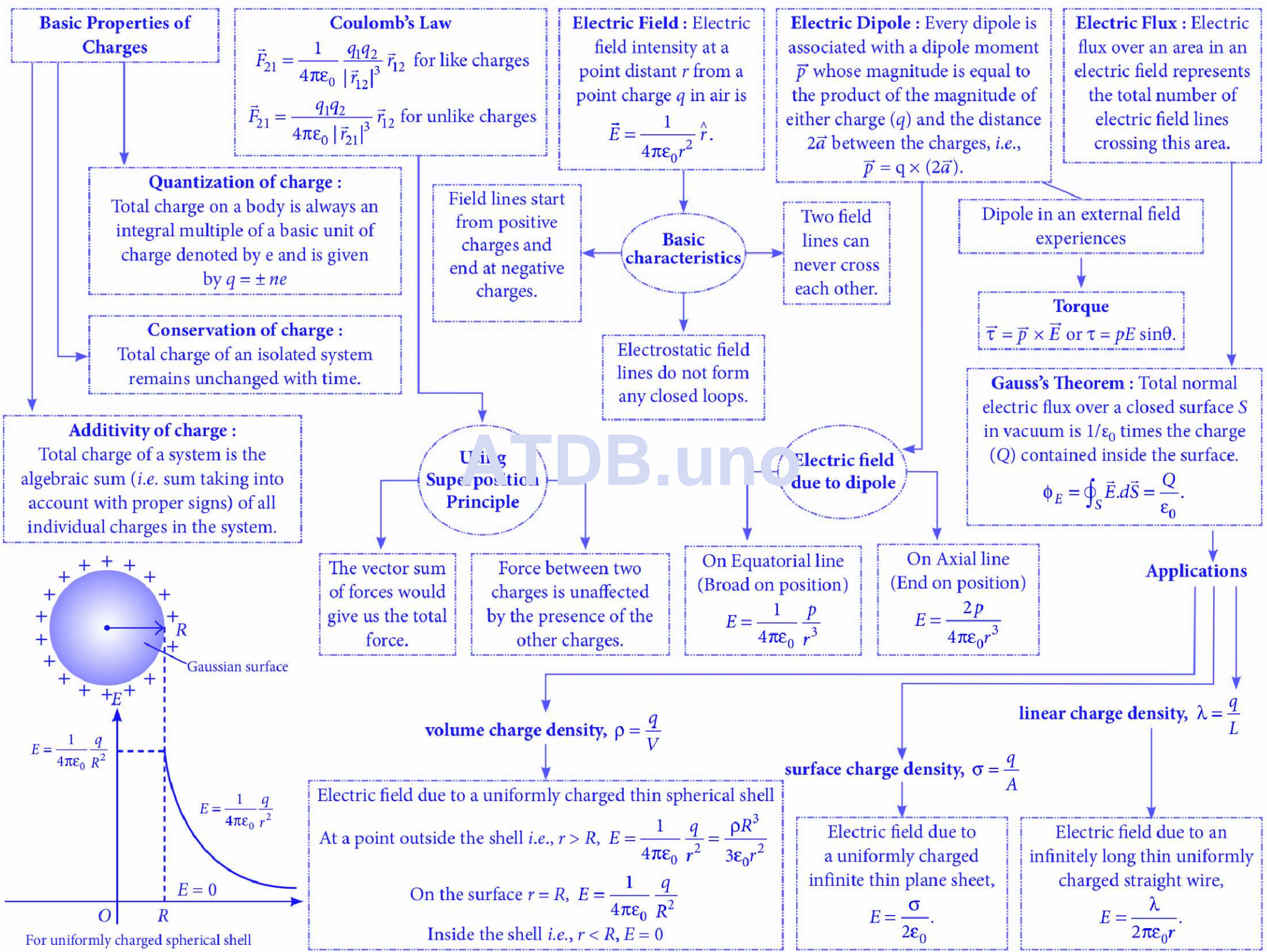
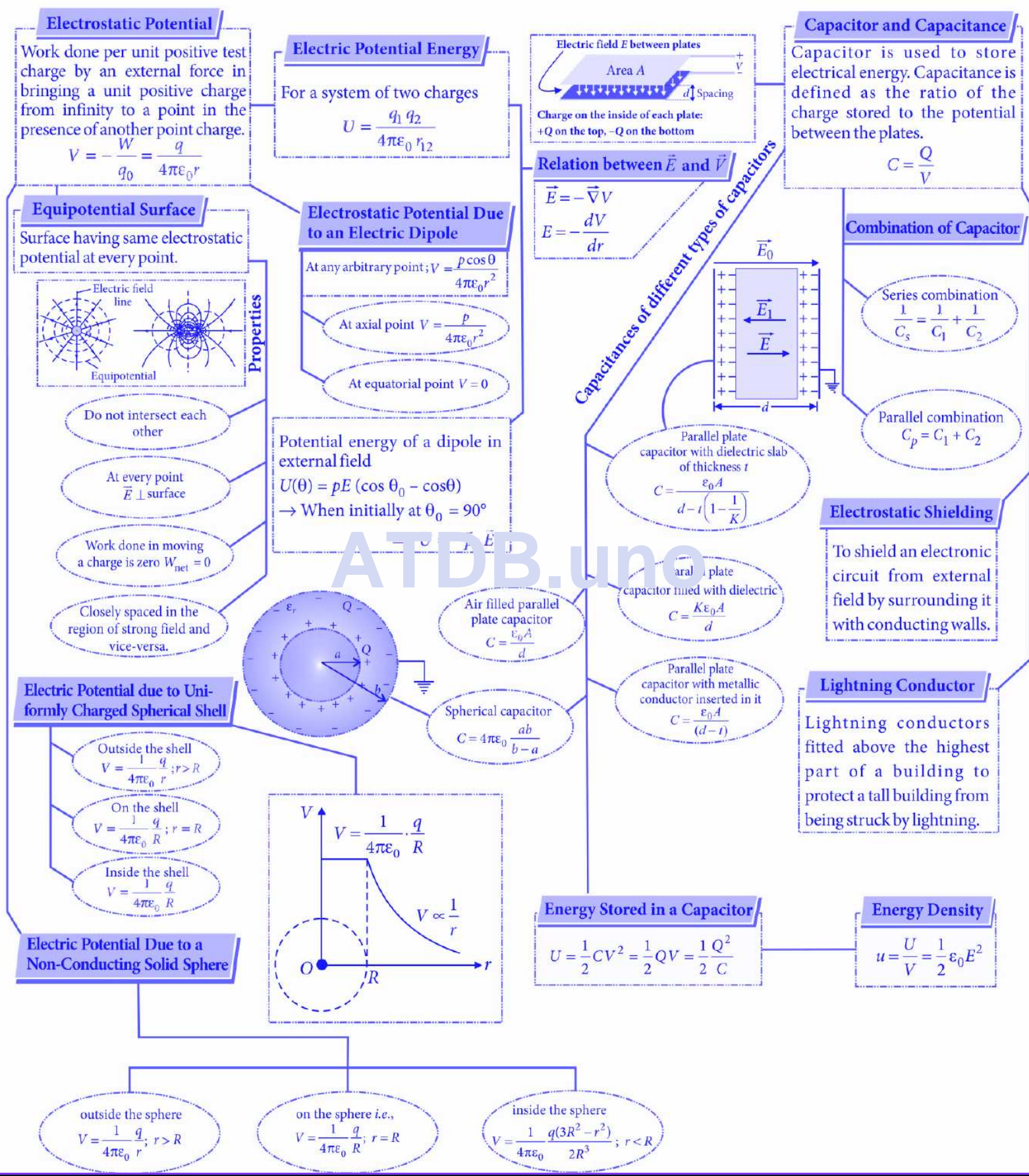


ELECTRIC CHARGES AND FIELDS



ELECTROSTATIC POTENTIAL AND CAPACITANCE



CURRENT ELECTRICITY

Electric Current

- $I = \frac{q}{t} = \frac{ne}{t}$
- In case of an electron revolving in a circle of radius r with speed v , period of revolution is $T = \frac{2\pi r}{v}$
- Frequency of revolution $\nu = \frac{v}{2\pi r}$
- Current at any point of the orbit is $I = \frac{e}{T} = \frac{ev}{2\pi r}$

Electric Power

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

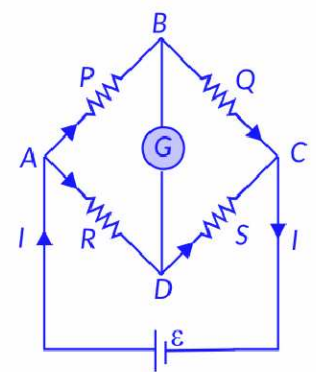
Variation of Resistance with Temperature

- Temperature coefficient of resistance, $\alpha = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$
- If $T_1 = 0^\circ\text{C}$ and $T_2 = T^\circ\text{C}$ then $\alpha = \frac{R_T - R_0}{R_0 \times T}$ or $R_T = R_0(1 + \alpha T)$

Current Electricity

Wheatstone Bridge

- It calculates the unknown resistance by balancing two legs of the bridge circuit
- $\therefore \frac{P}{Q} = \frac{R}{S}$



Ohm's Law, Resistance and Resistivity

- $V = IR$
- Resistance of uniform conductor of length l and cross sectional area A , $R = \frac{\rho l}{A}$
- Resistivity or specific resistance, $\rho = \frac{RA}{l}$
- Effective specific resistance in series combination is $\frac{\rho_1 l_1 + \rho_2 l_2}{l_1 + l_2}$ (A is same).
- Effective specific resistance in parallel combination is $\frac{(A_1 + A_2)\rho_1\rho_2}{A_1\rho_2 + A_2\rho_1}$ (l is same).

Kirchhoff's Laws

- Law of conservation of charge applied at a junction, i.e., $\Sigma I = 0$
- Law of conservation of energy applied in a closed loop, i.e., $\Sigma \mathcal{E} = \Sigma IR$

Current Density, Conductance and Conductivity

- Conductance, $G = \frac{1}{R}$
- Conductivity, $\sigma = \frac{1}{\rho} = \frac{l}{RA}$
- Current density, $J = \frac{I}{A} = \sigma E = nev_d$

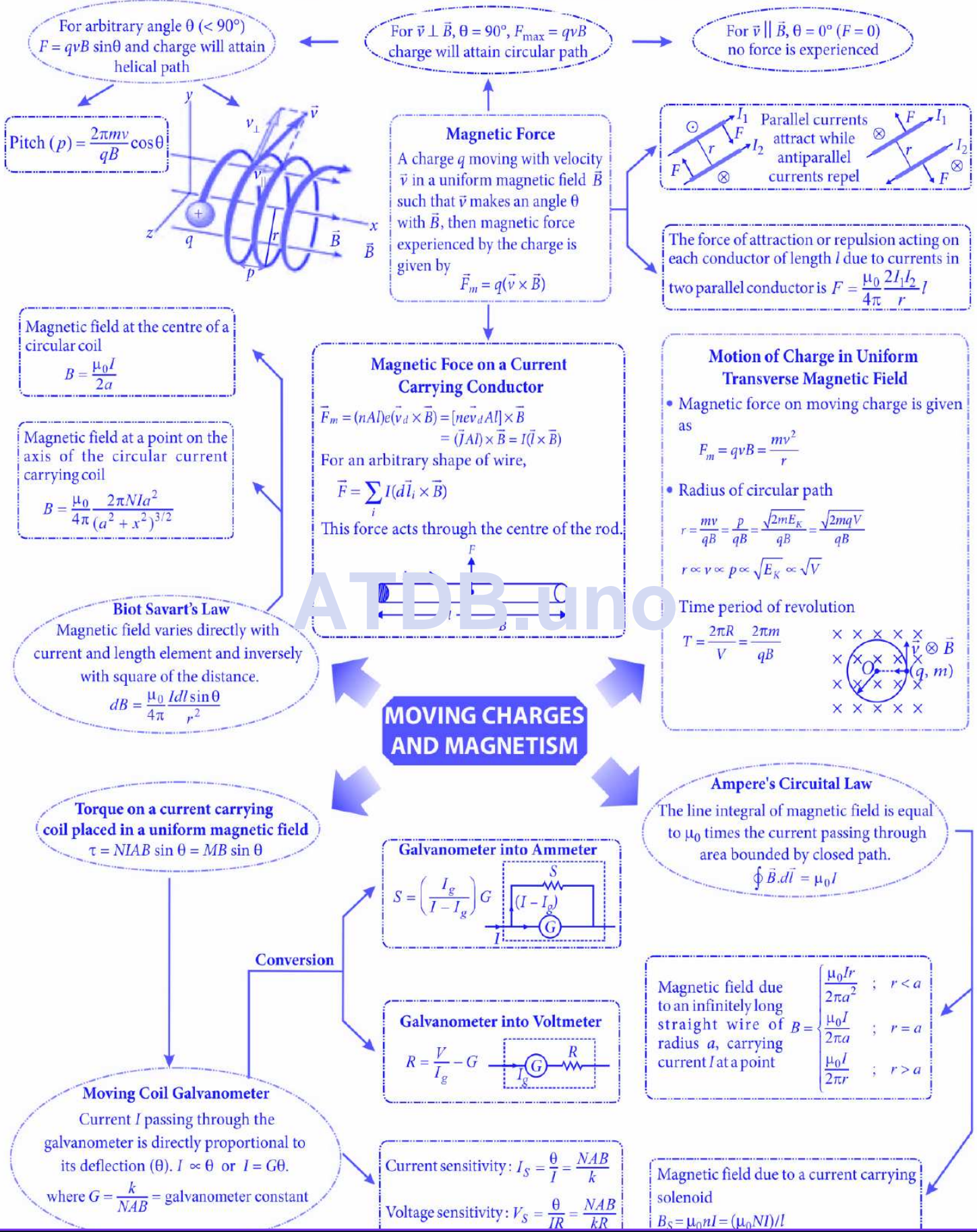
Drift Velocity and Mobility of Charge

- Drift speed, $v_d = \frac{eE}{m}\tau$
- Mobility, $\mu_e = \frac{v_d}{E}$
- Current in terms of drift velocity, $I = neAv_d = \frac{ne^2 A \tau E}{m} = neA\mu_e E = neA\mu_e \frac{V}{l}$
- In terms of relaxation time τ , $R = \frac{ml}{ne^2 \tau A}$ and $\rho = \frac{m}{ne^2 \tau}$

Emf, Internal Resistance, Current in case of Grouping of Cells

- Emf of a cell, $\mathcal{E} = \frac{W}{q}$
- Terminal potential difference where current is being drawn from the cell, $V = \mathcal{E} - Ir$
- Terminal potential difference when the cell is being charged $V = \mathcal{E} + Ir$
- Internal resistance of a cell, $r = R \left[\frac{\mathcal{E} - V}{V} \right]$
- Grouping of identical cells:
 - Cells in series, $I = \frac{n\mathcal{E}}{R + nr}$ (n cells)
 - Cells in parallel, $I = \frac{m\mathcal{E}}{mR + r}$ (m cells)
 - Cells in mixed grouping, $I = \frac{mn\mathcal{E}}{mR + nr}$

MOVING CHARGES AND MAGNETISM



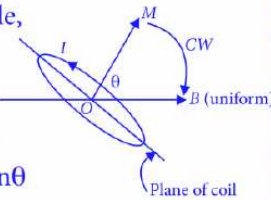
MAGNETISM AND MATTER

THE BAR MAGNET

Bar Magnet as an Equivalent Solenoid
 For solenoid of length $2l$ and radius a consisting n turns per unit length, the magnetic field is given by

$$B = \frac{\mu_0 2m}{4\pi r^3}$$
 (where $m =$ magnetic moment of solenoid $= n(2l)I(\pi a^2)$)

Magnetic Dipole in Magnetic Field
 Torque on magnetic dipole,
 $\tau = MB \sin\theta$
 Torque on coil or loop,
 $\vec{\tau} = \vec{M} \times \vec{B}$, here $\vec{M} = NI\vec{A}$,
 $\vec{\tau} = NI(\vec{A} \times \vec{B})$, $\tau = BINA \sin\theta$
 $\theta = 90^\circ \Rightarrow \tau_{\max} = BINA$
 $\theta = 0^\circ$ or $180^\circ \Rightarrow \tau_{\min} = 0$
 Potential energy of magnetic dipole,
 $U = -MB \cos\theta = -\vec{M} \cdot \vec{B}$



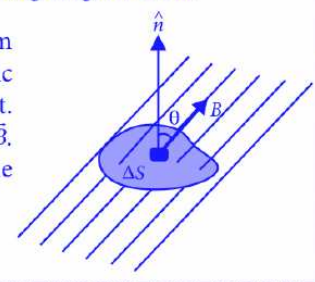
Magnetisation and Magnetic Intensity
 Relation between B , χ_m and H
 $\vec{B} = \vec{B}_0 + \mu_0 \vec{I}$
 $\vec{B} = \mu_0(\vec{H} + \vec{I})$ ($\because \vec{B}_0 = \mu_0 \vec{H}$)
 $\vec{B} = \mu_0(1 + \chi_m)\vec{H} = \mu\vec{H}$ ($\because \vec{I} = \chi_m \vec{H}$)
 $\mu = \mu_0 \mu_r = \mu_0(1 + \chi_m) \Rightarrow \mu_r = 1 + \chi_m$

GAUSS'S LAW IN MAGNETISM

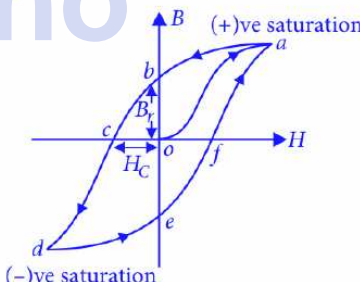
Magnetism and Gauss's Law

- The net magnetic flux through any closed surface is zero.

$$\phi_B = \sum_{\text{all}} \Delta\phi_B = \sum_{\text{all}} \vec{B} \cdot d\vec{S} = 0$$
- Incoming magnetic flux = Outgoing magnetic flux
- The Gauss's law of magnetism shows that isolated magnetic poles (monopoles) does not exist. There are no sources or sinks of \vec{B} . A dipole or current loop is the simplest magnetic element.

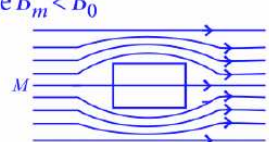


Magnetic Hysteresis
 Hysteresis is the phenomenon of lagging of magnetic induction (B) or intensity of magnetisation (I) behind the magnetising field (H), when a specimen is taken through a cycle of magnetisation. From the hysteresis loop of material, we can study about retentivity, coercivity etc. of the material. The study of these characteristics enables us to select suitable materials for different purposes.

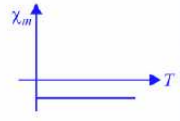


CLASSIFICATION OF MAGNETIC MATERIALS

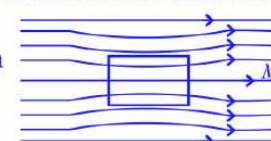
Diamagnetic
 Poor magnetisation in opposite direction.
 Here $B_m < B_0$



$\chi_m \rightarrow$ Small, negative and temperature independent
 $\chi_m \propto T^0$



Paramagnetic
 Poor magnetisation in same direction.
 Here $B_m > B_0$



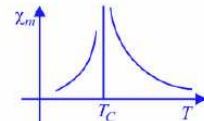
$\chi_m \rightarrow$ Small, positive and varies inversely with temperature
 $\chi_m \propto \frac{1}{T}$ (Curie's law)



Ferromagnetic
 Strong magnetisation in same direction. Here $B_m \gg B_0$



$\chi_m \rightarrow$ Very large, positive and temperature dependent
 $\chi_m \propto \frac{1}{T - T_C}$ (Curie-Weiss law) (for $T > T_C$)



ELECTROMAGNETIC INDUCTION

Magnetic Energy

- Energy stored in an inductor, $U_B = \frac{1}{2} LI^2$
- Energy stored in the solenoid, $U_B = \frac{1}{2\mu_0} B^2 Al$
- Magnetic energy density, $u_B = \frac{U_B}{V} = \frac{B^2}{2\mu_0}$

Combination of Inductors

- Inductors in series, $L_S = L_1 + L_2 \pm 2M$
- Inductors in parallel, $L_P = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$
- If coils are far away, then $M = 0$.
So, $L_S = L_1 + L_2$ and $L_P = \frac{L_1 L_2}{L_1 + L_2}$

Application of Lenz's Law

When a north pole of a bar magnet is moved towards a coil, the current induced in the coil will be in anti-clockwise direction (and vice versa) as shown in the figure.

Induced Electric Field

- It is produced by change in magnetic field in a region. This is non-conservative in nature.

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\phi_B}{dt} = -A \frac{dB}{dt} \neq 0$$

- This is also known as integral form of Faraday's law.

Inductance

- Emf induced in the coil/conductor, $\epsilon = -L \frac{dI}{dt}$
- Coefficient of self induction, $L = \frac{N}{I} \phi_B = \frac{-\epsilon}{dI/dt}$
- Self inductance of a long solenoid, $L = \mu_0 \mu_r n^2 Al = \frac{\mu_0 \mu_r N^2 A}{l}$
- Mutual inductance, $M = \frac{N_2 \phi_2}{I_1} = \frac{-\epsilon_2}{(dI_1/dt)} = \frac{-\epsilon_1}{(dI_2/dt)}$
- Mutual inductance of two long coaxial solenoids, $M = \mu_0 \mu_r \pi r_1^2 n_2 l = \frac{\mu_0 \mu_r N_1 N_2 A_1}{l}$
- Coefficient of coupling, $k = \frac{M}{\sqrt{L_1 L_2}}$
For perfect coupling, $k = 1$ so, $M = \sqrt{L_1 L_2}$

Lenz's Law

- The direction of the induced current is such that it opposes the change that has produced it.
- If a current is induced by an increasing(decreasing) flux, it will weaken (strengthen) the original flux.
- It is a consequence of the law of conservation of energy.

Magnetic Flux and Faraday's Law

- Magnetic flux $\phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta$
- Faraday's law : Whenever magnetic flux linked with a coil changes, an emf is induced in the coil.
 - Induced emf, $\epsilon = -N \frac{d\phi_B}{dt}$
 - Induced current, $I = \frac{\epsilon}{R} = N \frac{(-d\phi_B/dt)}{R}$
 - Induced charge flow, $\Delta Q = I \Delta t = -N \frac{\Delta \phi_B}{R}$

Energy Consideration in Motional emf

- Emf in the wire, $\epsilon = Bvl$
- Induced current, $I = \frac{\epsilon}{R} = \frac{Bvl}{R}$
- Force exerted on the wire, $F = \frac{B^2 l^2 v}{R}$
- Power required to move the wire, $P = \frac{B^2 l^2 v^2}{R}$
It is dissipated as Joule's heat.

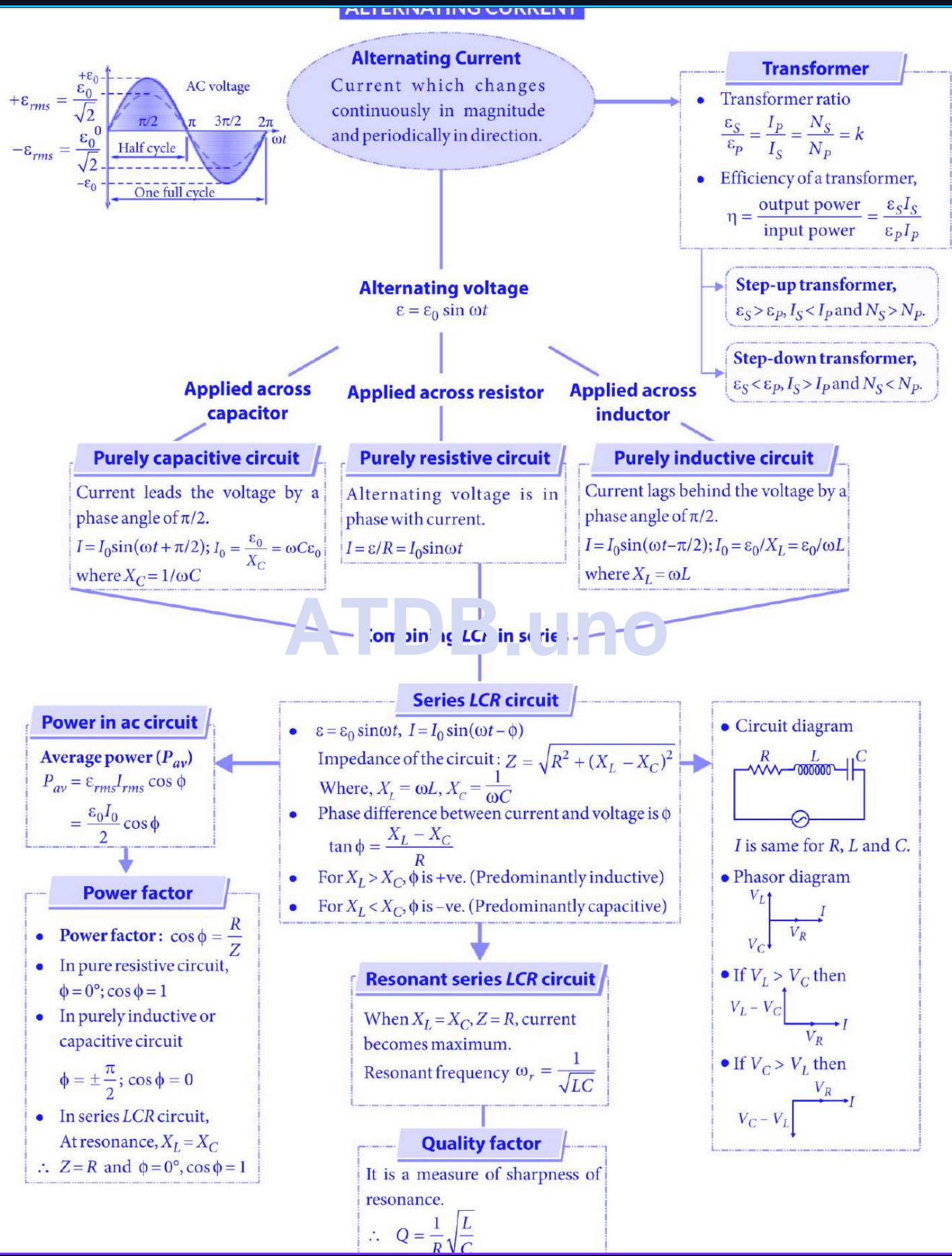
Motional emf

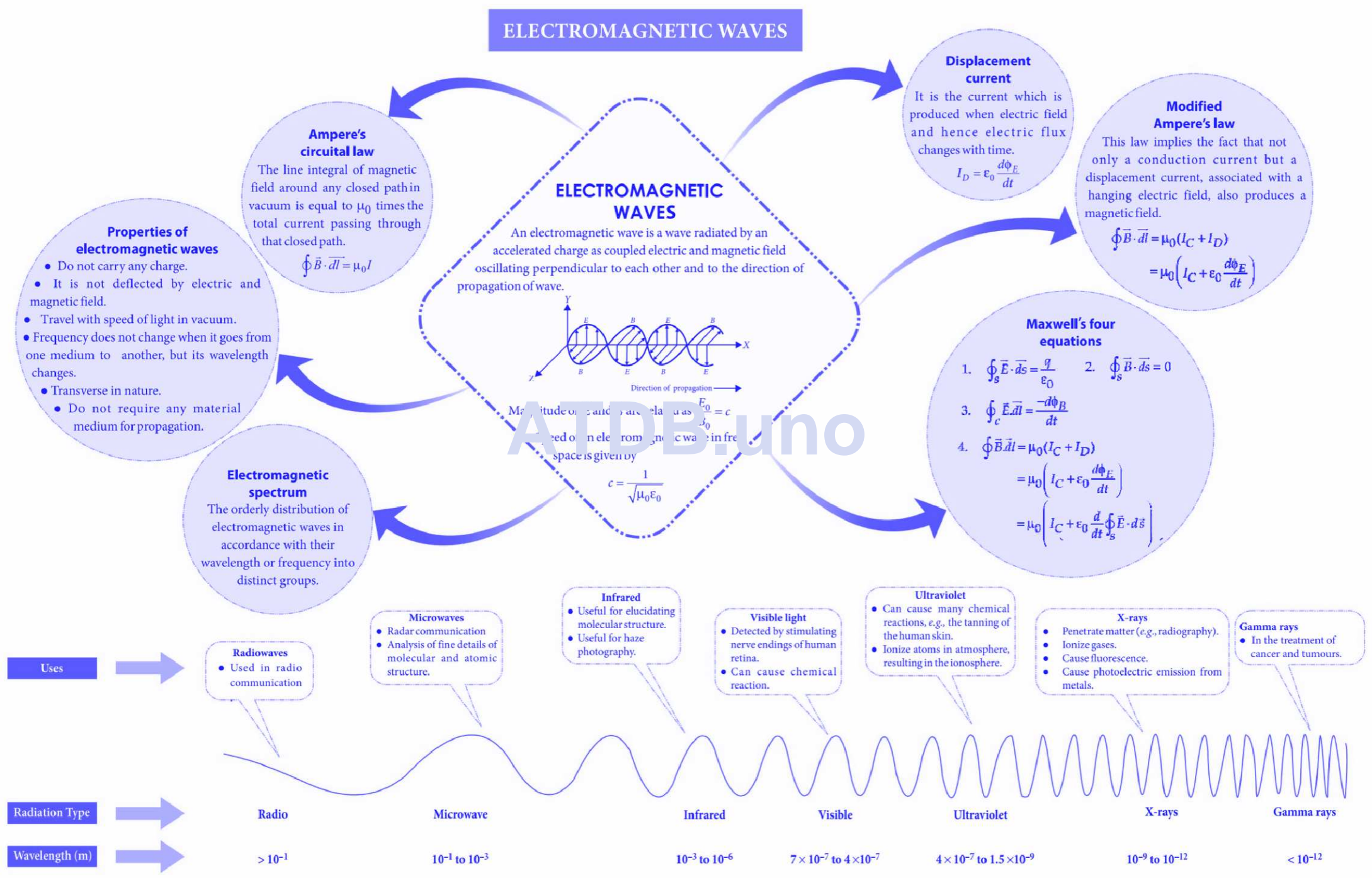
- On a straight conducting wire, $\epsilon = Bvl$
- On a rotating conducting wire about one end, $\epsilon = \frac{B\omega l^2}{2}$

Here, \vec{B} , $\vec{v}(= \omega r \hat{v})$ and \vec{l} are perpendicular to each other.

AC Generator

- Mechanical energy is converted into electrical energy by virtue of electromagnetic induction.
- Induced emf, $\epsilon = NAB\omega \sin \omega t = \epsilon_0 \sin \omega t$
- Induced current, $I = \frac{NBA\omega}{R} \sin \omega t = I_0 \sin \omega t$





Electromagnetic spectrum

The orderly distribution of electromagnetic waves in accordance with their wavelength or frequency into distinct groups.

RAY OPTICS AND OPTICAL INSTRUMENTS

OPTICAL FIBRES

are used for transmitting optical signal through long distance. Optical fibres based on the phenomenon of TIR.

TOTAL INTERNAL REFLECTION

TIR conditions

- Light must travel from denser to rarer.
- Incident angle $i >$ critical angle i_c

Relation between μ and i_c : $\mu = \frac{1}{\sin i_c}$

REFRACTION OF LIGHT

Snell's law: When light travels from medium a to medium b , $\mu_b = \frac{\mu_a \sin i}{\sin r}$

Refractive index,

$$\mu = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in medium}} = \frac{c}{v}$$

Real and apparent depth

$$\mu = \frac{\text{real depth (x)}}{\text{apparent depth (y)}}$$

REFLECTION OF LIGHT

- According to the laws of reflection, $\angle i = \angle r$
- If a plane mirror is rotated by an angle θ , the reflected rays rotates by an angle 2θ .

SIMPLE MICROSCOPE

Magnifying power

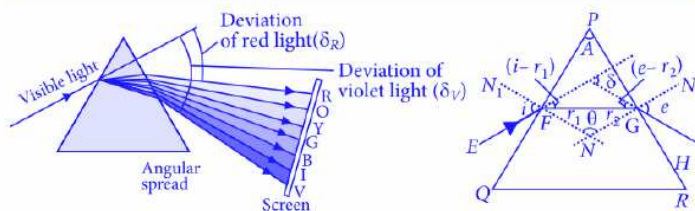
- For final image to be formed at D (least distance) $M = 1 + \frac{D}{f}$
- For final image formed at infinity

$$M = \frac{D}{f}$$

REFLECTING TELESCOPE

Magnifying power

$$M = \frac{f_o}{f_e} = \frac{R/2}{f_e}$$



REFRACTION THROUGH PRISM

Relation between μ and δ_m

$$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} \quad \left\{ \begin{array}{l} \text{where,} \\ \delta_m = \text{angle of minimum deviation} \\ A = \text{angle of prism} \end{array} \right.$$

or $\delta = (\mu - 1)A$ (Prism of small angle)

Angular dispersion

$$= \delta_V - \delta_R = (\mu_V - \mu_R)A$$

Dispersive power,

$$\omega = \frac{\delta_V - \delta_R}{\delta} = \frac{\mu_V - \mu_R}{\mu - 1}$$

Mean deviation, $\delta = \frac{\delta_V + \delta_R}{2}$

POWER OF LENSES

Power of lens: $P = \frac{1}{f}$ (in m)

Combination of lenses:

Power: $P = P_1 + P_2 - dP_1P_2$

(d = small separation between the lenses)

For $d = 0$ (lenses in contact)

Power: $P = P_1 + P_2 + P_3 + \dots$

THIN SPHERICAL LENS

Thin lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Magnification: $m = \frac{v}{u} = \frac{h_i}{h_o}$

REFRACTION BY SPHERICAL SURFACE

Relation between object distance (u), image distance (v) and refractive index (μ)

$$\frac{\mu_{\text{denser}}}{v} - \frac{\mu_{\text{rarer}}}{u} = \frac{\mu_{\text{denser}} - \mu_{\text{rarer}}}{R}$$

(Holds for any curved spherical surface.)

Lens maker's formula

$$\frac{1}{f} = (\mu - 1) \left[\frac{1}{R_1} - \frac{1}{R_2} \right]$$

REFLECTION BY SPHERICAL MIRRORS

Mirror formula, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f} = \frac{2}{R}$

Magnification, $m = -\frac{v}{u} = \frac{h_i}{h_o}$

COMPOUND MICROSCOPE

Magnifying power, $M = m_o \times m_e$

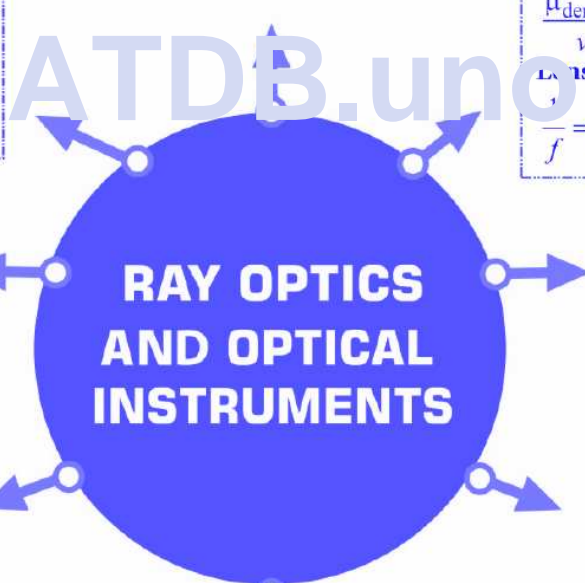
- For final image formed at D (least distance) $M = -\frac{L}{f_o} \left(1 + \frac{D}{f_e} \right)$
- For final image formed at infinity

$$M = -\frac{L}{f_o} \cdot \frac{D}{f_e}$$

TERRESTRIAL TELESCOPE

For normal adjustment $M = \frac{f_o}{f_e}$

Distance between objective and eyepiece $d = f_o + 4f + f_e$



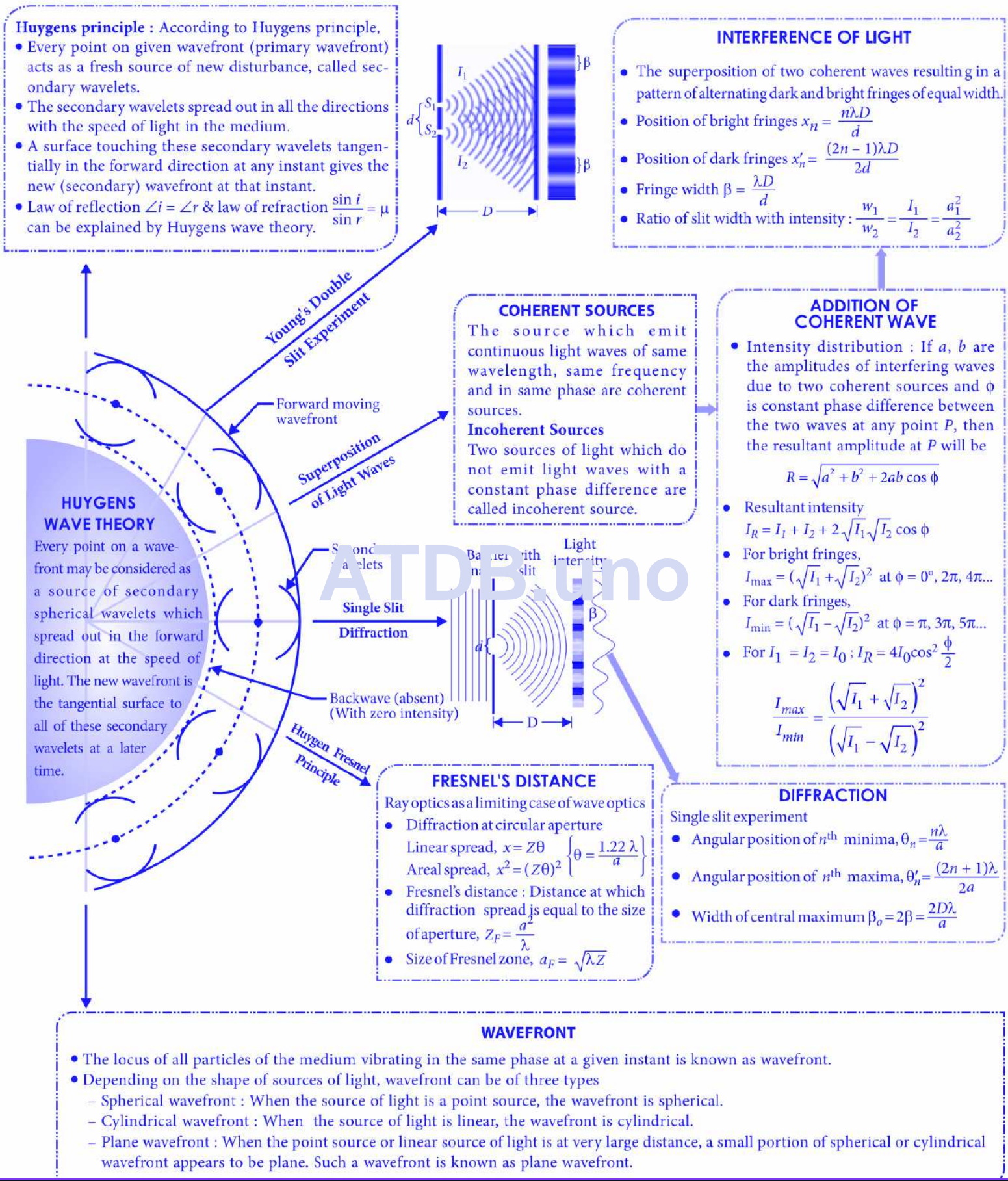
RAY OPTICS AND OPTICAL INSTRUMENTS

TELESCOPE

Astronomical telescope

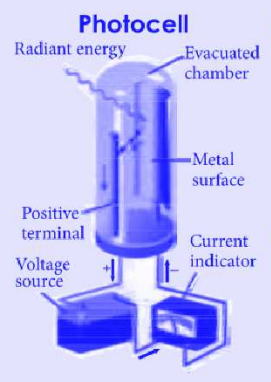
- For final image formed at D (least distance) $M = -\frac{f_o}{f_e} \left(1 + \frac{f_e}{D} \right)$
- In normal adjustment, image formed at infinity $M = -f_o/f_e$

WAVE OPTICS



DUAL NATURE OF RADIATION AND MATTER

Photoelectric Cell



- An electrical device which converts light energy into electrical energy, is called as photocell or photoelectric cell.
- It works on the principle of photoelectric emission of electrons.

Electron Microscope

- Electron microscope is a device designed to study very minute objects.
- Based on principle of de Broglie wave and the fast moving electrons can be focussed by E or B field in a same way as beam of light is focussed by glass lenses.

de-Broglie Wavelength

$$\lambda = \frac{h}{p}$$

- For electron having K.E. (K) is $\lambda = \frac{h}{\sqrt{2mK}}$, here $p = \sqrt{2mK}$
- For a charged particle accelerated by potential V is $\lambda = \frac{h}{\sqrt{2qmV}}$, here $p = \sqrt{2qmV}$

DUAL NATURE OF RADIATION AND MATTER

Application of Photoelectric Effect

Particle Nature of Radiation

Wave Nature of Matter

Application of de Broglie Waves

Photoelectric Effect

- The phenomenon of emission of electrons from a metal surface when an electromagnetic wave of suitable frequency is incident on it is called photoelectric effect.

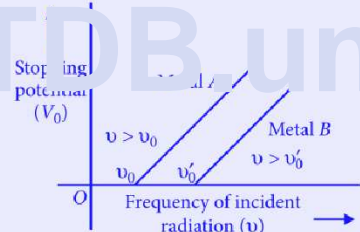
Einstein's Photoelectric Equation

- $E = K_{\max} + \phi_0$, where ϕ_0 = work function, E = energy of incident light, K_{\max} = maximum K.E. of e^-
- $\Rightarrow h\nu = \frac{1}{2}mv_{\max}^2 + h\nu_0$
- $\Rightarrow \frac{1}{2}mv_{\max}^2 = h(\nu - \nu_0)$

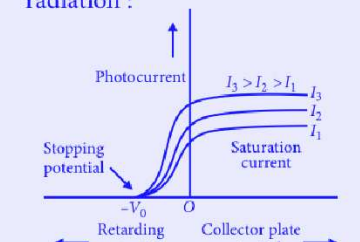
Experimental Study and Conclusion of Photoelectric Effect

- At constant frequency ν and potential V (Photo-current) $i_p \propto I$ (intensity)
- At constant frequency and intensity, the minimum negative potential at which the photocurrent becomes zero is called stopping potential (V_0).
- At stopping potential V_0 , K_{\max} of $e^- = eV_0$
- For a given frequency of the incident radiation, the V_0 is independent of I.
- The V_0 varies linearly with ν .

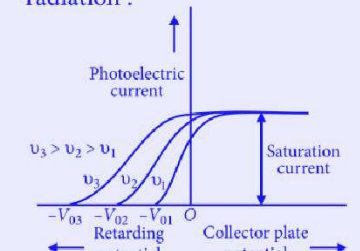
Variation of stopping potential V_0 with frequency ν of incident radiation:



Variation of photocurrent with collector plate potential for different intensity of incident radiation:



Variation of photocurrent with collector plate potential for different frequencies of incident radiation:

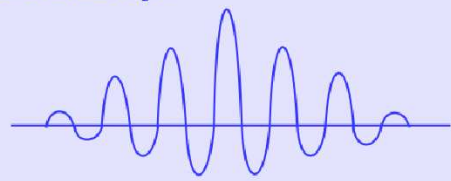


de-Broglie Hypothesis

- Due to symmetry in nature, the particle in motion also possess wave-like properties. And these waves are called matter waves.

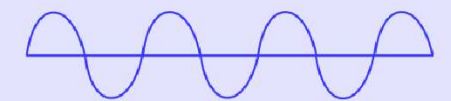
The wave packet description of an electron:

The wave packet corresponds to a spread of wavelength around some central wavelength (and hence by de Broglie relation, a spread in momentum). Consequently, it is associated with an uncertainty in position (Δx) and an uncertainty in momentum (Δp).

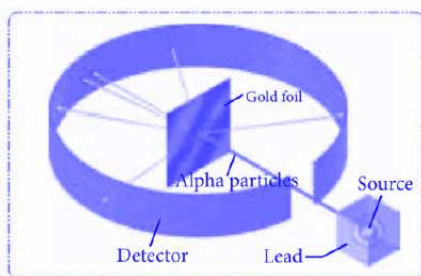


(a) A localised wave packet

- The matter wave corresponding to a definite momentum of an electron extends all over space. In this case, $\Delta p = 0$ and $\Delta x \rightarrow \infty$.

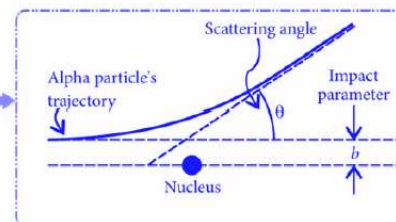


(b) An extended wave with fixed wavelength



Rutherford's Model of Atom

- K.E. of α -particles, $K = \frac{1}{2}mv^2$
- Distance of closest approach,
$$r_0 = \frac{1}{4\pi\epsilon_0} \cdot \frac{2Ze^2}{K} = \frac{1}{4\pi\epsilon_0} \cdot \frac{4Ze^2}{mv^2}$$
- Impact parameter,
$$b = \frac{1}{4\pi\epsilon_0} \cdot \frac{Ze^2 \cot \frac{\theta}{2}}{K} = \frac{1}{4\pi\epsilon_0} \cdot \frac{Ze^2 \cot \frac{\theta}{2}}{\frac{1}{2}mv^2}$$
- **Conclusion** : An atom consists of a small and massive central core in which entire positive charge and whole mass of atom is concentrated.

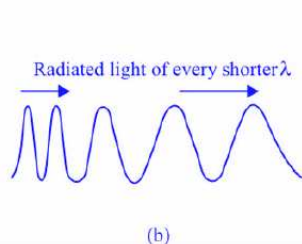
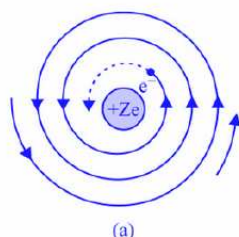


Important Expressions from Bohr's Atomic Model

- Electron orbits and their energy**
- Radius of permitted n^{th} orbits,
$$r_n = \frac{n^2 h^2}{4\pi^2 m k Z e^2} \Rightarrow r_n \propto n^2$$
 - Velocity of electron in n^{th} orbit,
$$v_n = \frac{2\pi k Z e^2}{n h} \Rightarrow v_n \propto \frac{1}{n}$$
 - Energy of electron in n^{th} orbit
$$E_n = \frac{-2\pi^2 m k^2 Z^2 e^4}{n^2 h^2} \Rightarrow E_n \propto \frac{1}{n^2}$$
 where the symbols have their usual meanings.

Drawbacks of Rutherford's atomic model

- According to electromagnetic theory, an accelerated charge particle always radiates energy. Electrons loses its energy and its radius of orbit decreases continuously and finally it would spiral into the nucleus. But in practical atoms do not collapse.
- An electron revolving in any orbit emits continuous radiation of all wavelengths. Actually the elements are found to emit spectral lines of definite frequencies and not all of them.



Bohr's Model of Atom

- Bohr developed a theory of hydrogen and hydrogen like atoms which have only one orbital electron.
- Angular momentum of the electron in a stationary orbit is an integral multiple of $h/2\pi$.
$$\text{i.e., } L = \frac{nh}{2\pi} \text{ or, } mvr = \frac{nh}{2\pi}$$

Ionization Energy and Ionization Potential

- Ionization energy and potential of an electron in hydrogen atom for n^{th} state.
- Ionization energy = $\frac{13.6Z^2}{n^2} \text{ eV}$
 - Ionization potential = $\frac{13.6Z^2}{n^2} \text{ V}$

Line Spectra of Hydrogen Atom

- While transition between different atomic levels, light radiated in various discrete frequencies are called spectral series of hydrogen atom.
- Rydberg formula :
$$\text{Wave number } \bar{\nu} = \frac{1}{\lambda} = R \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$$
 $R = \text{Rydberg's constant} = 1.097 \times 10^7 \text{ m}^{-1}$

Atomic Spectra

	Initial state	Final state	Wavelength formula	First member-second member	Series limit $n_i \rightarrow \infty$ to n_f	Maximum wavelength (n_f+1) to n_f	Lines found in
Lyman	$n_i = 2, 3, 4, 5, 6, \dots$	$n_f = 1$	$\frac{1}{\lambda} = R \left(\frac{1}{1^2} - \frac{1}{n_i^2} \right)$	$n_i = 2$ to $n_f = 1$ $n_i = 3$ to $n_f = 1$	From ∞ to 1 $\lambda = \frac{1}{R}$ $\lambda = 911 \text{ \AA}$	From 2 to 1 $\lambda = \frac{4}{3R}$ $\lambda = 1216 \text{ \AA}$	UV region
Balmer	$n_i = 3, 4, 5, 6, 7, \dots$	$n_f = 2$	$\frac{1}{\lambda} = R \left(\frac{1}{2^2} - \frac{1}{n_i^2} \right)$	$n_i = 3$ to $n_f = 2$ $n_i = 4$ to $n_f = 2$	From ∞ to 2 $\lambda = \frac{4}{R}$ $\lambda = 3646 \text{ \AA}$	From 3 to 2 $\lambda = \frac{36}{5R}$ $\lambda = 6563 \text{ \AA}$	Visible region
Paschen	$n_i = 4, 5, 6, 7, 8, \dots$	$n_f = 3$	$\frac{1}{\lambda} = R \left(\frac{1}{3^2} - \frac{1}{n_i^2} \right)$	$n_i = 4$ to $n_f = 3$ $n_i = 5$ to $n_f = 3$	From ∞ to 3 $\lambda = \frac{9}{R}$ $\lambda = 8204 \text{ \AA}$	From 4 to 3 $\lambda = \frac{144}{7R}$ $\lambda = 18753 \text{ \AA}$	IR region
Brackett	$n_i = 5, 6, 7, 8, 9, \dots$	$n_f = 4$	$\frac{1}{\lambda} = R \left(\frac{1}{4^2} - \frac{1}{n_i^2} \right)$	$n_i = 5$ to $n_f = 4$ $n_i = 6$ to $n_f = 4$	From ∞ to 4 $\lambda = \frac{16}{R}$ $\lambda = 14585 \text{ \AA}$	From 5 to 4 $\lambda = \frac{400}{9R}$ $\lambda = 40515 \text{ \AA}$	IR region
Pfund	$n_i = 6, 7, 8, 9, 10, \dots$	$n_f = 5$	$\frac{1}{\lambda} = R \left(\frac{1}{5^2} - \frac{1}{n_i^2} \right)$	$n_i = 6$ to $n_f = 5$ $n_i = 7$ to $n_f = 5$	From ∞ to 5 $\lambda = \frac{25}{R}$ $\lambda = 22790 \text{ \AA}$	From 6 to 5 $\lambda = \frac{900}{11R}$ $\lambda = 74583 \text{ \AA}$	Far IR region

SEMICONDUCTOR ELECTRONICS: MATERIALS, DEVICES AND SIMPLE CIRCUITS

TYPES OF SEMICONDUCTORS

Extrinsic Semiconductors

- The semiconductor whose conductivity is mainly due to impurity. On the basis of doping there are two type of extrinsic semiconductors.
 - p*-type semiconductor ($n_h \gg n_e$):
Obtained by doping a trivalent impurity atom.
 - n*-type semiconductor ($n_e \gg n_h$):
Obtained by doping a pentavalent impurity atom.
- Electrical conductivity, $\sigma = e [n_e \mu_e + n_h \mu_h]$

Intrinsic Semiconductors

The pure semiconductors having thermally generated current carriers.
 $n_e = n_h = n_i$; where, n_e = Electron density,
 n_h = Hole density, n_i = Density of intrinsic carriers.

Formation of *p-n* Junction

- Due to high carrier concentration difference, holes diffuses from *p*-side to *n*-side and electron diffuses from *n*-side to *p*-side, produces diffusion current.
- Due to barrier potential, majority charge carriers are forced to move to other side of the junction and such movement produces drift current.

Semiconductor Diode

- P-N* Junction Diode** : In layman language, when a *p*-type semiconductor is brought into contact with an *n*-type semiconductor such that structure remains continuous at boundary, *p-n* junction diode is formed.
- Forward bias characteristic
 - Width of depletion layer decreases
 - Effective barrier potential decreases
 - Low resistance offered at junction and high current flow of the order of mA.
- Reverse Bias Characteristics
 - Width of depletion layer increases
 - Effective barrier potential increases
 - High resistance offered at the junction and low current flow of the order of μ A.
 - Reverse break down occurs at a high reverse biased voltage where the ordinary diodes get damaged.

Characteristic and Symbol of *p-n* Junction Diode

The most important characteristic of a *p-n* junction is its ability to conduct current in one direction only.

- In the reverse direction, it offers very high resistance.

Forward Biased

- Effective barrier potential decreases.
- Depletion width decreases.
- Low resistance offered at junction.
- High current flows through the circuit.

Rectifier

Used to convert ac signal into dc signal.

Half Wave Rectifier

- $I_{max} = \frac{\epsilon_{max}}{(r_f + R_L)}$; $I_{dc} = \frac{I_{max}}{\pi}$
- Output frequency = Input frequency
- Efficiency = $\frac{P_{dc}}{P_{ac}} = 40.6\%$

Full Wave Rectifier

- $I_{max} = \frac{\epsilon_{max}}{(r_f + R_L)}$; $I_{dc} = \frac{2I_{max}}{\pi}$
- Output frequency = 2 × Input frequency
- Efficiency = $\frac{P_{dc}}{P_{ac}} = 81.2\%$