \theta_c$



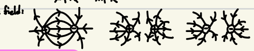
Lens



⑭ Static Electricity

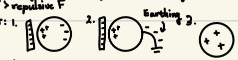
- Law of electrostatics: like charge repel, unlike charge attract
- Electric charge exert electric force
  - → Charge, Q (C)
- Electric field: region where E charge exp. E force
  - → E field lines:

- → E field:

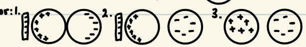


Electrostatic charging

- Insulator: no free moving e^-
- Charging insulator by friction: e^- with weaker bond transfer from one material to another
  - → obj. that gain e^-: e^- cannot move elsewhere & obj. −ve charge
  - → obj. that lose e^-: vacant e^- sites cannot be refilled & obj. +ve charge
  - → induce +ve & −ve charges, unlike charges closer like charges further
    - → attractive F > repulsive F
- Charge 1 conductor:



- Charge 2 conductor:



⑮ Electricity

- Current: rate of flow of electric charges (A)
  - → $I = \frac{Q}{t}$
  - → Conventional current: +ve to −ve
  - → Electron flow: flow of electrons
    - → −ve to +ve
  - → equal at all pts in circuit
- Ammeter connected in series
- e.m.f: work done by source to drive charge around circuit
  - → $\varepsilon = \frac{W}{Q}$ (V)
  - → not a force
- p.d.: work done by component to drive charge around circuit
  - → $V = \frac{W}{Q}$ (V)

Resistance

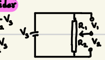
- Resistance: $R = \frac{V}{I}$ (Ω)
  - → $V = IR$
  - → ↑temp. ↑R
- Resistor: control amt of current
- Resistivity: constant that depends on material (Ωm)
  - → $R = \rho\frac{l}{A}$ (ρ: resistivity)
- Ohmic: V & I have linear rs

⑯ D.C circuit

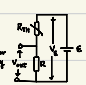
- Effective resistance: $R_e = \Sigma R_n$
- Total I in parallel circuit = ΣI_n from each branch
- In parallel, p.d. is same for all branches
  - → $R_e = [\Sigma \frac{1}{R_n}]^{-1}$

Potential divider

- $V_1 = \frac{R_1}{R_1+R_2}V_s$
- $V_2 = \frac{R_2}{R_1+R_2}V_s$



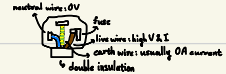
- Thermistor: semiconductor which R vary with temp.
- $V_{out} = \frac{R}{R_{TH}+R}V_\varepsilon$



- LDR: light intensity↑, R↓

⑰ Practical Electricity

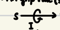
- Power: $P = IV$ (W)
  - → $P = I^2R$
  - → $P = \frac{V^2}{R}$
- Work done: $W = Pt$ (J)
  - → $E = IVt$
  - → $E = I^2Rt$
  - → $E = \frac{V^2t}{R}$
  - → when calculating cost, use kWh for E units
- When appliance becomes faulty, large I flow from live wire to metal casing
  - → appliance become live & earth wire direct I to ground
    - → fuse blow & I cut off



⑱ Magnetism

- Like poles repel, unlike poles attract
- N & S poles always occurs in pairs
- Weber theory: magnetised material can be represented as line-up of atomic magnets

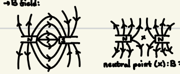
- Induction: 1. magnetic material placed close to a ferromagnet (strong magnet)
  2. magnetic material with current carrying solenoid (coil of wire)
- Magnetised by stroking: 1. stroke with 1 pole repeatedly
  2. must lift sufficiently high after each stroke
  - → opposite pole induced at the end the magnet leaves the bar
- Current-carrying solenoid produces a magnetic field
  - → magnetic field: region where magnetic force acts
  - → RH grip rule (solenoid)



- Demagnetisation:
  1. hitting/heating
  2. dropping
  } atomic magnets vibrate & settle in preferred orientation
  3. A.C solenoid
     - → A.C constantly change direction
     - → pull magnet out slowly from solenoid while A.C still flowing
- Soft ferromagnetic materials easy magnetise & demagnetise
  - → stronger induced magnetism
  - → temporary magnet
- Hard ferromagnetic materials difficult magnetise & demagnetise
  - → permanent magnet

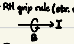
Magnetic fields (B)

- → B field:

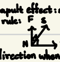


⑲ EM

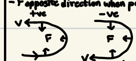
- RH grip rule (str. wire)



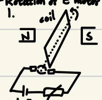
B stronger in middle of solenoid
- → insert soft iron core, B↑
- → ↑ magnitude of I
- → ↑ no. of turns of solenoid
- Motor/catapult effect: swinging motion by interaction of B field
- Fleming LH rule:



- F opposite direction when particle is opposite charge

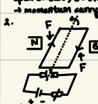


- In current-carrying coil: magnetic F produce a turning effect causing coil to rotate about an axle
- Rotation of E motor:
  1.



- open circuit, I = 0A
  - → momentum carry coil past vertical position

2.



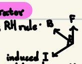
- closed circuit, current flowing

⑳ EMI

- EM induction: induced e.m.f due to changing B
- Faraday's law: $|e.m.f.| \propto \frac{\Delta\Phi}{\Delta t}$
  - → $\Phi = B \cdot A$
    - → change of Φ: induce e.m.f & current
      - → magnet in solenoid: change in Φ = 0, I = 0
- Lenz's law: induced e.m.f & current opposite direction to B

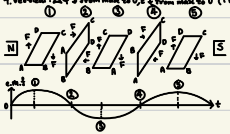
A.C generator

- Fleming's RH rule:



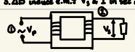
- A.C produced by alternating induced e.m.f
  - → I & V alternates, e.m.f goes max to 0 as coil rotates

1. Horizontal: $\Delta\phi \uparrow$ from 0 to max., $\varepsilon \uparrow$ from 0 to max
2. Vertical: $\Delta\phi \downarrow$ from max to 0, $\varepsilon \downarrow$ from max to 0
3. Horizontal: $\Delta\phi \uparrow$ from 0 to max., $\varepsilon \uparrow$ from 0 to max
   - → induced I & e.m.f in opposite direction (-ve)
4. Vertical: $\Delta\phi \downarrow$ from max to 0, $\varepsilon \downarrow$ from max to 0 (1 revolution)



Transformer

- Transformer: Δ high to low alt. V or vice versa
  1. A.C. V_p supplied to pri coil, ΔB around pri coil
  2. ΔB direct to sec coil through laminated soft iron core
  3. ΔB induce e.m.f V_s & I in sec coil



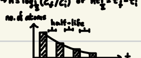
- Lamination: ↓ transfer of energy to internal store of surroundings by eddy currents
  - → Eddy current: induced I that flow in loops from ΔB by A.C
- $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ (N is no. of coils)
  - → $V_p I_p = V_s I_s$
- Transformer cannot work with D.C: no ΔB

22 Radioactivity

- ${}^{A}_{Z}X$: A = mass/nucleon no., Z = proton no.
  - → neutrons + Z = A
- Nuclear decay: unstable nucleus lose energy by EM radiation or particles
  - → spontaneous & random
- Ionisation: radiation knockout e^- from atom to form ion
- Penetrating ability: go through matter

1. α-decay: emit α-particles, ${}^{4}_{2}\alpha$ (helium nucleus, ${}^{4}_{2}He$)
   - → very high ionising & very low penetrating ability
   - → ${}^{Z}_{A}X \rightarrow {}^{Z-4}_{A-2}Y + {}^{4}_{2}He$
2. β-decay: emit β-particles, ${}^{0}_{-1}\beta$ (electron, ${}^{0}_{-1}e$)
   - → medium ionising & penetrating ability
   - → ${}^{Z}_{A}X \rightarrow {}^{Z}_{A+1}Y + {}^{0}_{-1}e$
3. γ-ray: emit during α- & β-decay
   - → very low ionising & very high penetrating ability
   - → ${}^{Z}_{A}X \rightarrow {}^{Z}_{A}X + {}^{0}_{0}\gamma$

- Half-life ($t_{\frac{1}{2}}$): t taken for half the nuclei of a nuclide to decay
  - → $n = \log_{\frac{1}{2}}(C_f/C_i)$ or $nt_{\frac{1}{2}} = t_f - t_i$ or $C_f = C_i \div 2^n$



- Nuclear fission: nucleus splits into 2 or more lighter nuclei & release huge amt of energy
  - → bombarded with a neutron
  - → total neutron & proton remain the same
  - → nuclear fuels can sustain nuclear fission (chain reaction)
- Nuclear fusion: 2 light nuclei combine to form 1 heavier nucleus & release huge amt of energy
  - → total neutron & proton remain the same
  - → require very high temp. & pressure to overcome repulsive forces between nuclei