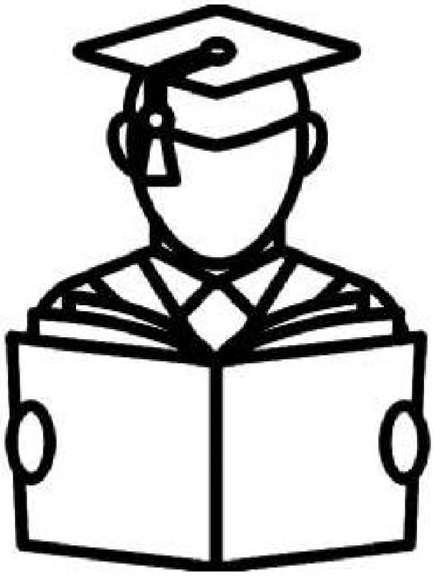
चौधरी PHOTOSTAT

"I don't love studying. I hate studying. I like learning. Learning is beautiful."



"An investment in knowledge pays the best interest."

Hi, My Name is

Physical Science for CSIR NET

Career Endeavour

E.M.T.

Electrostatics (Electric field) ($\vec{E}$)

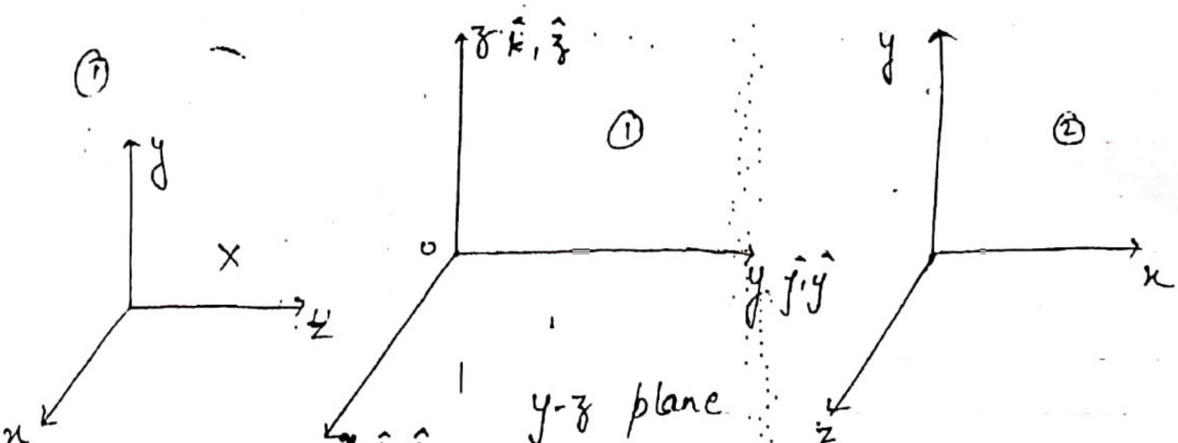
Magnetostatics (Magnetic field) ($\vec{B}$)

Electrodynamics (Electric & Magnetic field) (E & $\vec{B}$)

Mathematics required for EMT

Co-ordinate Systems:

① Cartesian system
② Spherical polar system
③ Cylindrical System



y-z plane
(i)

$i \to j \to k \to i$

$\hat{i} \times \hat{j} = \hat{k}$

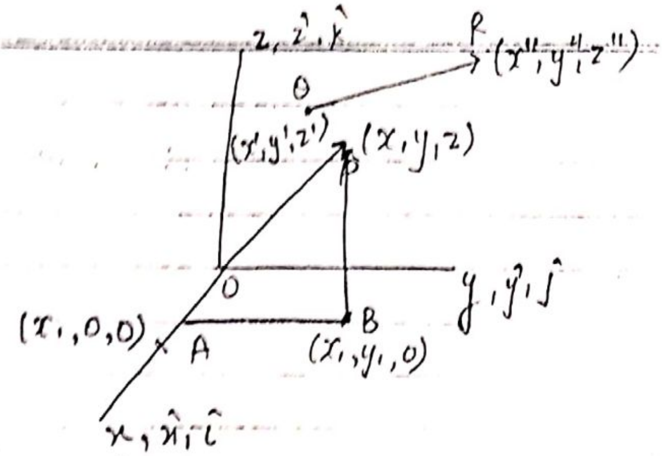
$\hat{i} \times \hat{k} = -\hat{j}$

length elements of (i)

$\vec{dl_x} = dx\,\hat{i}$, $\vec{dl_y} = dy\,\hat{j}$, $\vec{dl_z} = dz\,\hat{k}$

along OA line

$$\int_0^{x_1} f(x,y,z)\,dx \Big|_{\substack{y=0\\z=0}}$$



along AB line

$$\int_0^{y_1} f(x,y,z)\,dy \Big|_{\substack{x=x_1\\z=0}}$$

along BP line

$$\int_0^{z_1} f(x_1,y_1,z)\,dz \Big|_{\substack{x=x_1\\y=y_1}}$$

$$\vec{dl} = dx\,\hat{i} + dy\,\hat{j} + dz\,\hat{k}$$

$$\overrightarrow{OP} = (x-0)\hat{i} + (y-0)\hat{j} + (z-0)\hat{k}$$
$$\overrightarrow{QR} = (x''-x')\hat{i} + (y''-y')\hat{j} + (z''-z')\hat{k}$$

Surface elements (plane):

$$\vec{ds} = \vec{dl_y} \times \vec{dl_z}$$

$$\vec{ds} = \underbrace{dy\,dz}_{\text{magnitude}}\ \underbrace{\hat{i}}_{\text{dir}^n}$$

whatever vector is Constant over the Surface that will the direction of that Surface and here y & z is vary and x is Constant so $\hat{i}$ is dir^n.

15 Marks (5 M... 3 Q...)

Atomic & Molecular Physics

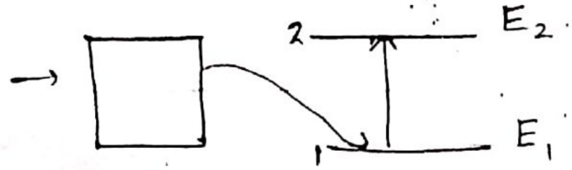
Spectroscopy is the interaction b/w. E.M radiation and the substance to be examined.

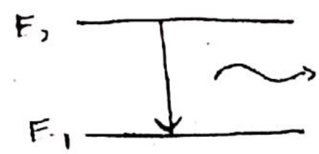
Absorption spectra

Sample → energy is less initially

I.R → Vibration , U.V → e- released

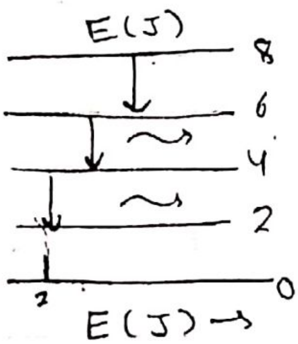
Emission





$h\nu = E_2 - E_1$

$\nu = \frac{E_2 - E_1}{h}$



8−6 = 2

6−4 = 2

4−2 = 2

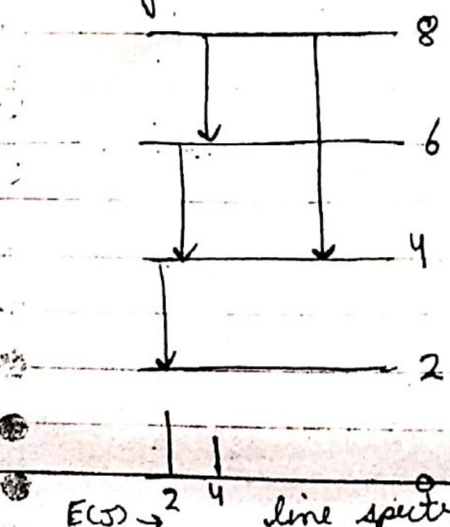
2−0 = 2

difference − peak

4−2 = 2

all are having difference same i.e 2 so we get only one peak at 2 instead of 3 different peaks.

As same time one atom is present at one level only.
Only one transition at a time



8−6 = 2

6−4 = 2

4−2 = 0

2−0 = 2

8−4 = 4

two peak at 2 and at 4.

line spectra

Band spectra.
Line are very closed which seems like bar

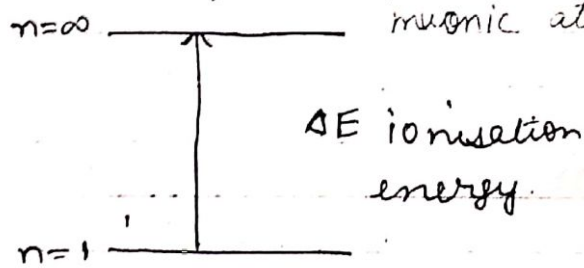
Hydrogen Atom:

Atom → +ve charge nucleus } electrically
→ -vely charged e^-s. } neutral

Atomic no. → no. of protons.

Bohr's theory of H- like atoms

This theory is applicable for $1e^-$ system like hydrogen(H), He^+, Li^{2+}, Be^{3+} positronium and muonic atom



Assumptions

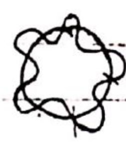
1 Electrons are revolving in circular orbits around the nucleus.

2 Electrons move only in those orbits in which orbital angular momentum is integral multiple of $\hbar$.

$$mvr = n\hbar \qquad n = 1, 2, 3 \dots \infty$$

or

$$m v_n r_n = \frac{nh}{2\pi}$$



Proof:- $2\pi r = n\lambda$

e^- move as wave having wavelength λ & this wave should having integral no of wavelengths.

21.

Newtonian Mechanics.

General approach for solving problem

Two Approaches

Start with equ^n of motion

① Newton EOM

$\vec{F} = \frac{d\vec{p}}{dt}$, $\vec{F} = m\vec{a}$

② Lagranges EOM

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = 0$$

$L = T - V$

③ Hamilton's EOM

$$\dot{q}_i = \frac{\partial H}{\partial p_i}, \quad \dot{p}_i = -\frac{\partial H}{\partial q_i}$$

(easy) Start with Conservation law. (for some selected problem)

① Conservation of linear momentum

$\Sigma \vec{p}_i = \Sigma \vec{p}_f$ if $F = 0$

② Conservation of angular momentum

$\Sigma \vec{l}_i = \Sigma \vec{l}_f$ if $\vec{\tau} = 0$,

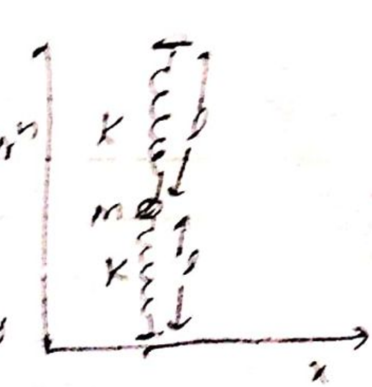
$\vec{l} = \vec{r} \times \vec{p}$

$\vec{\tau} = \vec{r} \times \vec{F}$

③ Cons. of energy

Example NET-2013 (5M)

If block is slightly displace in x-dir^n then write its equ^n of motion.



This Ques. can be solved by four methods

If only spring is attached, then E is conserved no other force applied.

Newtonian Mechanics

Basic assumption : Mass, length and time are absolute. These quantities donot change

Newtons laws:

2^{nd} law - $\vec{F} = \dfrac{d\vec{p}}{dt}$

Rate of change of momentum of the system is equal to net applied force.

$$\frac{d\vec{p}}{dt} = \frac{d}{dt}(m\vec{v})$$

Total mass never change.

$$\frac{d\vec{p}}{dt} = m\frac{d\vec{v}}{dt} + \vec{v}\frac{dm}{dt}.$$

Above formula is used for both constant and variable mass.

If $m =$ constant

$$\vec{F} = m\frac{d\vec{v}}{dt} = m\vec{a} \qquad \because \vec{a} = \frac{d\vec{v}}{dt}$$

used only if mass is constant $\boxed{\vec{F} = m\vec{a}}$

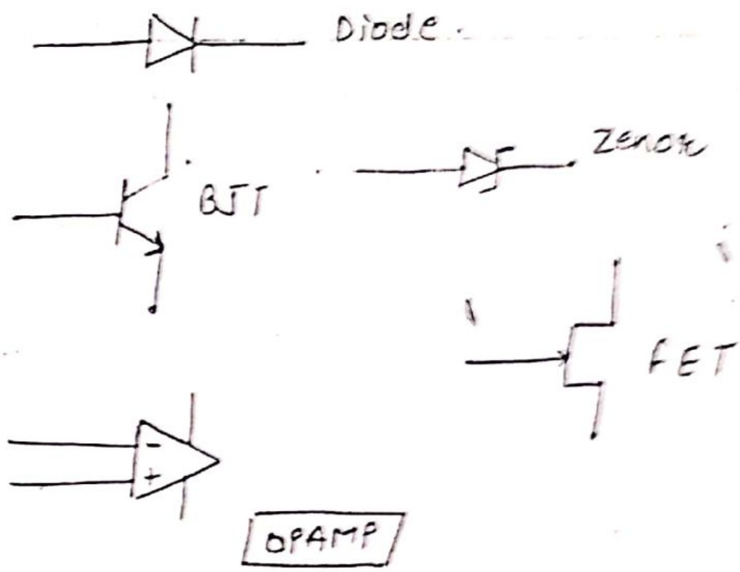
This force is obtained when we are assuming mass is constant.

acceleration is zero only when velocity is constant

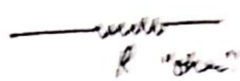
Notes

Electronics

Analog



Network theory



Resistor → Resistance is a property of resistor which opposes the flow of current.

Its behaviour is explained by ohm's law

Ohm's law

Basic Ω's law

OR

field theory Ω's law

$J \propto E$

$\boxed{J = \sigma E}$

$\sigma \rightarrow$ Conductivity

Modified ohm's law

OR

Circuit theory ohm's law

$V \propto I$ $\boxed{V = RI}$

$I \propto V$ $\boxed{I = GV}$

$R = \frac{V}{I} \Rightarrow \frac{\text{Volt}}{\text{Ampere}} = \text{Ohm} / \Omega$

Teacher's Signature

$G \rightarrow$ Conductance

Notes

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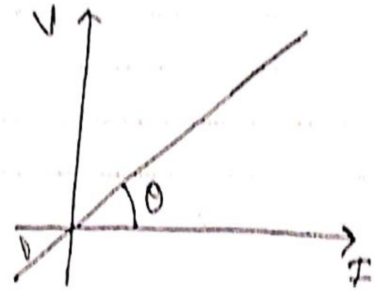
$$G = \frac{I}{V}$$

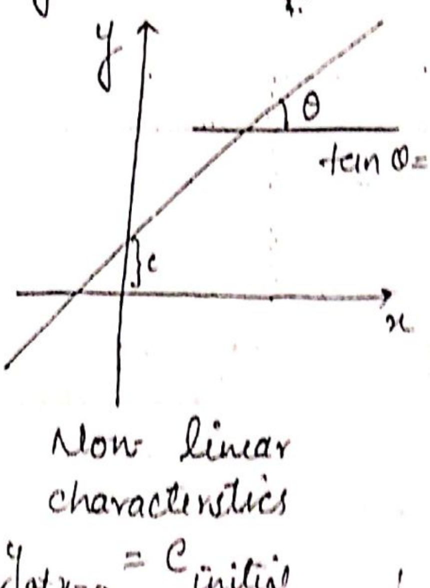
$$\text{mho} = \frac{\text{Ampere}}{\text{Volt}} = \mho$$

<u>Graph b/w V and I</u>

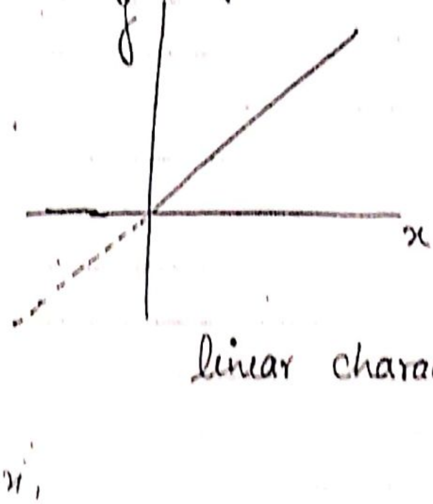
$\tan\theta = m = R_{ohm}$



$y = mx + c$



$\boxed{y = mx}$

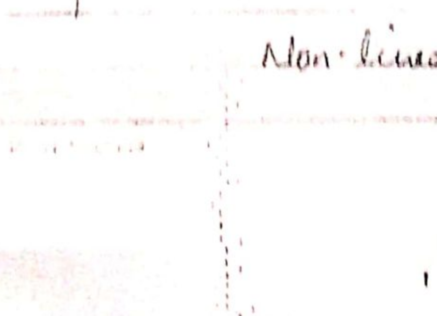


Non linear characteristics

linear characteristics

$y_{at\ x=0} = c$ initial value

for constant



Non-linear characteristics / curve

Notes

Teacher's Signature ________

Mathematical Physics

Part 1

Complex Analysis

Basic preview of Complex Variable.

$$az^2+bz+c=0$$

$$z \Rightarrow \frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

$b^2-4ac > 0$ ✓ (+ve)
$b^2-4ac < 0$ (−ve)

$\sqrt{-1} = i$
$i^2=-1$

$z = x+iy$ (CARTESIAN FORM)

$x \rightarrow$ real part, $y \rightarrow$ imaginary part

Electric field.

$$\vec{E} = \vec{E_0} \cos(kz-\omega t)$$

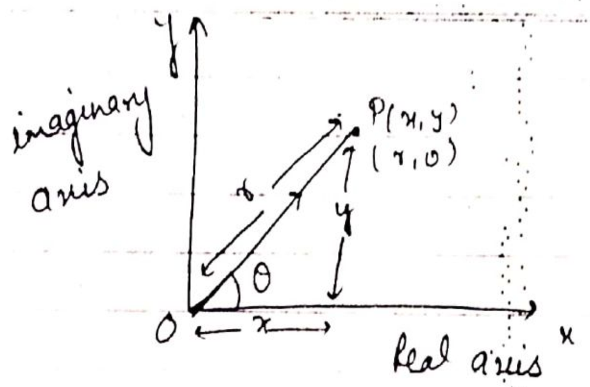
$\{\cos\theta + i\sin\theta\}$

$$\vec{E} = \vec{E_0} \left[\text{Realpart of } e^{i(kz-\omega t)}\right]$$

{Polar form} $z = r\cos\theta + ri\sin\theta$
$= r(\cos\theta + i\sin\theta)$
$= re^{i\theta}$

⇒ Geometrical Representation of a Complex Number

Complex Argand Plane.



$\vec{OP}$ = Radius vector Corresponding to the Complex no. z
$r \rightarrow$ length / Magnitude of the radius vector OP
$\rightarrow$ modulus of the 'z'

$\Rightarrow \quad r = |z| = \sqrt{x^2 + y^2}$
$= \sqrt{(R.P)^2 + (I.P)^2}$

$\Rightarrow \quad \theta$ = Angle which radius vector $\vec{OP}$ makes with +ve x-axis
= argument of z = Phase of z

$\theta = \arg . z = \tan^{-1}\left(\frac{y}{x}\right)$

$$\boxed{\theta = \tan^{-1}\left(\frac{I.P}{R.P}\right) = \text{Phase}}$$

Important Relⁿ regarding argument z and modulus.

(1) $|z_1 + z_2| \leq |z_1| + |z_2|$

(2) $|z_1 - z_2| \geq |z_1| - |z_2|$

(3) $|z_1 . z_2| = |z_1| . |z_2|$

(4) $\left|\frac{z_1}{z_2}\right| = \frac{|z_1|}{|z_2|}$

Nucleus

↓

Nucleons

↓ ↓

Neutrons Protons

$_{Z}X^{A}$ A = mass number (No. of n & p)
Z = atomic number (No of p)

Masses - can be expressed as

→ kg
→ Atomic mass unit (amu) or u
→ Relativistic unit (MeV/c^2)

	kg	u	MeV/c^2
proton	1.6726×10^{-27}	1.00726 u	938.3
Neutron	1.6750×10^{-27}	1.00867 u	939.6
Electron	9.1×10^{-31} kg	0.000554	0.51

Atomic mass unit (amu)

1amu = $\frac{1}{12}$ time the mass of one C^{12} atom

1 mole of C^{12} = 12gm.
1 mole has = 6.02×10^{23} atom.

Mass of one C^{12} atom = $\frac{12}{6.02 \times 10^{23}}$ gm.

$1amu = \frac{1}{\cancel{12}} \times \frac{\cancel{12}}{6.02 \times 10^{23}} gm \times 10^{-3} kg$

$$\boxed{1\, amu = 1.66 \times 10^{-27}\, kg}$$

1 amu in energy units.

$E = mc^2 = 1amu \times c^2$

$E = 1.66 \times 10^{-27} kg \times (3 \times 10^8)^2 (m/s)^2 = Joule$

=

$1\,J = \frac{1}{1.6 \times 10^{-19}}\, eV$ magnitude must be large

large small

$$\boxed{1eV = 1.6 \times 10^{-19}\, J}$$

$1\,MeV = 1.6 \times 10^{-19} \times 10^6\, J$

$1MeV = 1.6 \times 10^{-13}\, J$

$E = \frac{1.66 \times 10^{-27} \times (3 \times 10^8)^2\, J}{1.6 \times 10^{-13}\, J/MeV}$

Quantum Mechanics

	0/ Marks	0/Marks	
CSIR	4×3.5	4×5	= 34 Marks
Gate	4×1	4×2	= 8 Marks + 4 Marks
			= 12 Marks

⇒ Total @ of a material particle in relativistic case

$E = mc^2 = \gamma m_0 c^2$, $E = K.E + m_0 c^2$. $(v \sim c)$

$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ $E = \sqrt{c^2p^2 + m_0^2c^4}$

⇒ For non-relativistic free particle.

$E = K.E = \frac{1}{2} mv^2$ $(v << c)$

non-relativistic

$v << c$ non-rel. $(\gamma = 1)$ $v = 10^6 m/sec$

$v \sim c$ rel. $(\gamma > 1)$

$v = 10^6, \; v = 2\times10^7$

$\gamma = \frac{1}{\sqrt{1-\frac{10^{12}}{9\times10^{16}}}} = \frac{1}{\sqrt{\frac{9\times10^{16}-10^{12}}{9\times10^{16}}}} = \frac{1}{\sqrt{1-0.11\times10^{-4}}} = \frac{1}{\sqrt{0.99\times10^{-4}}}$

$\boxed{\gamma = 1.0001}$

If $v < 10^7 m/sec$ (non-relat)

$v \geq 10^7 m/sec$ (rel.)

$v = 2\times10^7$

$\gamma = \frac{1}{\sqrt{1-\left(\frac{2\times10^7}{3\times10^8}\right)}}$

$\boxed{\gamma = 1.002}$

$E = cp = h\nu$

Photon energy $= h\nu = \frac{hc}{\lambda} = cp$

total E of rel. free particle

$E = \sqrt{c^2p^2 + m_0^2c^4}$

$= K.E + m_0c^2$

$E = \gamma m_0 c^2$

<u>Comparison of Rel. & Non rel.</u>

\# (1) $v << c$, $v < 10^7$ m/sec. } non rel.
$\gamma \approx 1$
rel. mass $\approx$ rest mass

$v \sim c$, $v > 10^7$ m/sec } rel.
$\gamma > 1$
rel. mass > rest mass

(2)
$cp << m_0c^2$ — non-rel.
$cp \approx m_0c^2$ } rel
or $cp > m_0c^2$

(3)
$K.E << m_0c^2$ $\longrightarrow$ non rel.
$K.E \approx m_0c^2$ } rel.
$K.E > m_0c^2$

<u>For free particles</u>

$m_ec^2 = 0.511$ MeV

$m_pc^2 = 938.25$ MeV

$m_nc^2 = 939.57$ MeV

(1) $\int_0^\infty e^{-x} x^{n-1} dx = \Gamma n$

(2) $\int_0^\infty e^{-\alpha x} x^n dx = \frac{n!}{\alpha^{n+1}} = \frac{\Gamma(n+1)}{\alpha^{n+1}}$, $\alpha > 0$

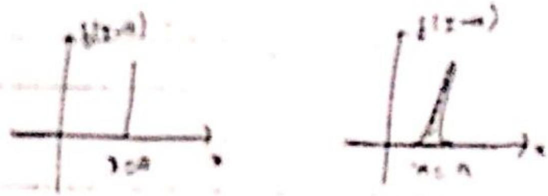
(3) $\int_0^\infty e^{-\alpha x^2} x^n dx = \frac{\Gamma\left(\frac{n+1}{2}\right)}{2\alpha^{\frac{(n+1)}{2}}}$

(4) $\int_{-\infty}^{\infty} e^{-\alpha x^2 + \beta x} = \sqrt{\frac{\pi}{\alpha}}\, e^{\left(\frac{\beta^2}{4\alpha}\right)}$, $\alpha > 0$

(5) $\int_{-\infty}^{+\infty} f(x)dx = \begin{cases} 2\int_0^\infty f(x)dx, & \text{if } f(x) = f(-x) \\ & f(x) = \text{even} \\ 0 & \text{if } f(x) = -f(x) \\ & f(x) = \text{odd} \end{cases}$

$\boxed{\text{Dirac Delta}}$

$\delta(x-a) = \begin{cases} 0 & x \neq a \\ \infty & x = a \end{cases}$



$\psi(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\left(\frac{x-a}{2\sigma^2}\right)^2}$

There is only single value of position $= a$] x
When

$\langle x \rangle = a$, $\langle x^2 \rangle = a^2$

$\Delta x = \sqrt{\langle x^2 \rangle - \langle x \rangle^2} = 0$

Lecture - 1

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Solid state Physics

NET → Marks ⇒ $5 \times 3 = 15 + 3.5 = 18.5$

↑ questions $\boxed{15-20}$

GATE → Marks contribution $\boxed{9-10}$

Books ⇒
1.) C. Kittel ✓
2.) Puri and Babbar ✓
3.) Wahab
4.) Ali Omar
5.) As chroft & Hermin
6.) Lim - series

We will study the properties of Solid (Physical)

Physical properties of Solid depends upon crystal structure.
For this, we take a Lattice
Lattice

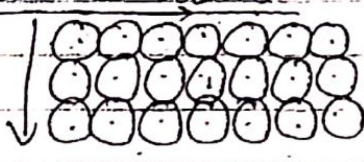
* consider a atom as a hard sphere

$r \to$ radius of atom
Solid is composed of millions atoms.

Solids
- Crystaline
  - single crystal
  - poly crystalline
- Amorphous (non - crystalline)

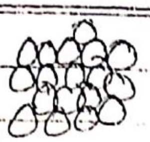
- if atom in solid not arranged periodicaly then it is non-crystalline solid
- If they are arranged periodicaly then it is crystalline solid

eg. diamond, quartz



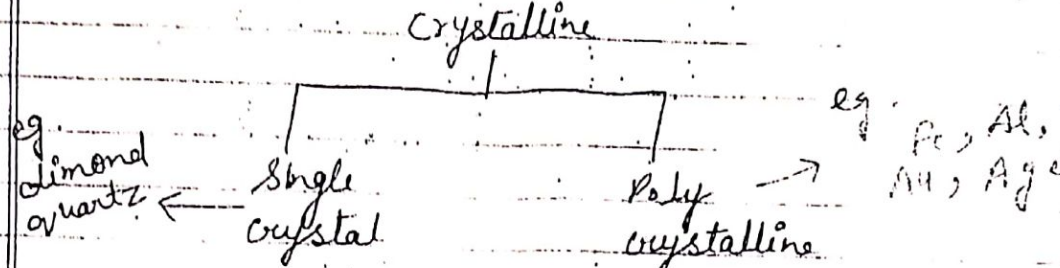
(It 2-d i.e a plane)

if you place one layer of atom on this It become atomic plane.
if one more then it become 3-d.

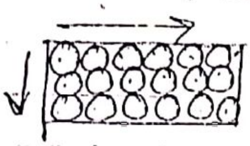


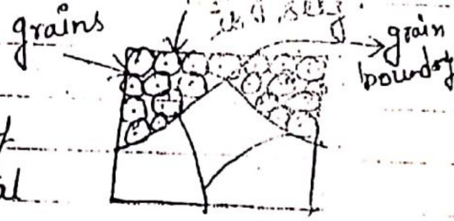
Non - Crystalline (randomly arranged)

eg. glass, rubber



- If their is no break in the arrangement of atom in solid . then it is single crystal





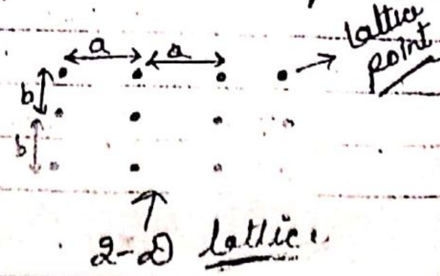
- Poly Crystaline solid are considered as aggerigate of large no of single crystal

If we break poly crystal it will break through grain boundary

We will study the periodic arranged ~~Crystals~~ solids

Lattice :— Lattice is periodic arrangement of imaginary points in the space.

If we consider these points in space then distance b/w them will be same.



Thermodynamics : → Macroscopic approach

Statistical Mechanics → Microscopic approach.

Microscopic Parameter or Variable:

The parameters related to the constituents of the system are called microscopic parameter.

Macroscopic Parameter:

The parameters related to the system as a whole are called macroscopic parameter.

P, V, T, U, S, G.

* Pressure is net momentum transfer per unit time per unit area.

* The state related to the parameters of the system is called Macroscopic state or Macro state.

* The state related to the parameters of the constituents of the system is called microstate or microscopic state.

System & Surrounding:

* The portion of universe of a particular mass in which observer is interested is called System.

* The part of the universe that is exterior to the system and influence or affect the system or ~~affect~~ interact with the system is called Surroundings or environment.

③

$\boxed{\text{System + Surrounding = Universe}}$

★ Depending on the interaction of system and surrounding, system are classified as follows.

Open System

(excluding rest mass-energy)

→ A system that can exchange energy as well as matter (rest mass energy) with its surrounding is called Open system.

Ex Ocean is open system. Sun is acting as surrounding.

Ex Most part of universe is open system.

Closed System

→ A system that can exchange energy but not matter with its surrounding is called closed system.

Isolated System

A system that can not exchange energy as well as matter with its surrounding is called isolated system.

→ No real system is absolute isolate.

→ Universe is example of isolated system.

Closed & isolated ~~these~~ systems can be called as bodies.