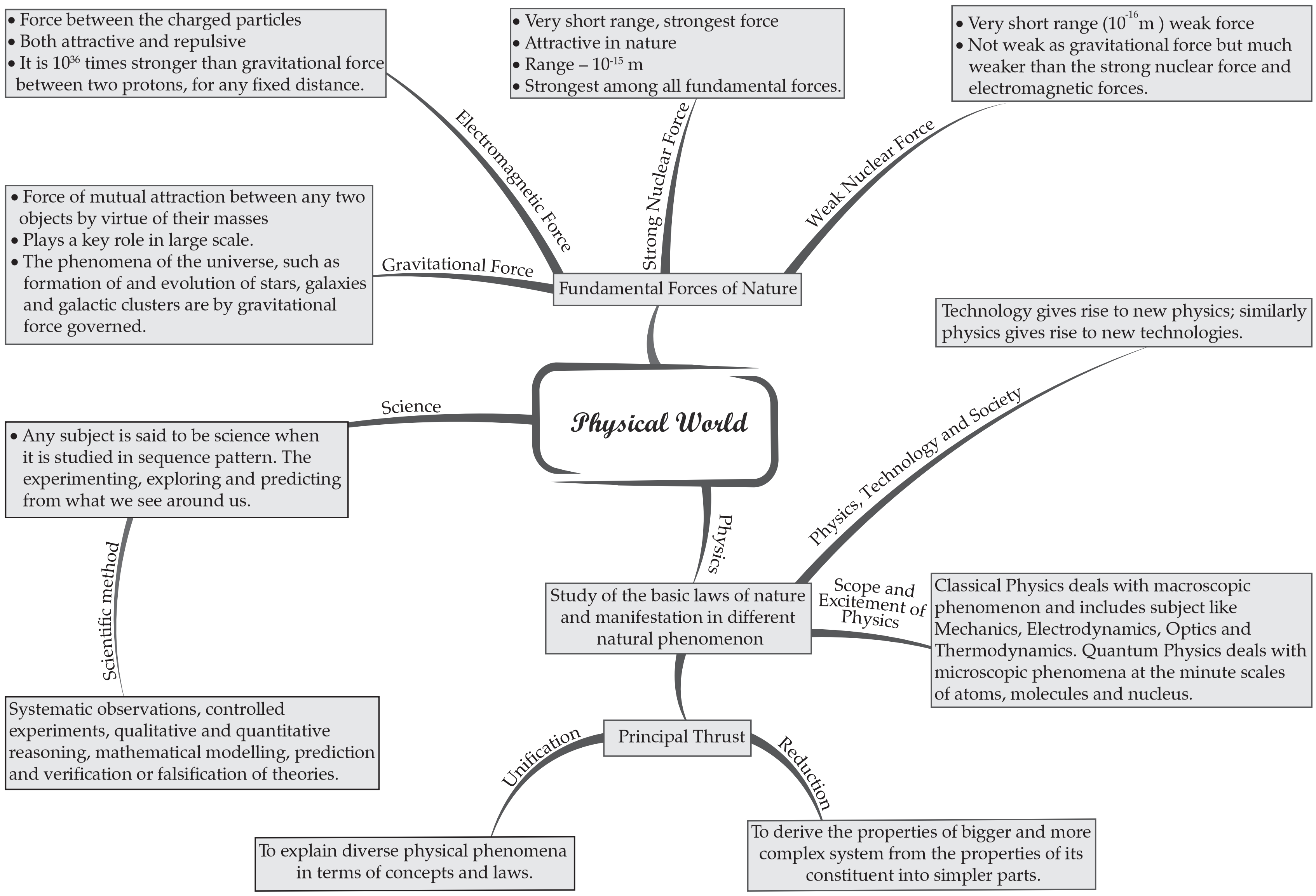
MIND MAP : LEARNING MADE SIMPLE

CHAPTER - 1



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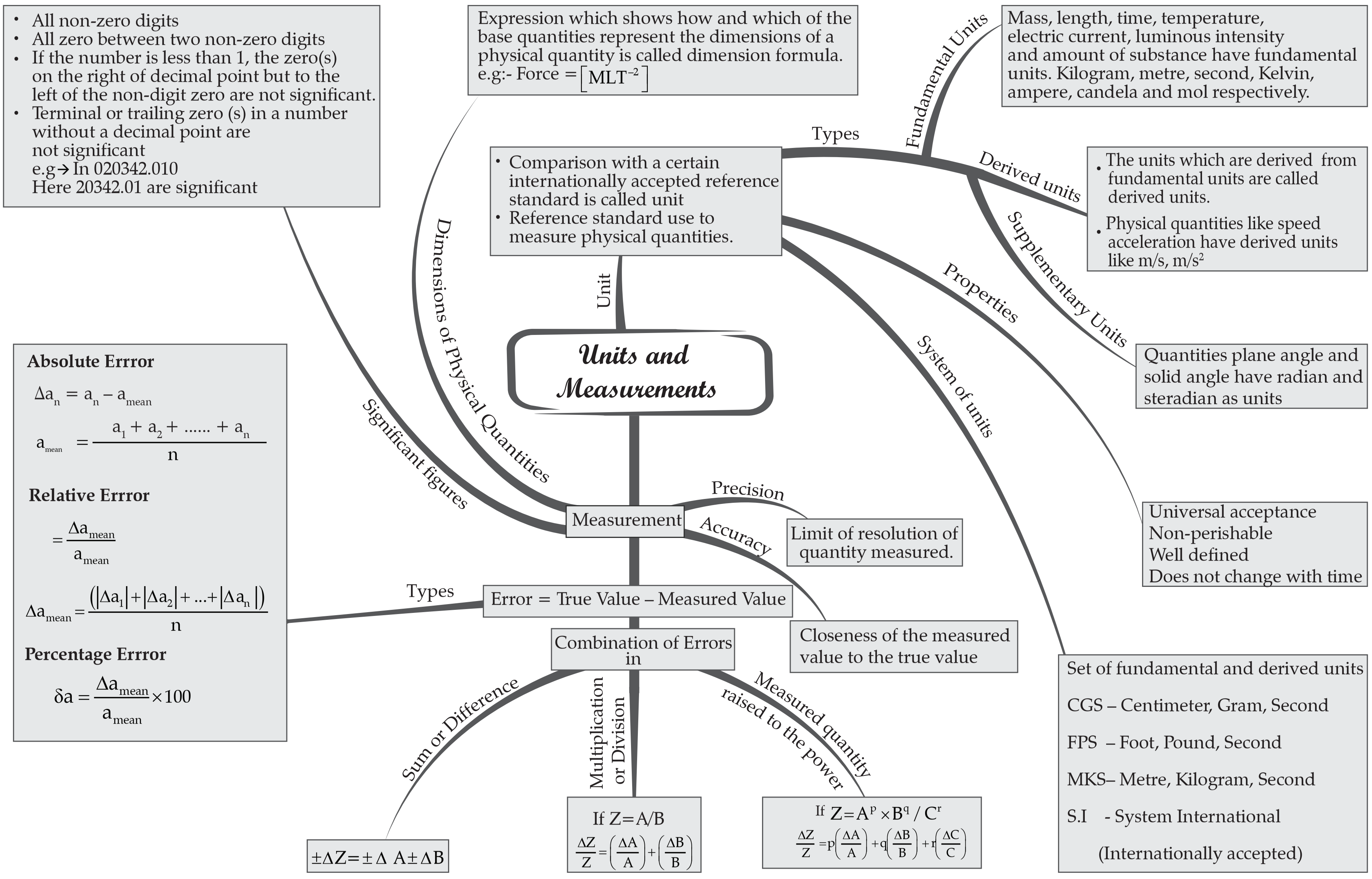
CHAPTER - 2



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CHAPTER - 3

Motion in a Straight Line

- **Acceleration**: Rate of change of velocity, $\vec{a} = \frac{\vec{v}}{t}$
  - **Instantaneous acceleration**: $\vec{a}_{inst} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$
  - **Average Acceleration**: $\vec{a}_{avg} = \frac{\text{Total change in velocity}}{\text{Total time interval}} = \frac{\Delta \vec{v}}{\Delta t}$
- **Types**
  - **Uniform Motion**: Equal distances are traversed in equal amount of time.
  - **Non - uniform motion**: When the magnitude or the direction of velocity changes w.r.t. time.
- **Distance**
  - Total length of the path traversed by any object is called its distance
  - It is scalar quantity.
- **Displacement**
  - The shotest distance traversed by any object in called displacement
  - It in a vector quantity.
- **Speed**: Distance traversed/time taken . Scalar quantity
  - **Average Speed**
    - When object traversed different distances with different speeds. $\frac{s_1}{v_1} + \frac{s_2}{v_2} + \frac{s_3}{v_3} + ... \frac{s_n}{v_n}$
    - When object traversed different speeds in different time of intervals. $\frac{v_1 t_1 + v_2 t_2 + ... + v_n t_n}{t_1 + t_2 + ... + t_n}$
- **Velocity**: Rate of change of position of an object w.r.t time in given direction . Vector Quantity
  - **Instantaneous Velocity**: $\vec{v}_{inst} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$
  - **Average Velocity**: $\vec{v}_{avg} = \frac{\text{Total displacement}}{\text{Total time taken}} = \frac{\Delta x}{\Delta t}$
  - **Relative Velocity**
    - (i) $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$
    - (ii) $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$
    - In opposite direction, it will be Difference
    - In same direction, it will be Sum
- **Kinematic equations of uniformly acceleration motion**
  - (i) $v = v_0 + at$
  - (ii) $x = v_0 t + at$
  - (iii) $v^2 = v_0^2 + 2ax$
  - (iv) $x_{nth} = v_0 + \frac{a}{2}(2n-1)$
- **Free Fall**: An object falling because of Earth's gravity ($g = 9.8 m/s^2$). On neglecting air resistance, it is a case of motion with uniform acceleration. e.g Apple falling from a tree.

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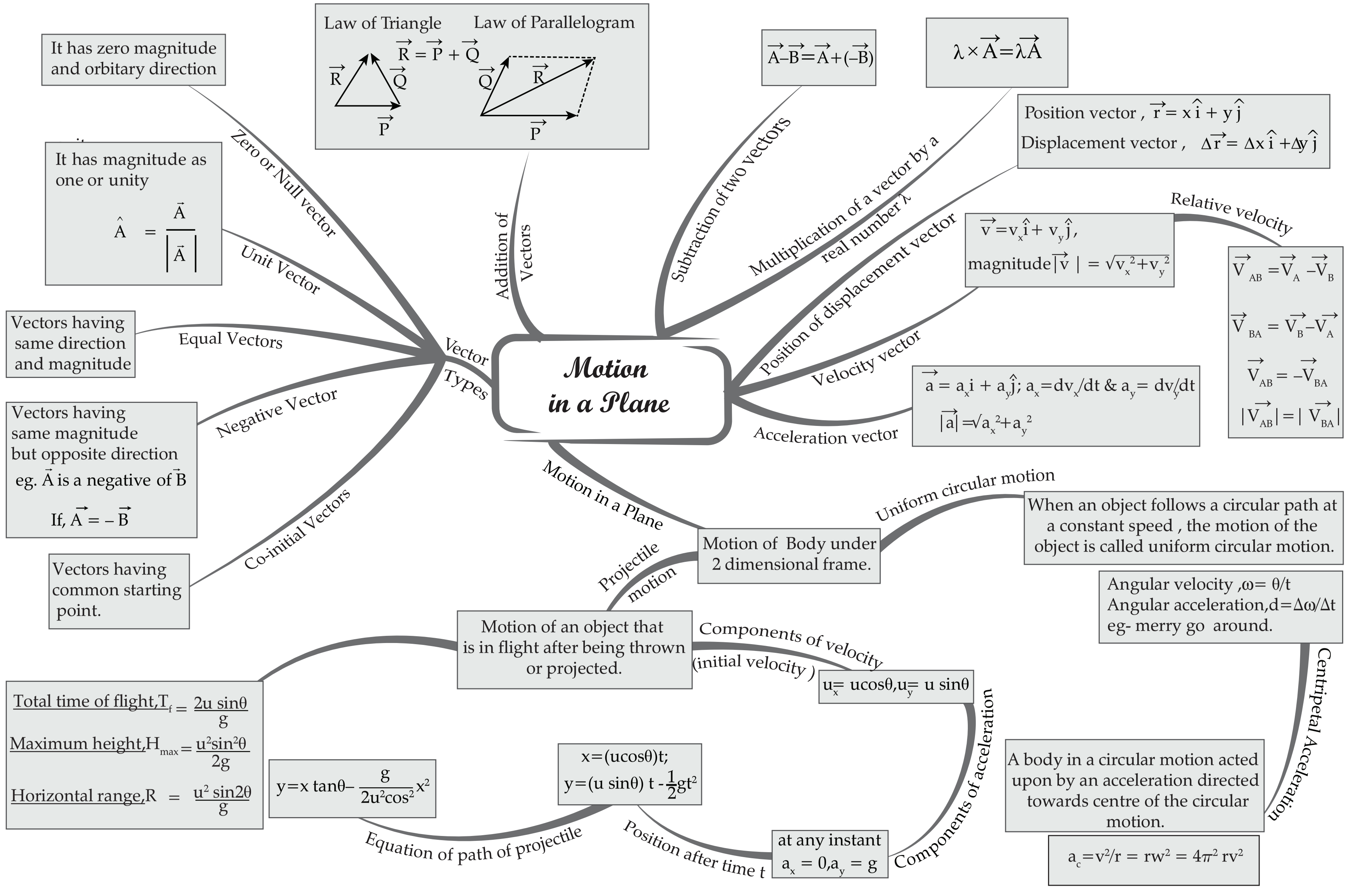
CHAPTER - 4



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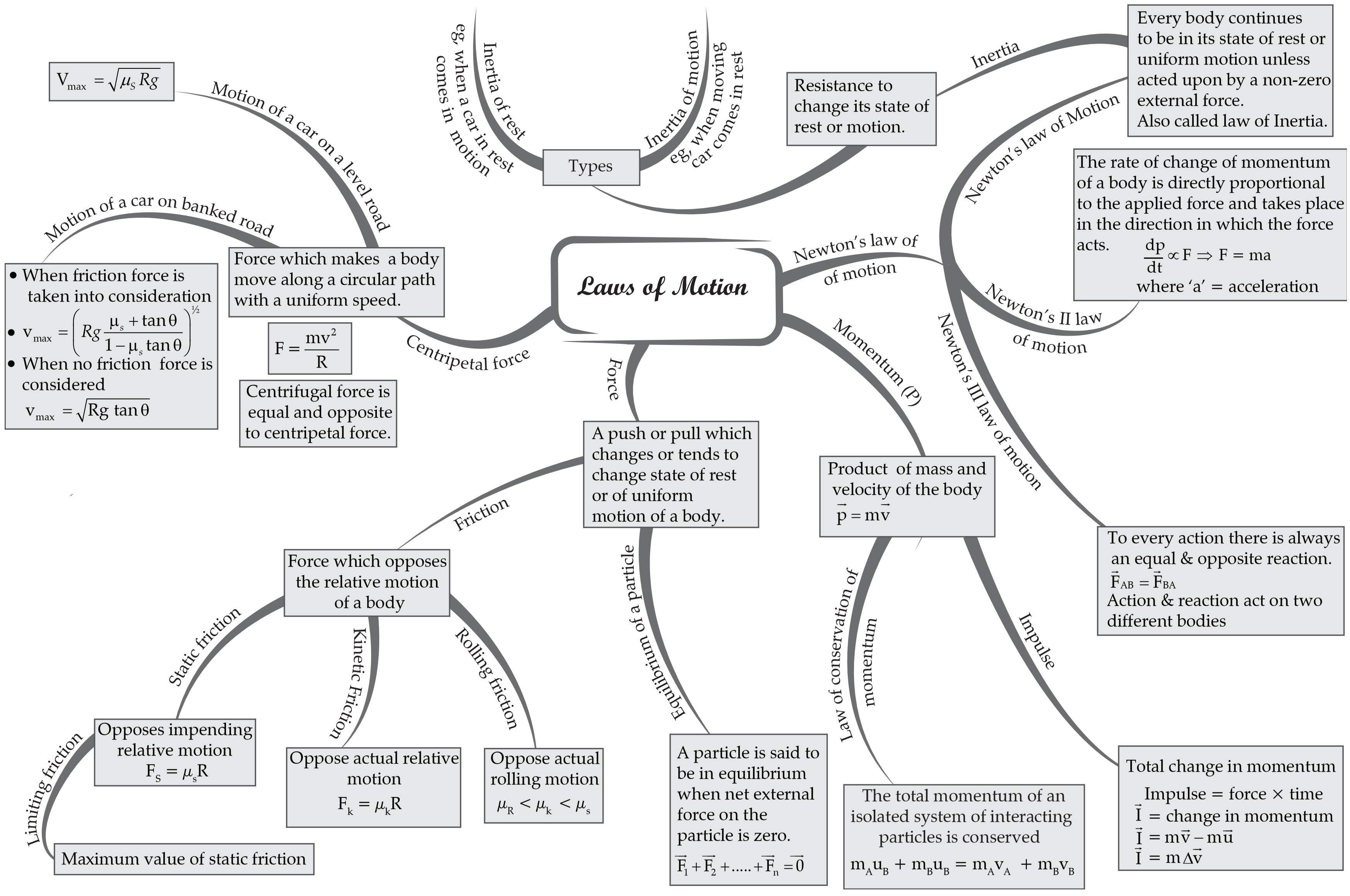
CHAPTER - 5



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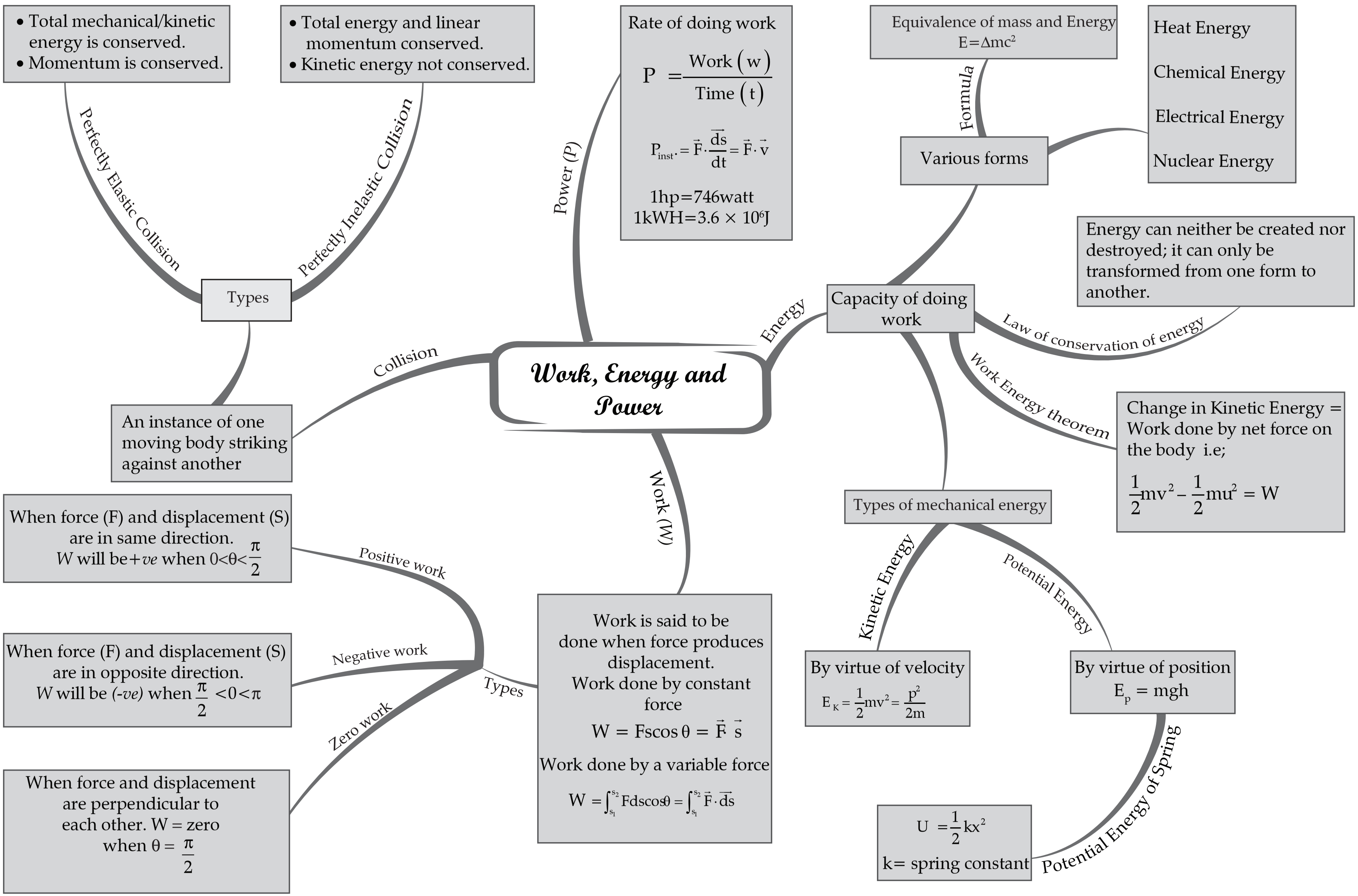

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CHAPTER - 7

Systems of Particles and Rotational Motion

- **Moment of Inertia** → Inertia of rotational motion, M.I., $I = \sum_{i=1}^{n} m_i r_i^2$
  - **Theorems of moment of Inertia**
    - Theorem of perpendicular axes → $I_z = I_x + I_y$; I_x, I_y & I_z moments of inertia about perpendicular axes x, y and z respectively
    - Theorem of parallel axes → $I = I_{cm} + mr^2$; I_{cm} = M.I. about the parallel axis through the centre of mass
  - Moment of interita of some regular shaped body →
    - (1) Rod $I_{cm} = \frac{ml^2}{12}$; $I_{one\ edge} = \frac{ml^2}{3}$
    - (2) Ring $I_{cm} = mR^2$; $I_{diameter} = \frac{mR^2}{2}$
    - (3) Disc $I_{cm} = \frac{mR^2}{2}$; $I_{diameter} = \frac{mR^2}{4}$
    - (4) Solid sphere $I_{diameter} = \frac{2}{5}mR^2$
- **Radius of gyration** → $K = \sqrt{\frac{r_1^2 + r_2^2 + ... + r_n^2}{n}}$; $K = \sqrt{\frac{I}{m}}$
- **Rigid body** → A body with perfectly definite and unchanging shape.
- **Equations of rotational motion** →
  - (i) $\omega_2 = \omega_1 + \alpha t$
  - (ii) $\theta = \omega_o t + \frac{1}{2}\alpha t^2$
  - (iii) $\omega_2^2 = \omega_1^2 + 2\alpha\theta$
- **Torque or couple or moment of force** → $\vec{\tau} = \vec{r} \times \vec{F} = \hat{r}\ F\sin\theta\ \hat{n}$; $\tau_{rotational} = I\alpha$
- **Angular momentum** → $L = I\omega = mvr = r \times mv$; $L = r \times p = rp\sin\theta$
- **Centre of mass** → The point where the whole mass of the system is supposed to be concentrated
  - Centre of mass for rigid bodies → is independent of the state i.e., rest or motion of the body.
  - Acceleration of centre of mass of the system → $a_{cm} = \sum_{i=1}^{n} \frac{m_i a_i}{\sum m_i}$
  - Velocity of Center mass of the system → $V_{cm} = \frac{\sum_{i=1}^{n} m_i v_i}{\sum_{i=1}^{n} m_i}$
  - Position of centre of mass of the system → $V_{cm} = \frac{\sum_{i=1}^{n} m_i r_i}{\sum_{i=1}^{n} m_i}$
    - Position of centre of mass of an object changes in translatory motion but remains unchanged in rotatory motion.
    - Position of centre of mass depends upon shape, size, distribution of mass of the body.

MIND MAP : LEARNING MADE SIMPLE

CHAPTER - 8

Gravitation

Satellite

Heavenly object that revolves around a planet

Geostationary satellite

Height from surface of earth =36000km
Radius of orbit = 42,400km
Time periods = 24 hours
Orbital velocity = 3.1km/s

Polar satellite

Height from earth's surface = 880km
Time period = 84min
Orbital velocity = 7.92km/s

Escape speed $v_{esc} = \sqrt{2GM/R} = \sqrt{2gR}$

Earth 's v_{esc} = 11.2km/s

Orbitals speed $v_{orb} = \sqrt{gR} = \frac{v_e}{\sqrt{2}}$

Total Energy of a satellite

$E = K.E + P.E$

$= \left(\frac{GMm}{2r}\right) + \left(\frac{-GMm}{r}\right) = -\frac{1}{2}G\frac{Mm}{r}$

Weightlessness

During free fall under gravity inside a spacecraft or satellite a body is weightless i.e., effective weight becomes zero.

Acceleration due to gravity (g)

Acceleration possessed by an object during free fall due to earth's gravitational pull,

$g = \frac{G M_e}{R_e^2}$

Variation in acceleration due to gravity (g)

(i) with height $g' = g\left(1 - \frac{2h}{R_E}\right)$,
i.e. g decreases with height

(ii) with depth $g' = g\left(1 - \frac{d}{R_E}\right)$,
i.e. g decreases with depth

(iii) with rotation of earth about its own axis
$g' = g - R\omega^2 \cos^2 \lambda$,
At poles, $\lambda = 90^0$, g maximum
At equator, $\lambda = 0^0$, g minimum

Kepler's Law-of planetary motion

(i) Law of Orbit: Every planet revolves around the Sun in an elliptical orbit and Sun is at its one focus.

(ii) Law of Area: The radius vector drawn from the Sun to a planet sweeps out equal areas in equal intervals of time.

$\frac{dA}{dt} = \frac{L}{2m}$ = Constant

(iii) Law of Periods: $T^2 \propto a^3$
where, a = length of semi-major axis

Gravitational Field and potential

• Gravitational field Intensity

$I = \frac{Gm}{r^2}$

• Gravitational potential

$V_g = \frac{work\ done}{mass} = \frac{-Gm}{r}$

• Gravitational Potential Energy

$U = \frac{-GMm}{r}$

Newton's universal law of Gravitation

When two mass bodies are separted by a distance, they experience an attractive force which is directly proportional to the product of their masses and inversaly proportional to the square of their separation.

$F = \frac{Gm_1m_2}{r^2}$, $G = 6.67 \times 10^{-11} Nm^2kg^{-2}$

Characteristics of gravitational force

(i) Weakest force in Nature.
(ii) Central as well as conservative.
(iii) Always attractive in nature.
(iv) Applicable for all bodies irrespective of their shape, size and position.

MIND MAP : LEARNING MADE SIMPLE — CHAPTER - 9

Mechanical Properties of Solids

Elastic Potential energy
Elastic potential energy in a stretched wire $= \frac{1}{2} \times$ stress $\times$ strain $\times$ volume of the wire

Elasticity
Property of material by virtue of which it regains it original shape & size after the removal of deforming force

Relation between Y, B, η & σ
(i) Y=3B (1 − 2 σ)
(ii) Y=2η (1 + σ)
(iii) $\sigma = \frac{3B - 2\eta}{2\eta + 6B}$
(iv) $\frac{9}{Y} = \frac{1}{B} + \frac{3}{\eta}$ or $Y = \frac{9B\eta}{\eta + 3B}$

Poision's ratio(σ) $= \frac{\text{Laternal strain } (\beta)}{\text{Longitudinal strain } (\alpha)} = \frac{\Delta d / d}{\Delta l / l}$

Value of σ lies between 0 and 0.5

Hooke's law
Within the elastic limit, stress is directly proportional to strain. i.e., stress ∝ strain

Stress
Restoring force per unit area i.e., stress= $\frac{F}{A}$

Types
(i) Longitudinal stress
$= \frac{\text{Deforming force applied normal}}{\text{Area}} = \frac{F_n}{A}$
(ii) Volumetric stress
$= \frac{\text{Force Changing Volume}}{\text{Area}} = \frac{F_V}{A}$
(iii) Shearing area or tangential stress
$= \frac{\text{Tangential Force}}{\text{Area}} = \frac{F_t}{A}$

Strain
Ratio of change in configuration to original configuration
Strain $= \frac{\text{change in configuration}}{\text{original configuration}}$

Types
(i) Longitudinal strain $= \frac{\text{change in length}}{\text{original length}} = \frac{\Delta l}{l_o}$
(ii) Volumetric strain $\varepsilon_V = \frac{\text{change in volume}}{\text{original volume}} = \frac{\Delta V}{V_o}$
(iii) Shearing strain=angular displacement of the plane perpendicular to the fixed surface = θ

Types of Modulus of Elasticity

Young's Modulus
Young's modulus of elasticity
$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{F / A}{l / \Delta l}$
$Y = \frac{F\Delta l}{Al} = \frac{Mg\Delta l}{\pi r^2 l}$

Bulk Modulus
Bulk modulus or volume modulus of elasticity
$B = \frac{\text{hydraulic stress}}{\text{volume strain}}$
$B = -\frac{\Delta P}{\frac{\Delta V}{V}}; \frac{1}{B} =$ compressibility

Modulus of Rigidity
Rigidity or shear modulus of elasticity
$\eta = \frac{\textit{tangential stress}}{\textit{shearing strain}}$
$\eta = \frac{\sigma_s}{\varepsilon_s} = \frac{\frac{F}{A}}{\theta} = \frac{F}{A\theta}$

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CHAPTER - 10

Mechanical Properties of fluids

That can flow like liquids and gases

Pressure

Pressure(P) $= \frac{\text{thrust}(F)}{\text{area}(A)} = \lim_{\Delta A \to 0} \frac{\Delta E}{\Delta A} = \frac{dF}{dA}$

Pressure exerted by a liquid column of height h, (p)=hρg

- **Atmospheric Pressure(Pa)**: Pressure (atm) exerted by the atmosphere. At sea level, 1 atm=pressure exerted by 0.76m of Hg=hρg=0.76×13.6×10^3×9.8=1.013×10^5 Nm^{-2} =101.3kPa
- **Absolute Pressure(P)**: Total or actual pressure at a point. Absolute pressure= atmospheric pressure + gauge pressure
- **Gauge Pressure (Pg)**: Difference between the absolute pressure at a point and the atmospheric pressure. Pg=absolute pressure(P) – atmospheric pressure(Pa)

Density

Density(ρ)= $\frac{\text{Mass(m)}}{\text{Volume(v)}}$

Density of water at 4°C i.e., maximum density of water=1.0×10^3 kg/m^3

Relative Density or specific gravity= $\frac{\text{density of substance}}{\text{density of water at } 4^{\circ}C}$

Formulae

- Surface tension $S = \frac{F}{l}$
- Surface Energy= $\frac{\text{work done in increasing area}}{\text{increase in surface area}} = \frac{W}{\Delta A}$
- Capillary rise or fall, $h = \frac{2S\cos\theta}{r\rho g}$
- Excess Pressure inside a drop (liquid) $P_{excess} = \frac{2S}{R}$
- Excess Pressure inside a bubble (soap) $P_{excess} = \frac{4S}{R}$

Viscosity

Opposing force between different layers of fluid in relative motion

Viscous drag $F = -\eta A \frac{dv}{dx}$

η=coefficient of viscosity

Stroke's law F=6 ηvr

Bernoulli's principle

For an incompressible non-viscous streamline,irrotational flow of fluid,

$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$

Applications

- **Venturimeter**: Device used to measure the rate of flow of liquid. Volume of liquid flowing per second $Q = a_1 a_2 \sqrt{\frac{2h\rho_m g}{\rho(a_1^2 - a_2^2)}}$
- **Toricell's Law**: Velocity of efflux of liquid through an orifice $V = \sqrt{2gh}$
- o Lift of an aircraft wing.
- o Sprayer or atomizer
- o Blowing off the roofs during windstorm.

Flow of fluids

Streamline : In liquid flow when the Velocity is less than critical velocity, each particle of the liquid passing through a point travels along the same path and same velocity as the preceding particles.

Turbulent : When velocity of liquid flow is greater than critical velocity and particles follow zig-zag path.

Laws of Fluids

- **Equation of continuity**
  $m = a_1 v_1 \rho_1 = a_2 v_2 \rho_2$
  for an incompressible liquid,
  $\rho_1 = \rho_2$ then $a_1 v_1 = a_2 v_2$
  or av=constant
- **Pascal's law :** The pressure exerted at any point on an enclosed liquid is transmitted equally in all direction. Hydraulic brakes and hydraulic lifts are based on Pacal's law.

MIND MAP : LEARNING MADE SIMPLE — CHAPTER - 11

Thermal Properties of Matter

- **Thermal Laws**
  - **Krichoff's law**: At any given temperature $\frac{e_\lambda}{a_\lambda} = E_\lambda$ = constant
  - **Wien displacement law**: $\lambda_m \frac{1}{T}$ or $\lambda_m = \frac{b}{T}$; b(wine's constant) = 2.9×10^{-3} mK
  - **Stefan's Boltzmann law**: $E\propto T^4$; $E = \sigma T^4$; $\sigma = 5.672 \ Js^{-1}m^{-2}k^{-4}$. For a perfectly black body $E = \sigma\left(T^4 - T_0^4\right)$
  - **Newton's law of cooling**: For small temperature difference between a body and its surroundings, the loss of heat is given by $-\frac{dQ}{dt} = k\left(T_2 - T_1\right)$
- **Thermal conductivity**: $(K) = \frac{Q.x}{A(T_2 - T_1)\,t}$
- **Heat**: A form of energy, transferred between two systems by virtue of temperature difference.
  - **Latent Heat**: Heat required to change the state of unit mass substance without changing its temperature, $L = \frac{Q}{m}$. For water, latent heat of fusion, $L_f = 3.33\times10^5$ J/ kg. Latent heat of vapourisation, $L_v = 22.6\times10^5$ J/ kg
  - **Specific Heat**:
    - Specific heat capacity $C = \frac{s}{m} = \frac{Q}{m\Delta T}$
    - Heat capacity $s = \frac{\Delta Q}{\Delta T}$
    - Molar specific heat capacity, $c = \frac{s}{n} = \frac{\Delta Q}{n\Delta T}$
- **Principle of calorimetry**: Heat lost = Heat Gain
- **Mode of heat transfer**:
  - (i) **Conduction :** heat transfer through molecular collisions without any actual motion of matter.
  - (ii) **Convection :** heat transfer by actual motion of matter within the medium. Land breeze, sea breeze, trade winds based on natural convection are some examples.
  - (iii) **Radiation :** method of heat transfer requiring no material medium.
- **Temperature**: Degree of hotness or coldness of a body measuring device = Thermometer
  - Relation among different temperature scales: $\frac{T_C - 0}{100 - 0} = \frac{T_F - 32}{212 - 32} = \frac{T_K - 273.15}{373.15 - 273.15} = \frac{R - 0}{80 - 0}$
- **Thermal Expansion**: Increase in dimensions due to increase in temperature
  - **Thermal Stress**: $\frac{\Delta F}{A} = Y\left(\frac{\Delta l}{l}\right)$, Y = Young's modulus
  - **Types (In solids)**
    - **Linear expansion**: Increase of length of a solid on heating. Coefficient of linear expansion $\alpha = \frac{\Delta l}{l_0 \Delta T} = \frac{L - l_0}{l_0(T - T_0)}$
    - **Superficial or area Expansion**: Increase in area of a solid on heating. Coefficient of superficial expansion $\beta = \frac{\Delta A}{A\Delta T} = \frac{dA}{A\,dT} = \frac{A - A_0}{A_0(T - T_0)}$
    - **Relation**: $\gamma = 2\beta = 3a$ or $a:b:\gamma = 1:2:3$
    - **Cubical or volume expansion**: Increase in volume of a solid on heating. Coefficient of cubical expansion. $\gamma = \frac{\Delta V}{V_0\Delta T} = \frac{dV}{V_0 dT} = \frac{V - V_0}{V_0(T - T_0)}$

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CHAPTER - 12

Thermodynamics

Branch of Science which deals with concepts of heat & temperature and their interconversion by thermodynamic process

- **Laws**
  - **Zeroth Law of Thermodynamics**: If two systems A&B are in thermal equilibrium with a third system C, then A&B are in thermal equilibrium with each other.
  - **First law of thermodynamics**: It is the statement of law of conservation of Energy; $\Delta Q = \Delta U + \Delta W = \Delta U + P\Delta U$ (Here, $\Delta U = P\Delta U$)
  - **Second law of thermodynamics**: It is impossible for an engine working between a cyclic process to extract heat from a reservoir and convert completely into work.
    - **Entropy (S)**: Measure of molecular disorder of a system. Change in entropy $\delta S = \frac{\delta Q}{T}$
  - **Thermodynamic state variable**
    - (i) Extensive – indicate the size of the system. e.g. U, volume, total mass.
    - (ii) Intensive – do not indicate size of the system. e.g. , pressure & temperature
    - **Thermal Equilibrium**: Two systems are in thermal equilibrium with each other if they have the same temperature.
- **Specific heat capacity Relation**
  - $\frac{C_P}{C_V} = \gamma$
  - Mayer's Equation $C_P - C_V = R$
- **Reversible & Irreversible Process**: Any process made to proceed in the reverse direction by changing its conditions is called **Reversible Process.** Any process which cannot be retraced in the reverse direction exactly is called **Irreversible Process.**
  - **Carnot' Engine**: An Ideal engine works on a reversible cycle of four operations in succession. (i) isothermal expansion , (ii) adiabatic expansion, (iii) isothermal compression, (iv)adiabatic compression.
    Efficiency of Carnot's engine $\eta = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_2}$
  - **Heat Engine**: Converts continuously heat into mechanical energy in cyclic process.
    Efficiency $\eta = \frac{W}{Q} = 1 - \frac{Q_2}{QT_1} = 1 - \frac{T_2}{T_1}$
    - **Refrigerator and heat pump**: Refrigerator is a heat engine working in the reverse direction. Coefficient of performance, $\beta = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}$
- **Quasi-static process**: Infinity slow process such that systems remain in thermal & mechanical equilibrium with the surroundings throughout.
  - **Property**: The pressure (P) & temperature (T) of the environment can differ from those of the system only infinitesimally.
- **Cyclic Process**: In this process, system returns to initial state for a cyclic process $\Delta U = 0$ (zero)
- **Isobaric Process**: Pressure = Constant; $\frac{V}{T}$ = Constant; $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
- **Isochoric Process**: Volume = Constant; $\frac{P}{T}$ = Constant; $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
- **Adiabatic Process**: A thermally insulated system neither gains nor loses heat
  PV^{γ} = Constant
  $TV^{\gamma-1}$ = Constant
  $\frac{P^{n-\gamma}}{T^{\gamma}}$ =Constant; $\frac{C_p}{C_v} = \gamma$
- **Isothermal Process**: Temperature = Constant; PV= Constant = n RT; $W = \int_{V_1}^{V_2} \frac{nRT}{V} dv$

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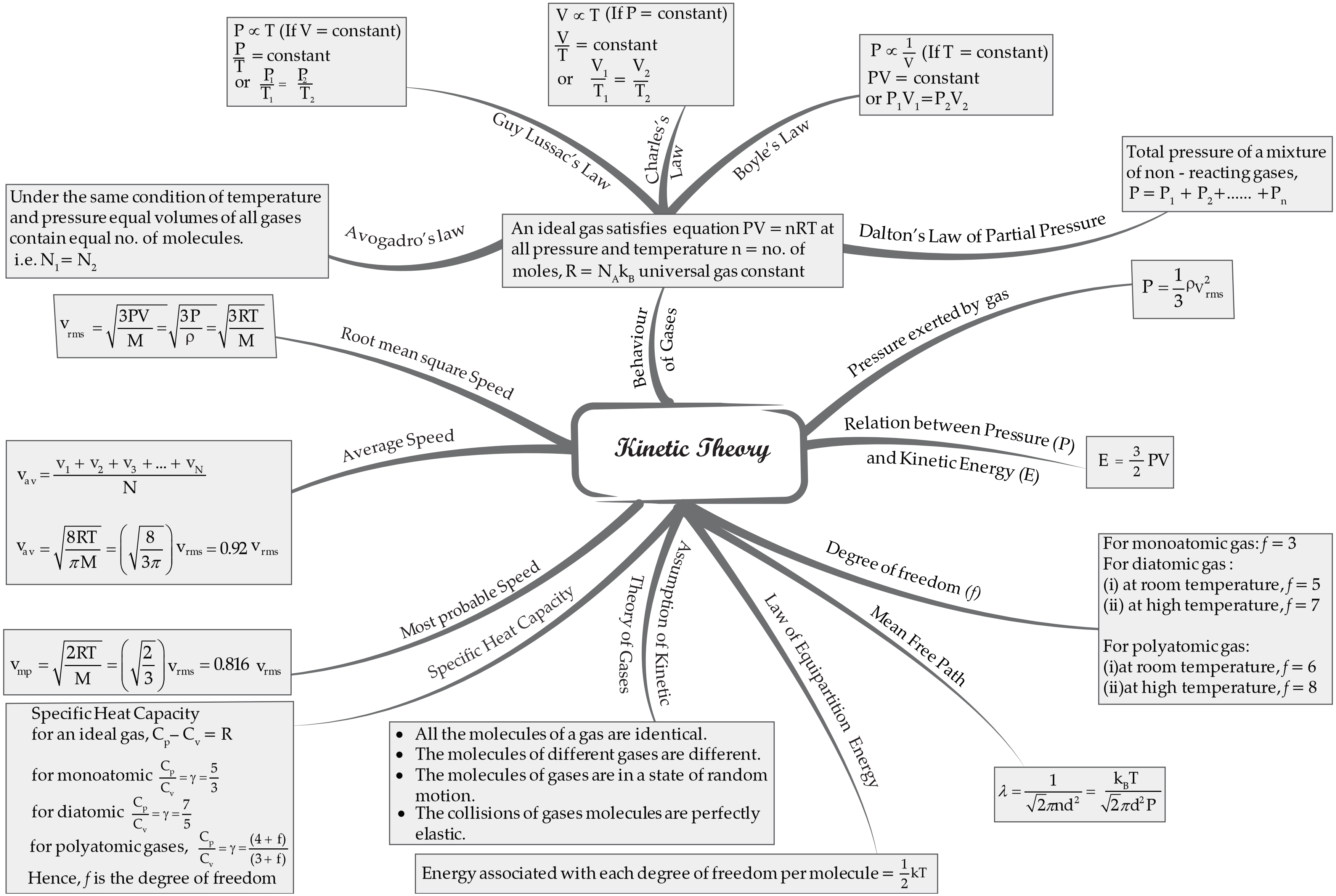
CHAPTER - 13



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CHAPTER - 14(A)

Oscillations

- Every oscillatory motion is periodic, but every periodic motion need not be oscillatory.
- To and fro motion repeatedly about a fixed point in a definite interval of time.

SHM

Simple Harmonic Motion is the simplest form of oscillatory motion

Displacement in SHM

$x(t) = A(\cos\omega t + \phi)$

A = Amplitude i.e., maximum displacement of particles.

Phase

Time varying quantity $(\omega t + \phi)$

Phase constant or Phase angle (ϕ)

- It depends upon velocity (v) and displacement of particle at t = 0

Time period (T)

The smallest interval of time after which the motion is repeated

Frequency

The number of oscillations per second

i.e., $f = \frac{1}{T} = \frac{\omega}{2\pi}$

Velocity in SHM

$v = \frac{dx}{d(t)} = -\omega A \sin(\omega t + \varphi)$

$v_{max} = \omega A$

Acceleration in SHM

$a = \frac{dv}{dt} = -\omega^2 A \cos(\omega t + \varphi)$

$a_{max} = \omega^2 A$

Energy in SHM

Kinetic Energy

$K.E = \frac{1}{2} m\omega^2 A^2 \sin^2(\omega t + \varphi)$

Potential Energy

$P.E = \frac{1}{2} m\omega^2 A^2 \cos^2(\omega t + \varphi)$

Total energy, T.E. = K.E. + P.E.

$= \frac{1}{2} kA^2 [\cos^2(\omega t + \varphi) + \sin^2(\omega t + \varphi)]$

Force law equation for SHM

$F = -k(x), k = m\omega^2$

$\therefore \omega = \sqrt{\frac{k}{m}}$

Simple pendulum

Time period $T = 2\pi\sqrt{\frac{I}{mgl}} = 2\pi\sqrt{\frac{l}{g}}$

Oscillations due to a spring

Time period $T = 2\pi\sqrt{\frac{m}{k}}$

Here, $k = \frac{F}{x}$ = *spring constant*

Damped Oscillations

Oscillation of a body whose amplitude goes on decreasing with time.

Damping force $F_d = -bv$, b = damping constant

Displacement of damped oscillator

$x = x_m e^{-bt/2m} \sin(\omega t + \varphi)$

Amplitude decreases with time as

$x = x_m e^{-(b/2m)t}$

Forced Oscillations

Driving force, $F(t) = F_o \cos\omega_d t$

Displacement, $x(t) = A\cos(\omega_d + \varphi)$

Amplitude, $A = \frac{F_o}{\{m^2(\omega^2 - \omega_d^2)^2 + \omega_d^2 b^2\}^{\frac{1}{2}}}$

$\tan\varphi = \frac{-v_o}{\omega_d x_o}$

Resonance

When frequency of external force is equal to natural frequency of oscillator.

MIND MAP : LEARNING MADE SIMPLE

CHAPTER - 14(B)

Waves

Stationary Waves

Stationary waves
(i) In string: Fundamental Frequency, $\nu = \frac{1}{2l}\sqrt{\frac{T}{m}}$

(ii) In organ pipe:
(a) Open at both ends,
Fundamental freq. or I harmonic $\nu = \frac{v}{2l}$
(b) Closed at one end $\nu = \frac{v}{4l}$

(iii) • In open organ pipe, higher harmonics, both odd & even.
• In closed organ pipe, higher harmonics, odd only.

Dopoler Effect

General Formula, Apparent Frequency
$n^1 = n\left(\frac{\nu \pm \nu_s \pm \nu_m}{\nu \mp \nu_0 \pm \nu_m}\right)$
Here, v = speed of sound,
v_0 = observer speed
v_s = source speed
v_m = medium speed

Relation b/w wave velocity (v), wavelength (λ) & frequency (ν)

$v = \nu\lambda$
Time period (T) $= \frac{1}{\text{Frequency}} = \frac{1}{\nu}$
Angular Frequency (ω) $= 2\pi\nu$
Wave number, $v = \frac{1}{\text{wavelength}} = \frac{1}{\lambda}$

Displacement relation in a plane progressive wave

$y(x, t) = A \sin(-kx + t)\, \omega_\phi$
$y(x,t) = A\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$
Velocity amplitude $v_0 = A\omega^2$
Acceleration Amplitude $a_0 = A\omega^2$

Beats

Difference in frequencies of two superposing waves, $\nu_{beat} = \nu_1 \sim \nu_2$

Principle of superposition of waves

When two or more waves are propagating with different displacements then the net displacement of collective wave is given as $Y = y_1 + y_2 + y_3 + ... + y_n$

Types

- **Matter Waves**: Waves associated with particles like-electrons, protons, neutrons, atoms, molecules etc.
- **Electromagnetic Waves**: Do not require any material medium for their propagation e.g., light waves
- **Mechanical Waves**: Require material medium for their propagation
  - **Properties**: Essential properties for propagation
    - Elasticity
    - Inertia
    - Minimum friction
  - **Transverse waves**: Individual particles of the medium oscillate perpendicular to the direction of propagation of wave
    - Speed of transverse wave in a stretched string $V = \sqrt{\frac{T}{m}}$, T = tension & M = mass/length
  - **Longitudinal waves**: Individual particles of the medium oscillate along the direction of propagation of wave.
    - Speed of a longitudinal wave speed of sound, $V = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{P}{\rho}} = \sqrt{\frac{\gamma P}{\rho}}$ for air, $\gamma = 7/5$

MIND MAP : LEARNING MADE SIMPLE

CHAPTER - 15

Ray Optics

Reflection & Laws

When beam of incident light bounces in the same medium.
Laws :
(i) Incident ray, reflected ray and normal lie in the same plane.
(ii) Angle of incidence (∠i) = Angle of reflection (∠r)

Refraction & Laws

When beam of light goes from one medium to another medium, it deviates from its path, such deviation of light in called refraction of light.
Laws :
(i) Incident ray, refracted ray & normal lie in the same plane.
(ii) Snell's Law, refractive index $(\eta) = \frac{\sin i}{\sin r}$

Dispersion of light

The separation of visible light into its different colours.
$\delta_{red} < \delta_{violet}$ because $\eta_{red} < \eta_{violet}$
(ii) Angular dispersion : $\theta = \delta_v - \delta_r = (\eta_v - \eta_r)A$
(iii) Dispersive power : $\omega = \frac{\delta_v - \delta_r}{\delta_r}$

Spherical Mirrors

(1) Focal length $f = \frac{R}{2}$
Mirror formula ⇒ $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$
(2) Linear magnification, $m = \frac{I}{O} = \frac{-v}{u} = \frac{f}{f-u} - \frac{f-v}{f}$

Len's Maker Formula

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Astronomical Telescope

Magnifying Power (MP)
- When image is at ∞
  $MP = -\frac{f_o}{f_e}$ & $L = f_o + f_e$
- When image is at D
  $MP = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$
  & $L = f_o + \left(\frac{f_e}{f_e + D}\right)$

Compound Microscope

Magnifying Power (MP)
- When image is at ∞
  $MP = -\frac{v}{u}\left(\frac{D}{f_e}\right)$ & L = u + f_e
- When image is at D
  $MP = -\frac{v}{u}\left(1 + \frac{D}{f_e}\right) = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$

Combination of thin lenses and power

- $P = \frac{1}{f}$
- $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$
- $P = P_1 + P_2$

Dispersion of light through Prism

- $\delta = i + e - A$
- $A = r_1 + r_2$
- $\mu = \frac{\sin(\delta_{min} + A)/2}{\sin A/2}$
- $\delta = A(\mu - 1)$

Optical Instrument

- Compound microscope
- Astronomical microscope
- Newtonian Telescope

Total Internal Reflection

The complete reflection of a light ray reaching an interface with a less dense medium when the angle of incidence exceeds the critical angle.