Shri Swami Vivekanand Shikshan Sanstha's

Vivekanand College, Kolhapur (Empowered Autonomous).

Department of Physics

Date: 01/03/2024

Internal Examination Notice

The students of M.Sc. I and II are hereby informed that the internal examination of current semester is scheduled as per following time table:

Sr. No.	Class and Sem	Paper Code.	Title of the paper	Date and time
1.	M.Sc. I, SEM II	DSC-III	Quantum Mechanics	12/03/2024 12:00 to 01:00 pm
2.	M.Sc. I, SEM II	DSC-IV	Condensed Matter Physics	13/03/2024 12:00 to 01:00 pm
3.	M.Sc. I, SEM II	OEC -II	Solid State Physics II	14/03/2024 12:00 to 01:00 pm
4.	M.Sc. II, SEM IV	CP-1118D	Experimental Techniques	12/03/2024 12:00 to 01:00 pm
5.	M.Sc. II, SEM IV	CP-1119D	Electronic Devices and applications	13/03/2024 12:00 to 01:00 pm
6.	M.Sc. II, SEM IV	CP-1120D	Solid State Physics- III (Physical Properties of Solid)	14/03/2024 12:00 to 01:00 pm
7.	M.Sc. II, SEM IV	CP-1121D	Solid State Physics-IV (Energy Conversion and Storage Devices)	15/03/2024 12:00 to 01:00 pm

(M.Sc. Co-ordinator)

HOD
HEAD
DEPARTMENT OF PHYSICS
VIVEKANAND COLLEGE, KOLHAPUR
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Shri Swami Vivekanand Shikshan Sanstha, Kolhapur

Vivekanand College, Kolhapur (Autonomous)

Department of Physics

M.Sc. Part-II SEM IV Internal Examination (2023-24)

Experimental Techniques

Paper code: CP-1118D

Date: - 12-03-2024 Time: - 12.00 to 1.00 pm Total Marks: 20

Day: - Tuesday

Instructions: -

1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Use of log table and calculator is allowed.

Q.1 Select Correct Alternative: **(5)**

i) Rotary pump is _____ type of pump.

(a) negative displacement (b) positive displacement

(c) neutral displacement (d) none of these

ii) In sputter ion pump gas is ionized by _____.

(a) electric field (b) magnetic field

(c) both (a) & (b) (d) gravitational filed

iii) McLeod gauge is used to measure pressure range at _____ torr.

(a) 10^{-2} (b) 10^{-6}

(c) 10^{-8} (d) 10^{-12}

iv) In penning gauge magnetic filed is applied _____ to the plane of electrodes.

(a) perpendicular (b) parallel

(c) indirectly (d) elliptically

v) Which type of light source is mainly used in halogen gas detector.

(a) UV (b) visible

(c) IR (d) sodium

Q.2 Attempt any one **(10)**

i) Explain McLeod in detail.

ii) Give detailed account of diffusion and sputter ion pump.

Q.3 Attempt any one **(5)**

i) Write a note on thermocouple gauge.

ii) Explain palladium barrier detector in detail.

(31

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Vivekanand College, Kolhapur (Empowered Autonomous)

Department of Physics

Internal Examination-M.Sc-II-2023-24-SEM-IV

Paper: Experimental Techniques

Day & Date: Tuesday, 12 /03/ 2024

Attendance Sheet

Sr. No.	Name of the students	Roll. No.	Sign	Marks
1)	Shivaraj. C. Kavalagi	1606	[illegible]	08
2)	Jadoli Smit Kallappa	1605	[illegible]	18
3)	Anand N. Biradar	1603	[illegible]	10
4)	Snehal. N. Ahiwale	1601	[illegible]	15
5)	Shruti Harish Bam	1602	[illegible]	15
6)	Rajshree mahesh Randive	1608	[illegible]	11
7)	Shivani Dattatray Sagar	1609	[illegible]	18
8)	Pranali Pradeep Shirke	1610	[illegible]	20
9)	Shweta Sardar Mithari	1607	[illegible]	15
10)	Dnyaneshwari P. Todkar	1611	[illegible]	15
-	—	—	—	
-	—	—	—	
-	—	—	—	

Teacher In Charge 12.03.24

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– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

51100

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor	15/20 22.04.24

Suppliment No. :

Roll No. : 1611

Class : M.Sc. II (Physics)

Subject : Experimental Techniques

Test / Tutorial No. : Sem IV Internal examination

Div. :

Q.

i)

Ans:- b) Positive displacement

ii)

Ans:- c) both (a) & (b)

iii)

Ans:- b) 10^{-6} torr.

iv)

Ans:- a) Perpendicular

05

v)

Ans:- c) TR

137

.2.

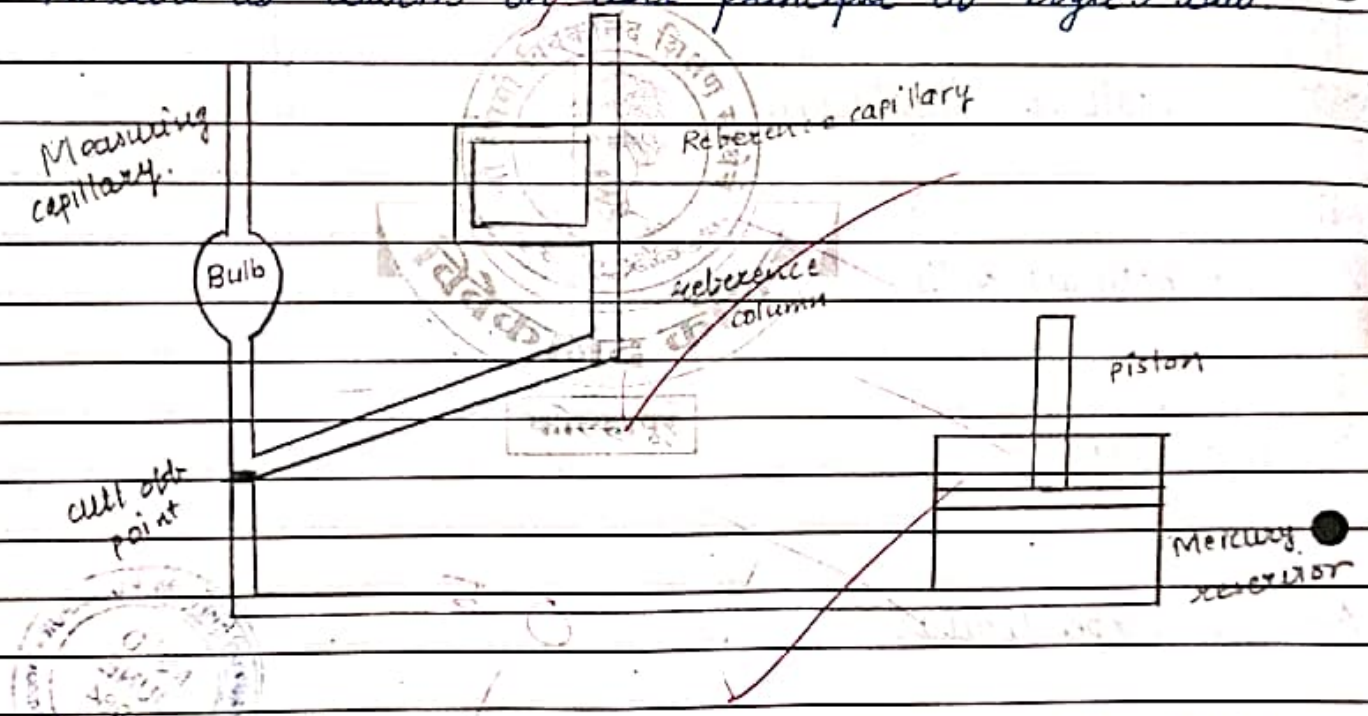
i)

Ans:-

i) Mc Leod is used to measure pressure about range 10^{-6} to
ii) It is also used to measure vaccum pressure.
iii) It is also known as compression gauge.
iv) It is similar to mercury manometer.
v) In mc leod gauge known volume is compressed at constant temperature and unknown pressure is to measured.

construction and working :-

Mc leod is works on the principle of Boyle's law.



1) Working fluid :- Here we use mercury as an working fluid the level of mercury maintained at ~~below~~ the cut off point intially.

2) Mercury reservior :- The purpose of mercury reservior is to store the mercury, it consists the piston which pushes mercury to the reference column, bulb & into the bulb.

3) Reference column :- one end of the reference column is connected to the cut off point and other end is for enetering gas. The diameter of reference column is greater than the reference capillary.

4) Reference capillary :- Both the ends of reference capillary are connected to reference column. The purpose of reference capillary is to measure height difference h. The diameter of reference capillary and measuring capillary are same. It is closer to measuring capillary.

5) Bulb :- The one end of bulb is connected reference column and another end is connected to measuring capillary. The volume of bulb is greater than the measuring capillary.

6) Measuring capillary :- Here one end is sealed and another is connected to capillary. Scale is fixed in between these capillaries to measure the height difference betn mercury.

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Working :-

i) First remove the mercury into the bulb and reference column below the cut off point so that the gas from enters into bulb & capillary so that the piston in mercury reservior moves upwards & mercury enters into the column.

ii) connect the reference column to source of gas whose pressure is to be measured.

iii) After filling the gas into the capillary, starts filling the mercury by moving piston downwards.

iv) when mercury crosses the column, measuring capillary is compressed & gas.

v) When mercury is reached at final cutt off point.

vi) By using the height 'h' we can calculate volume of it

vii) We can calculate height difference between them.

viii) We can find initial & final cutt off point.

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15/20
5109
2.4.24

SUPPLIMENT

Miss. Shruti Harish Bam.

Suppliment No. : 1

Roll No. : 1602

Class : MSc-II

Signature of Supervisor :

Subject : Experimental Techniques.

Test / Tutorial No. : Internal Examination

Div. :

Q.1.

i) Rotary pump is positive displacement pump

ii) In sputter ion pump gas is ionized by both (a) &

iii) Mcleod gauge is used to measure pressure range at 10^{-6} torr.

iv) In penning guage, magnetic field is applied Perpendic to the plane of electrodes.

iv) IR

05

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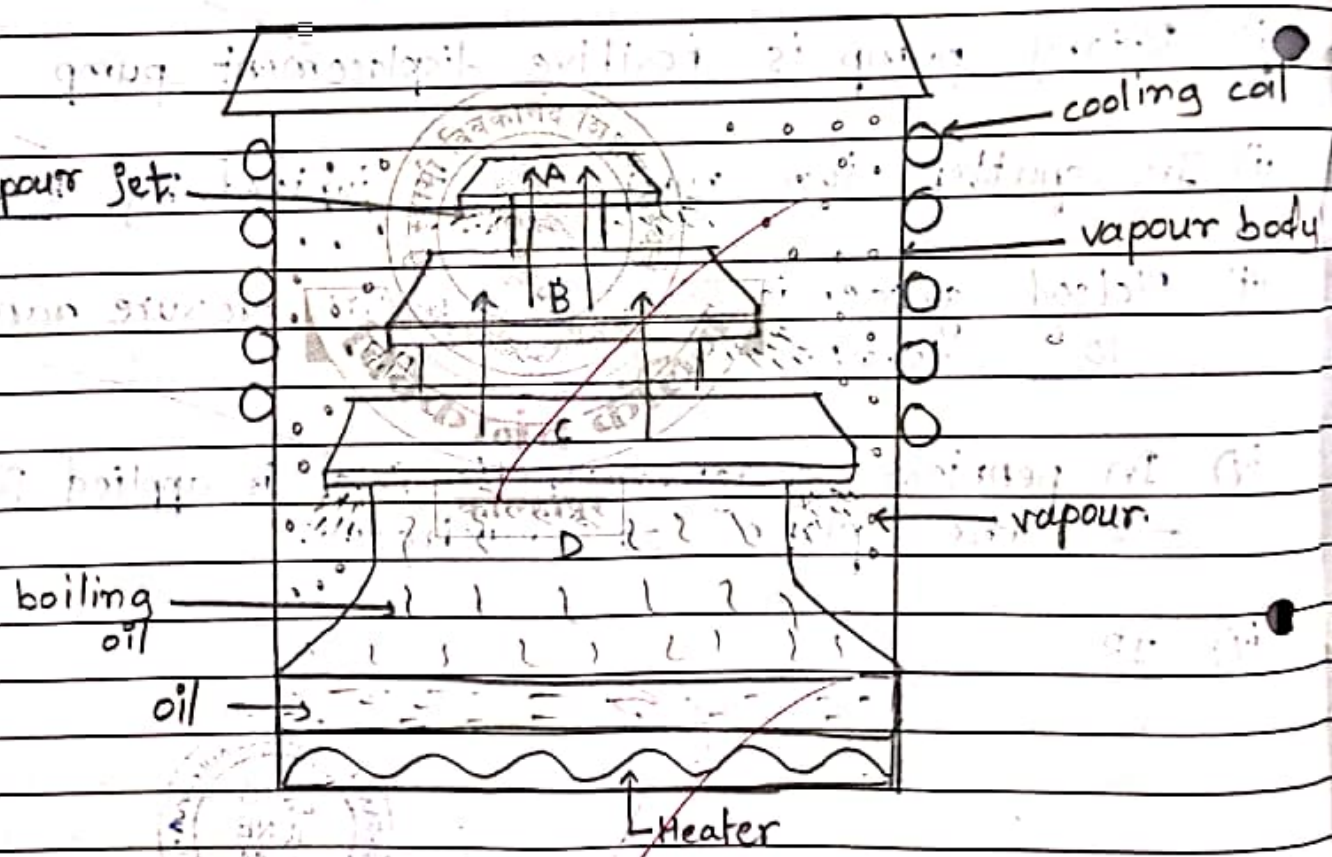
Q.2.

2) Diffusion and sputter ion pump.

a) Diffusion ion pump:

i) Diffusion ion pump is most commonly used in high vaccum processes to create high vaccum.

ii) It is used in ~~spectro~~ instrumented spectroscopy, anlytical intrumentation, research and development.



iii) Diffusion ion pump is highly effective vaccum producing pump which is also reactive in the presence of reactive gas.

iv) It is made up of stainless steel called as chamber.

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v) Inside of this chamber there are three cone shaped bodies are present which does not varry ~~by~~ in size by the pressure which is coming from the downward.

vi) The three cone shaped bodies are ~~stak~~ stacked on the lowest body.

vii) The very lowest body varry in size when there is increase in pressure.

viii) On the bottom of this chamber there is fixed beater which beats the oil above.

ix) This oil boils and converts into gaseous state

x) Vapour made up ~~of~~ because of the boiling oil gets hit on wall of the chamber and gets cooled ~~down~~ down due to presence of the water cooling coil ~~pre~~ on the wall

xi) Boiling oil goes upward in the cone shaped body and jet sprayed out of the body which are present on the bodies in the downward direction.

xii) ~~This p~~ This oil goes downward and process continues as before.

xiii) The pressure in here is almost 10^{-11} mbr.

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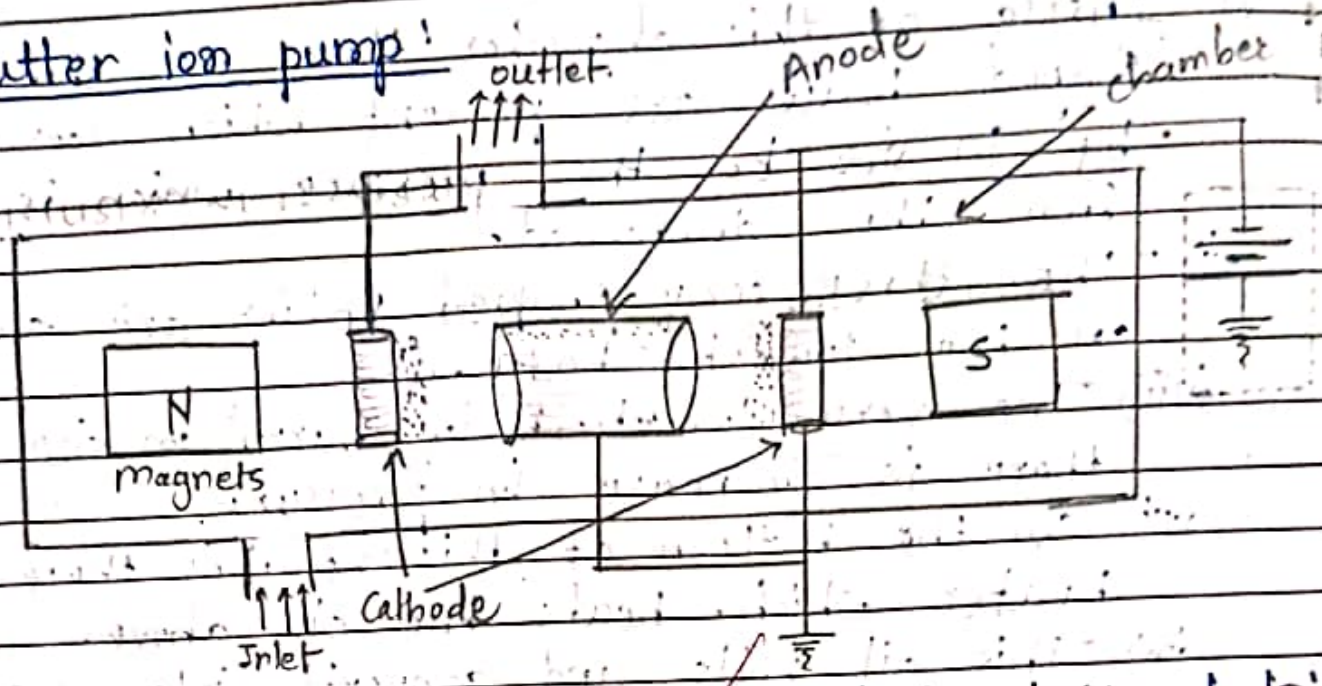
b) Sputter ion pump:



i) In sputter ion pump gas is ionized by both electric and magnetic field.

ii) In this, there are cathodes and anodes are present.

iii) ~~ca~~ Anode is madeup of stainless steel material and electric field flows the current along with axis of anode.

iv) Cathodes are positioned on the both sides of the anode and these are madeup of titanium material.

v) Current starts flowing due to electric field and ~~its~~ ~~dire~~ in the direction of helical trajectories.

vi) Due to magnets which are placed on the both side of the cathode magnetic field is produced.

vii) Electrons strats flowing due to these fields.

viii) positive and negative ions produced due to electric field.

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Department of Physics

M.Sc. Part-II SEM IV Internal Examination (2023-24)
Electronic Devices and Applications
Paper code: CP-1119D

Date: - 13/03/2024
Day: Wednesday

Time: - 12.00 pm- 1.00 pm
Mark: 20

Q.1 Select Correct Alternative: **(5)**

i) In common base configuration circuit, emitter-base junction is _____ biased & collector-emitter junction is _____ biased.

(a) reverse, forward (b) forward, reverse (c) forward, forward (d) none of these

ii) Input resistance of MOSFET is _____.

(a) low (b) high (c) constant (d) zero

iii) In PIN photo-detector p & n regions are separated by a very_____ n-doped intrinsic region.

(a) heavily (b) lightly (c) moderately (d) constantly

iv) Organic Light Emitting Diode works on the principle of _____

(a) luminescence (b) photo-luminescence (c) electro-luminescence (d) none of these

v) In magneto-optic effect linearly polarized light undergoes change in a plane by an angle _____.

(a) $\theta = BLV$ (b) $\theta = ELV$ (c) $\theta = ETV$ (d) $\theta = ETP$

Q.2 Attempt any one **(10)**

i) What is NPN transistor. Explain it with common base configuration.

ii) Explain P-N Junction solar cell in details.

Q.3 Attempt any one **(5)**

i) Show BJT's response to low and high frequency.

ii) Give brief account of photodetector.

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Electronic Devices and applications.

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SUPPLIMENT

Date: 13/03/2024

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Students Sign. :	
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क्र. No.

1) i) forward, reverse

ii) high

iii) lighting

iv) electro luminescence

v) $\theta = VBL$

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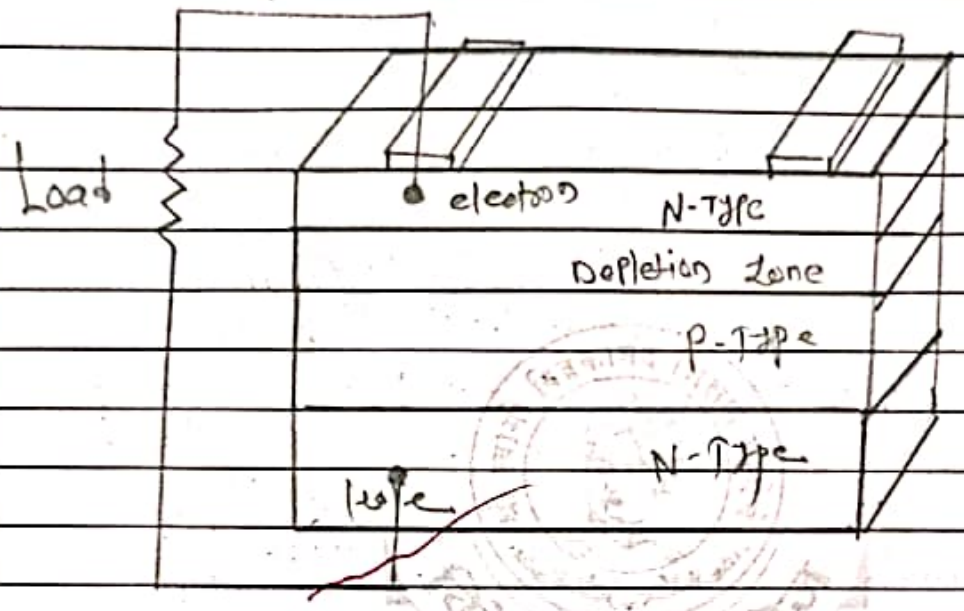
Section	Q. No.													
	Marks													

प्र. क्र.
Q. No. 2]

• P-N Junction Solar cell •



A P-N junction solar cell converts light energy in the electric energy through the photovoltaic effect. It utilize the structure with P-type semiconductor layer and n-type semiconductor layer, with junction between them.

When light hits the junction it creates hole-electron pair & produce electric field which generates voltage & current.

1) Structure:

• A solar cell typically consists of thin P-type semiconductor layer on the top of thicker n-type semiconductor layer.

- Electrodes are placed on the top and bottom surface to collect the current.

• Working Principle:

- When light enters p-n junction, it can be absorbed by semiconducting material.
- If the photon's energy is greater than bandgap of the semiconductor, it can excite an electron, creating hole-electron pair.
- The built-in electric field at the p-n junction separates these electron pairs
- electron move towards n-type region & holes move towards p-type region.
- This charge separation creates voltage & when connected to the external circuit, a current flows thereby producing electrical energy

• Components:

1) P-type semiconductor -
2) N-type semiconductor
3) Depletion region
4) Photovoltaic effect.
5) Quantum efficiency

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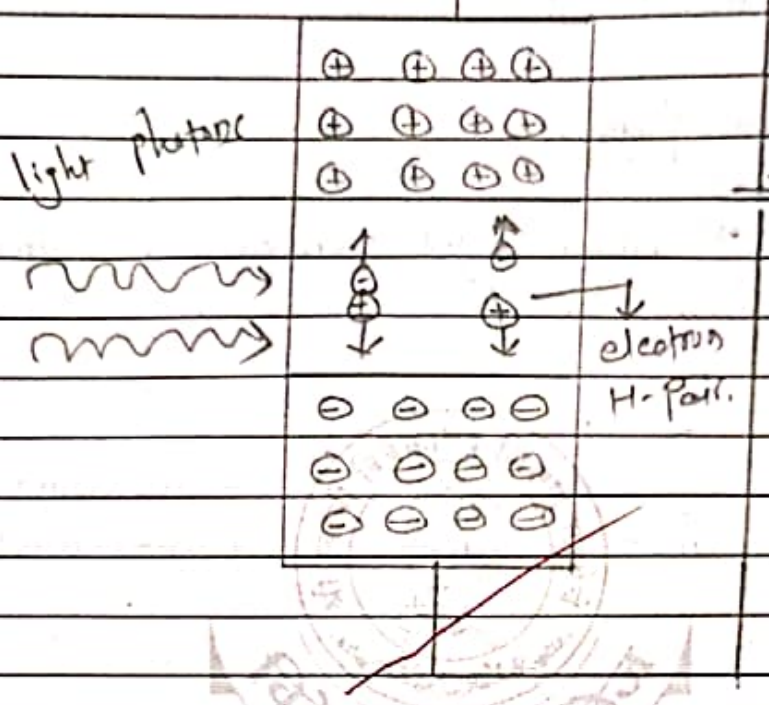
04 Section | Q. No. | Marks

प्र. क्र. Q. No. 3)

Photodetector.



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- Photo detector is a device which converts light signal into electrical signal.

- Types - a) PIN photo diode b) Avalanche Photo diode

05 * **Principle** : • electron-Hole pair created due to incident of light on 'i' region

• separated by external bias circuit result into photo current

* **Construction** : P & N type region by heavy doping created by rigde mat.

• i region is lightly doped

* **Working**

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- depletion layer created due to application of reverse bias voltage.
- Electron-Hole pair created in 'i' region due to absorption of photon.
- The mobile charges accelerated due to application of voltage
- photo current is directly proportional to photon energy.

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Date: 13/03/2025

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SUPPLIMENT

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Students Sign. :	
Seat No. :	1609
Seat No. in words :	
Suppliment No. :	
	47355
Centre :	Dept of Physics

· Electronic Devices & Applications

प्र. क्र.
Q. No.

(1)

1) forward & reverse
2) High
3) lighting
4) Electro-luminescence
5) $\theta = V/R$

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05

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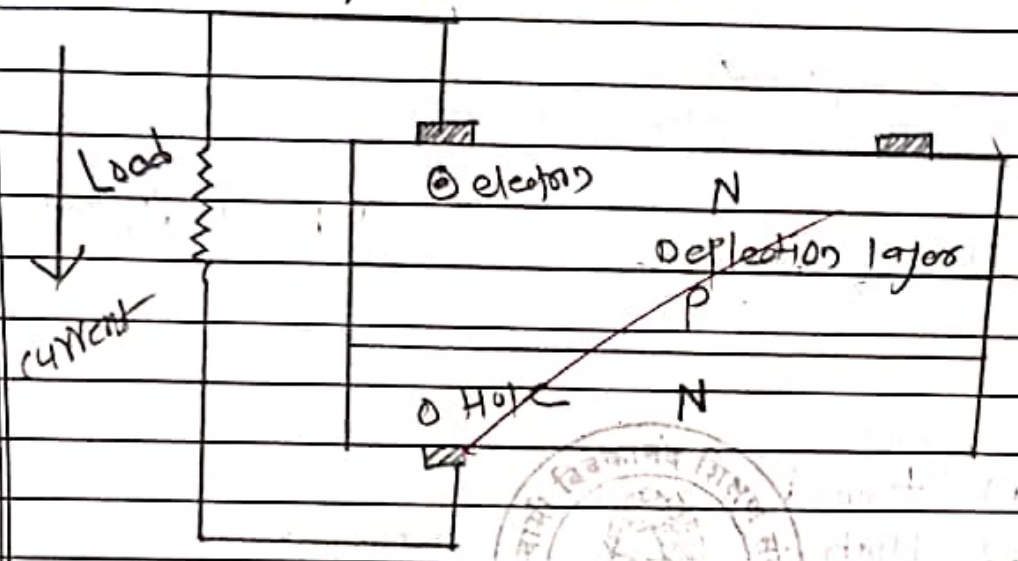
2 Section	Q. No.													
	Marks													

प्र. क्र.
Q. No.

(2) P-N junction solar cell :



- P-N junction solar cell mainly converts light energy into electrical energy.
- Works on photovoltaic effect.
- P-type layer separated from N-type layer by Depletion layer.
- light hits the junction & creates E-H pair & produces electric field which creates voltage & current.

Structure :

- It typically consist of P-type semiconducting layer on the top of N-type semiconducting layer.

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Q. No.														03
Marks														

- Electrodes are placed on the top & bottom surface to collect current.

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Working principle :-

- When light enters P-N junction, it can be absorbed by semiconducting material.

- If the photon energy is greater than bandgap of the semiconductor, it can excite an electron, creating hole-electron pair.

- The built-in electric field at the P-N junction separates these electron pairs.

- electron moves towards n-type region & holes moves towards P-type region

- So charge separation created voltage & when connected to the external applied voltage & current flows so finally we get ~~photon energy~~ electrical energy.

10

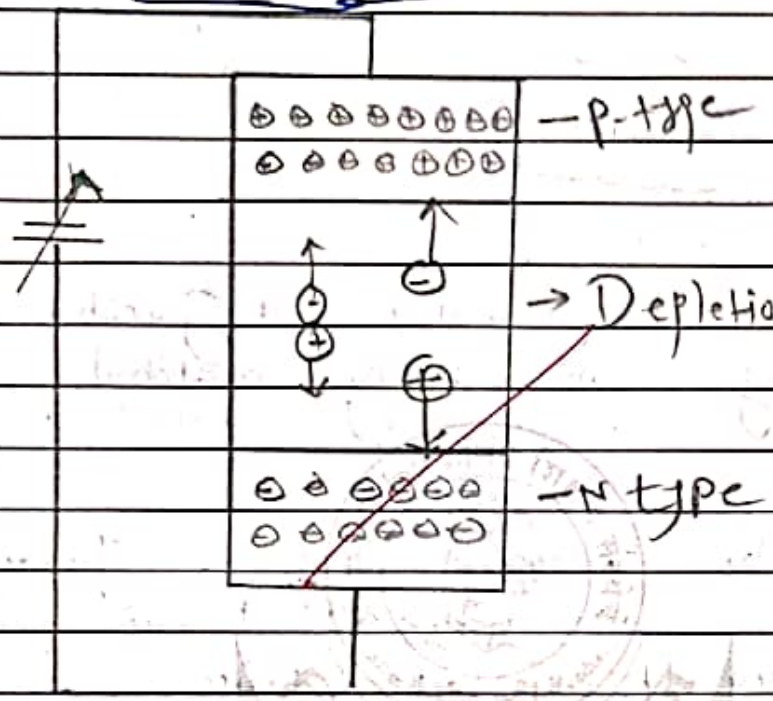
Components :

i) P-type semiconductor
ii) N-type semiconductor
iii) Depletion layer
iv) Photovoltaic effect
v) Quantum efficiency

4 Section	Q. No.												
	Marks												

प्र. क्र. Q. No. (3)

Photo-detector



Basic It is a device which converts photo electrical energy into electrical energy.

The main types of the photodetector are
1) PIN Photo diode
2) Avalanche photo diode

Principle: when light incident on i- region it creates E-H pair in that region.

· They are separated from each other by applying ext. field and which result in generation of Photo current

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SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	
Seat No. :	169.
Seat No. in words :	
Suppliment No. :	1
	47356
Centre	

प्र. क्र.
Q. No.

· Construction

· In this device P type semiconductor is separated by N-type by lightly dopped intrinsic layer.
· These semiconducting materials are Ge & Si.

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Working

· When we apply reverse bias voltage depletion layer is created in intrinsic layer.

· When photons are incident on i region E-H pairs created in i region.

· and these pair are separated & accelerated by ext. applied voltage.

· photo current is directly proportional to incident photon energy

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Department of Physics

M.Sc. Part-II SEM IV Internal Examination (2023-24)

Paper- Electronic Devices and Applications

Day: - Wednesday

Date: - 13/03/2024

Time: - 12.00 pm- 01.00 pm

Total Marks:20

Attendance

Sr. No.	Name of the students	Sign
1	Jarkoli Amit Kallappa	
2	Anand N. Biradar	
3	Shivraj C. Kavatagi	
4	Gnehal. N. Ahiwale	
5	Shruti Harish Bam	
6	Rajshree mahesh Randive	
7	Shivani Dattatraj Sagar	
8	Pranali Pradeep Shirke	
9	Sweta Sardar mithari	
10	Dnyaneshwari P. Patkar	
11		
12		
13		
14		
15		

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Department of Physics

M.Sc. Part-II SEM IV
Internal Examination 2023-24
Solid State Physics-III
Physical Properties Of Solids

Date: 14/03/2024
Day: Thursday

Total Marks: 20
Time: 12:00-1:00pm

Instructions:

1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Use of log table and calculator is allowed.

Q.1 Select correct alternative **(2)**

1. In lattice vibration heat is generated called ----------.
   (a) Photons (b) Polarons (c) Plasmons (d) Phonons

2. The transverse electromagnetic wave propagates with phase velocity when ----------.
   (a) $\varepsilon < 0$ (b) ε = complex (c) $\varepsilon > 0$ (d) $\varepsilon = \infty$

Q.2 Short Answer Question (Any one) **(06)**

1. What is Group velocity and phase velocity?
2. What is transverse optical mode in plasmons?

Q.2 Long Answer Question (Any one) **(12)**

1. What is vibrational motion? And Derive expression of monoatomic lattice also 1st Brillouin zone.
2. Discuss dielectric function of an electron gas.

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VIVEKANAND COLLEGE, KOLHAPUR.
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प्र. क्र.
Q. No.

Q1.

1. d) Phonons

2. a) $\epsilon < 0$

Q.2.

Vibrational Motion:- (अधिकारप्रदत्त स्वायत्त)

The particle is in the motion & when it will propogate from mean to extreme position & back to extreme is called vibrational motion.

OR

The to & fro motion of the particle is called as vibrational motion. will happens when the particle at rest gain external energy & its velocity gets increased. it perform to & fro motion

Monoatomic lattice—

When ~~at the~~ only one atomic model is present in definite structure it is called as monoatomic lattice.

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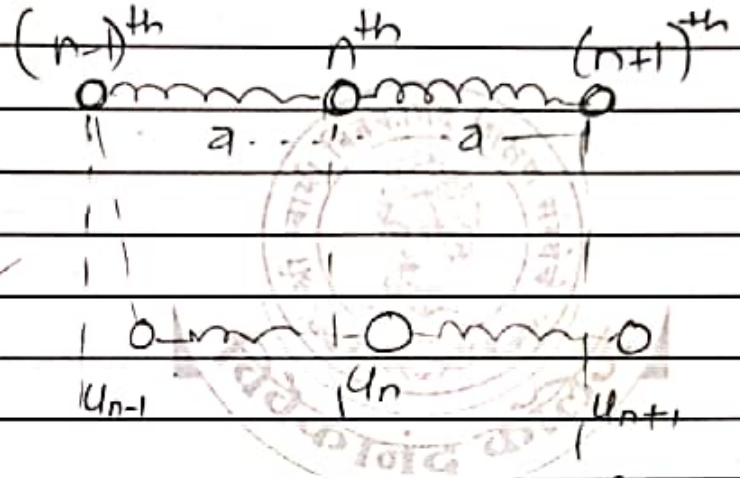
There are some assumptions & conditions are present -

1) All particles have same mass & they are identical.
2) All are situated at same distance.
3) They only performes linear vibrational motion.
4) they only interact between nearby particles.
5) Are attached by imaginary spring structure.



All partical - performing vibrational motion.
& are displacing by u_n, u_{n+1}, u_{n+1} distance

distance betn them is a.

As we know
force = mass × displacement
let C_p force constant.
for $(n+1)^{th}$ particle
$\therefore \quad F_1 = -C_p(u_n - u_{n+1})$
& for $(n-1)^{th}$ particle

$F_2 = -C_p(u_n - u_{n-1})$

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Net force is given by –

$$F = f_1 + f_2$$

$$F = -C_p(u_n - u_{n+1}) - C_p(u_n - u_{n-1})$$

$$= C_p(-u_n + u_{n+1} - u_n + u_{n-1})$$

$$F = C_p(u_{n+1} - 2u_n + u_{n-1}) \quad \text{—(1)}$$

As we know. $u_n = u_0 e^{i(\omega t - kna)}$ —(2)

for $u_{n+1} = u_0 e^{i(\omega t - k(n+1)a)}$

$$= u_0 e^{i\omega t - ikna - iak} \quad \text{—(3)}$$

$$u_{n-1} = u_0 e^{i(\omega t - k(n-1)a)}$$

$$= u_0 e^{i\omega t - ikna + iak} \quad \text{—(4)}$$

putting above eqn (2), (3) (4) in eqn no. (1)

$$F = C_p\left(u_0 e^{i\omega t - ikna - iak} - 2u_0 e^{i(\omega t - kna)} + u_0 e^{i(\omega t - kna)}\right)$$

on differenciating $\frac{d^2u_n}{dt} = -\omega^2$ as acc^n 'a' $\therefore F = ma = -m\omega^2$

$$-m\omega^2 = C_p\left(e^{-iak} - 2 + e^{+iak}\right)$$

this equating with

$$(a-b)^2 = a^2 - 2ab + b^2$$

$$= C_p\left(e^{\frac{iakx2}{2}} - 2(e^{-ika} \cdot e^{ika}) + e^{\frac{-iakx2}{2}}\right)$$

as we know ~~as~~ sine formula

$$= C_p\left(e^{\frac{ika}{2}} - e^{-\frac{ika}{2}}\right)^2$$

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$$\sin\theta = \frac{e^{i\frac{ka}{2}} - e^{-i\frac{ka}{2}}}{2i}$$

let $\theta = \frac{ka}{2}$

$\therefore$ we get

$$-m\omega^2 = C_p\left(2i\sin\frac{ka}{2}\right)^2$$

$$-m\omega^2 = C_p\left(4i^2\sin^2\frac{ka}{2}\right)$$

$$-m\omega^2 = C_p\, 4(-1)\sin^2\frac{ka}{2}$$

$$m\omega^2 = 4C_p\sin^2\frac{ka}{2}$$

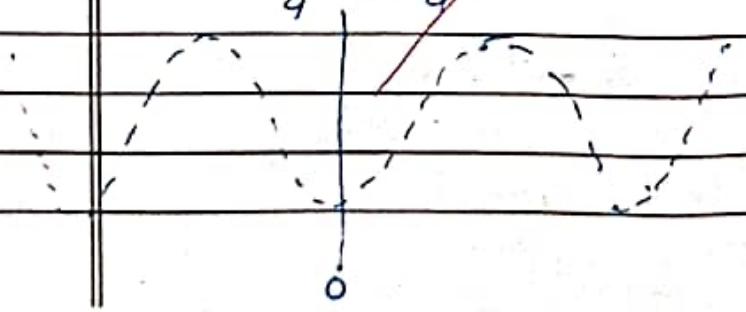
$$\omega^2 = \frac{4C_p}{m}\sin^2\frac{ka}{2}$$

$$\therefore \boxed{\omega = 2\sqrt{\frac{C_p}{m}}\sin\frac{ka}{2}}$$

1st Brillioun zone -

It is reciprocal zone of size -
It is located bet

$-\frac{\pi}{a}$ & $\frac{\pi}{a}$, as sin



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– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

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Q.2. Group velocity & phase velocity.

Phase velocity: (V_p)

The velocity of single particle in phase is called as phase velocity.

It is restricted upto only a particle.

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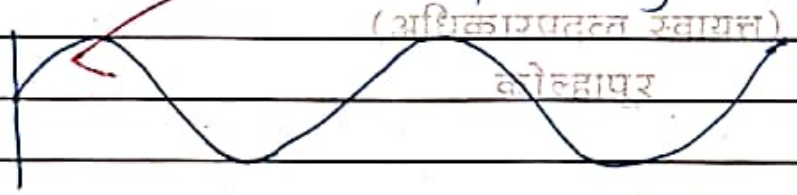

V = wavelength × freq.

$V = \lambda \times \nu$

$V_p = \frac{\omega}{K}$

as we know,

$\omega = 2\sqrt{\frac{C_p}{m}} \sin\frac{ka}{2}$ is angular velocity of monoatomic lattice.

as we know $\omega = \frac{2\pi}{T}$ & $V = \omega r$

$\left(\frac{V}{r}\right)$

$V = \omega r = 2\sqrt{\frac{C_p}{m}} \sin\frac{ka}{2} \times a$

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Group velocity: (V_g)

It is complete compilation of group i.e. net or complete velocity of wave packet.

$$V_g = \frac{d\omega}{dk} = \frac{\omega_2 - \omega_1}{k}$$

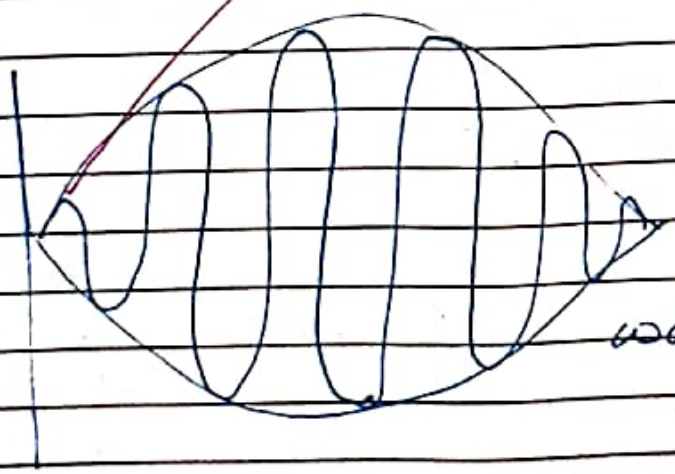
It is summation of all the phase velocities present over there.

as $\omega = 2\sqrt{\frac{C_p}{m}} \sin\frac{ka}{2}$

$$\therefore \frac{d\omega}{dk} = -2\sqrt{\frac{C_p}{m}} \cdot \cos\frac{ka}{2} \cdot a$$

$$V_g = -2a\sqrt{\frac{C_p}{m}} \cos\frac{ka}{2}$$

this is nothing but group velocity of wave.



wave packet

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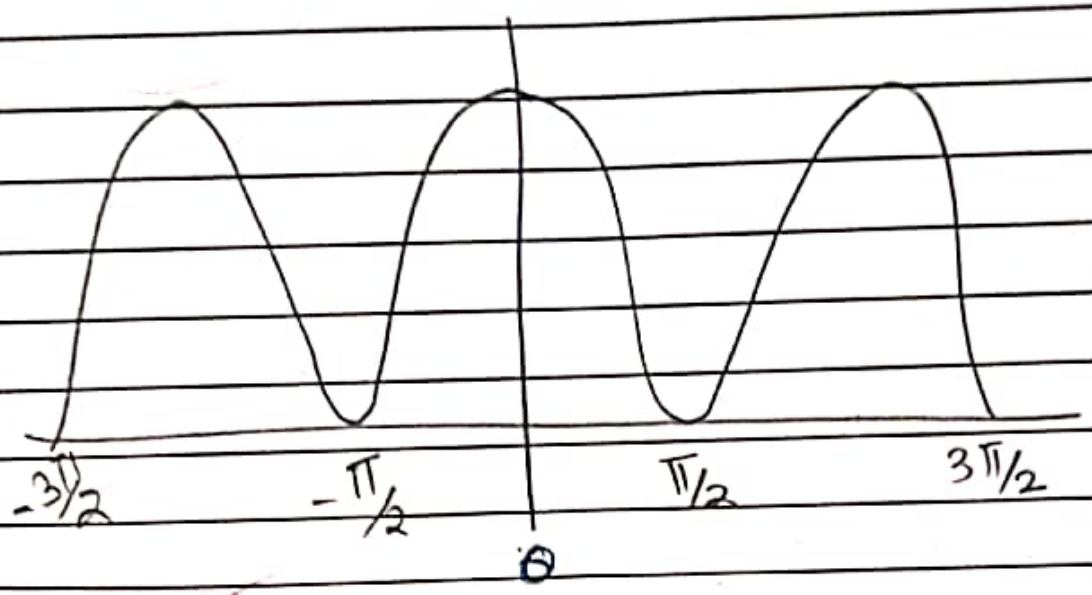

Group velocity.

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क्र. No. 1.

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→ d) Phonons.

2.

→ a) $\varepsilon < 0$.

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3.

1.

Vibrational motion –

When the particle is in the motion and then the particle changes is position from its original by vibrating by applied force it is called vibrational motion.

Monoatomic lattice –

In this vibrational motion only one atom ~~take~~ type of atom take for system. i.e. single type of atom is taken. all the particles is are of that single type i.e. its called mono atomic lattice.

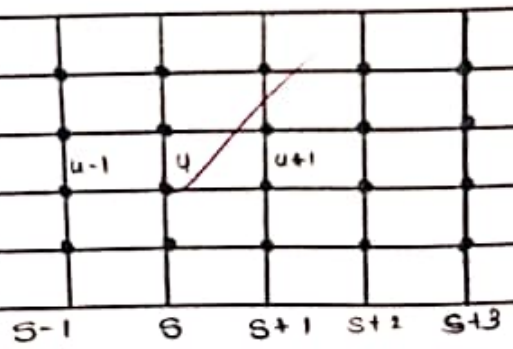

fig. (a) when particle is in original position

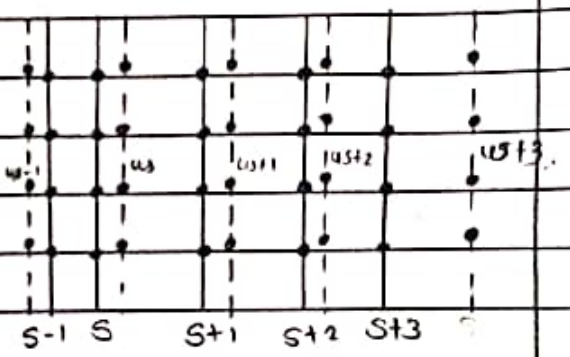

fig. (a). Position of portical after vibration. solid lines are original position & dotted line particle are after vibration.

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In monoatomic lattice vibrational motion the single particle is taken.

~~The total energy of system is taken as,~~

In. fig (b). The line represent by s is original particle position and dotted line particle is after the vibration i.e. s+p.

The total energy of system is taken as,

$$F_s = \sum_p c_p \left(u_{s+p} - u_s \right) \quad \text{——} \quad (1)$$

where, c_p = force constant in Hooks law,

Now, ~~pla~~ motion plane,

$$M \frac{d^2 u_s}{dt^2} = \sum_p c_p \left[u_{s+p} - u_s \right] \quad \text{——} \quad (2)$$

$$u_s = u(0)\, e^{i(sKa - \omega t)} \quad \text{——} \quad (3)$$

$$u_{s+p} = u(0)\, e^{i(s+p)(Ka - \omega t)} \quad \text{——} \quad (4)$$

differentiate eqn (3) w.r.t. t.

$$\frac{d^2 u_s}{dt^2} = u(0)\, e^{i(sKa - \omega t)} \cdot i\omega$$

again differentiate.

$$\frac{d^2 u_s}{dt^2} = u(0)\, e^{i(sKa - \omega t)} \cdot -\omega \quad \text{——} \quad (5)$$

put eqn (5) in eqn (2),

$$-M\omega u(0)\, e^{i(sKa - \omega t)} = \sum_p c_p \left[u_{s+p} - u_s \right] \quad \text{——} \quad (6)$$

put values of u_{s+p} & u_s from eqn (3) & (4)

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$$-M\omega u_0 e^{i(sKa-\omega t)} = \sum_p c_p \left[u_0 e^{i(s+p)(Ka-\omega t)} - u_0 e^{i(sKa-\omega t)} \right]$$

$$-M\omega \cancel{u_0 e^{i(sKa-\omega t)}} = \sum_p c_p \left[\cancel{u_0 e^{i(sKa-\omega t)}} - e^{ipKa} - 1 \right]$$

$$-M\omega = \sum_p c_p \left[e^{ipKa} + e^{-ipKa} - 2 \right]$$

$$M\omega = -\sum_p c_p \left[e^{ipKa} + e^{-ipKa} - 2 \right]$$

But,

$$\cos pKa = \frac{e^{ipKa} + e^{-ipKa}}{2}$$

$$\therefore \quad M\omega = -\sum_p c_p \left[\cos pKa - 2 \right]$$

Now,

For s is greater,

$$M\omega = -\sum_{p>0} c_p \left[\cos pKa - 2 \right]$$

$$\omega = \frac{2}{M} - \sum_{p>0} c_p \left[\cos pKa - 2 \right]$$

as $-\omega^2 = \dfrac{d^2 u}{dt^2}$

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by equating above equation

$$-m\omega^2 = c_p\left(2i\sin\frac{ka}{2}\right)^2$$

$$-m\omega^2 = c_p\, 4i\sin^2\frac{ka}{2}$$

$$-m\omega^2 = 4c_p\sin^2\frac{ka}{2}$$

$$\omega^2 = \frac{4c_p}{m}\sin^2\frac{ka}{2}$$

$$\omega = 2\sqrt{\frac{c_p}{m}}\sin\frac{ka}{2}$$

This is the dispersion relation for monoatomic lattice.

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प्र. क्र. Q. No. 2.

1. Group Velocity & Phase Velocity.

→

$$v_p = \frac{\omega}{k} \qquad v_p = \frac{d\omega}{dk}$$

$$\omega = \left(\frac{4C1}{M}\right)^{1/2} \sin ka$$

$$\omega = 2\left(\frac{C1}{M}\right)^{1/2} \frac{\sin ka}{2}$$

$$\sin ka = \frac{2}{M} \qquad C1 = \frac{1}{4}$$

$$V_g = \frac{1}{dk}\left[4\frac{C}{M}\right] \cancel{\cos\frac{ka}{2}} \frac{a}{2}$$

$$V_g = 2\left(\frac{C}{M}\right)^{1/2} \cos\frac{ka}{2} \frac{a}{2}$$

$$V_g = 2\left(\frac{C}{M}\right) \cos$$

05

$$k = \frac{\pi}{a}$$

$$\cos\frac{\pi}{a} \cdot \frac{a}{2} \qquad \cos\frac{\pi}{2} = 0$$

$V_g = 0$ at the edge of zone.

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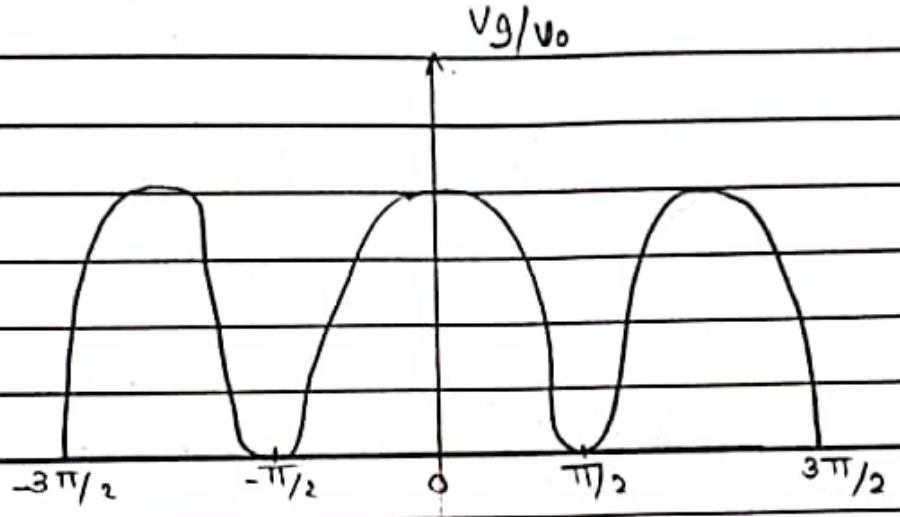

Fig. Graph of phase and group velocity.

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1	D] Phonons
2	A] E < 0

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2 1) Group velocity and Phase velocity :-

The velocity of wave packed called in called group velocity

we know that

$$\frac{d\omega}{dk} = 2\left[\frac{C_1}{m}\right]^{1/2} \frac{\sin ka}{2}$$

$$\frac{d\omega}{dk} = V_g \left(\frac{C_1}{m}\right)^{1/2} \frac{\cos ka}{2} \quad a \quad \frac{d\omega}{dk^{1/2}}$$

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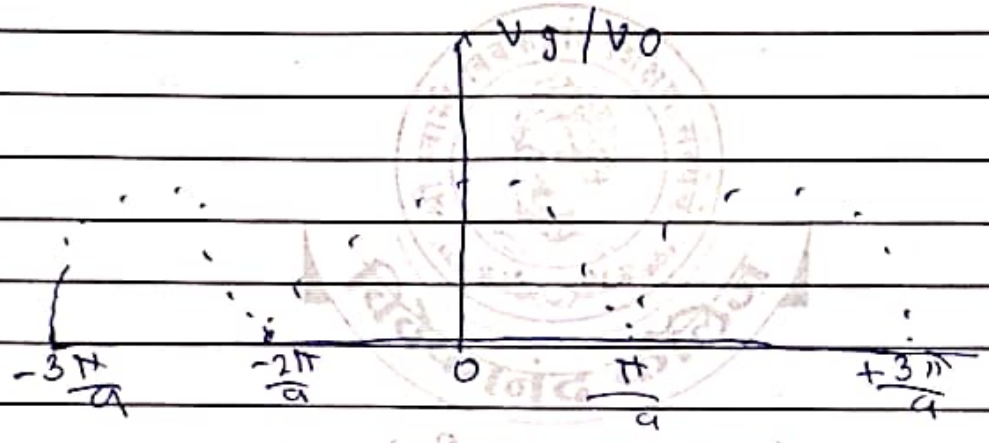
$$V_g = \frac{d\omega}{dk} = a\left(\frac{C_1}{m}\right)^{1/2} \cos\frac{ka}{2}$$

If $k = \pm\frac{\pi}{a}$ then $\cos \pm\frac{\pi}{a}\cdot\frac{a}{2} = \cos$

$V_g = 0$ at edge of zone



Thus, It is called Group velocity and Phase velocity.

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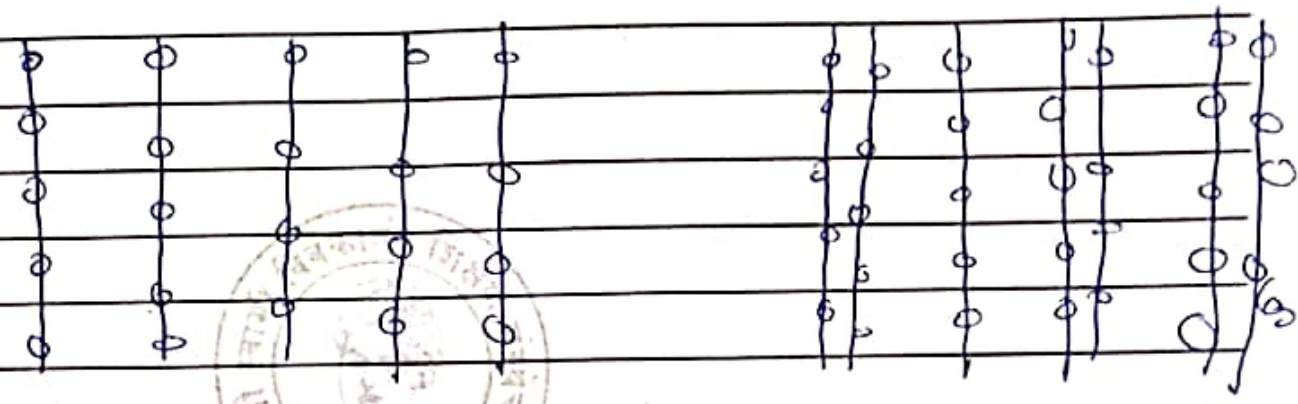
17 Vibrational motion :-

When any atom is exted by external fake or heat energy it begins to vibrate about its mean position and this motion is called as vibrational motion.

Expression for monoatomic lattice :-

consider some dimensional problem and also suppose that all planes of atoms are identical.



we assume that force on the plane labbled because of displacment of plane labbled so the force on plane 's' is given by

$$F_0 = \sum_p C_p (u_{s+p} - u_s) \quad \text{--- (1)}$$

This eqn. is linear in displacment used it.

$$M \frac{d^2 u_2}{dt^2} = \sum_p C_p (u_{s+p} - u_s) \quad \text{--- (2)}$$

The solutions of eqn (2) is

$$u_s = u_0(0) \, e^{i[sKa - \omega t]} \quad \text{--- (3)}$$

$$\therefore u_{s+p} (u_0(0) \, e^{i(s+p)Ka - \omega t} \quad \text{--- (4)}$$

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Diff. equation

$$\frac{du_s}{dt} = u(0)\, e^{i(ska - \omega t)}$$

Again diff.

$$\frac{d^2u_s}{dt^2} = u(0)\, e^{i(ska - \omega t)}\,(i\omega^2)$$

$$\frac{d^2u_s}{dt^2} = -u(0)\, e^{i(ska - \omega t)} \cdot \omega^2 \quad \text{--- (8)}$$

$$\therefore \quad M\frac{d^2u_s}{dt^2} = \sum_p C_p\,(u_{s+p} - u_s)$$

$$\therefore \quad -M\omega^2\, u(0)\, e^{i(ska - \omega t)} = \sum_p C_p\,(u_{s+p} - u_s)$$

$$\therefore \quad -M\omega^2 = \sum_p C_p\,[e^{ipka} - 1]$$

$$F = C[u_s + 1 - u_s] + C[u_s - 1 - u_s]$$

$$C[u_s + u_s - p - 2u_s]$$

For plane greater than S

$$\therefore \quad M\omega^2 = -\sum_{p>0} C_p\,[e^{ipka} + e^{-ipka} - 2]$$

but we know

$$\cos pka = \frac{e^{ipka} + e^{-pka}}{2}$$

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$$\therefore \omega^2 = \frac{2}{M} \sum_{p=0} C_p \left[1 - \cos pKa\right] \quad \text{--- (6)}$$

For 1st Plane

$$\omega^2 = \frac{4C_1 \sin^2 Ka}{2m}$$

$$\boxed{\omega = \left(\frac{2C_1}{m}\right)^{1/2} \sin\left(\frac{Ka}{2}\right)}$$

1st Brillouin zone :-

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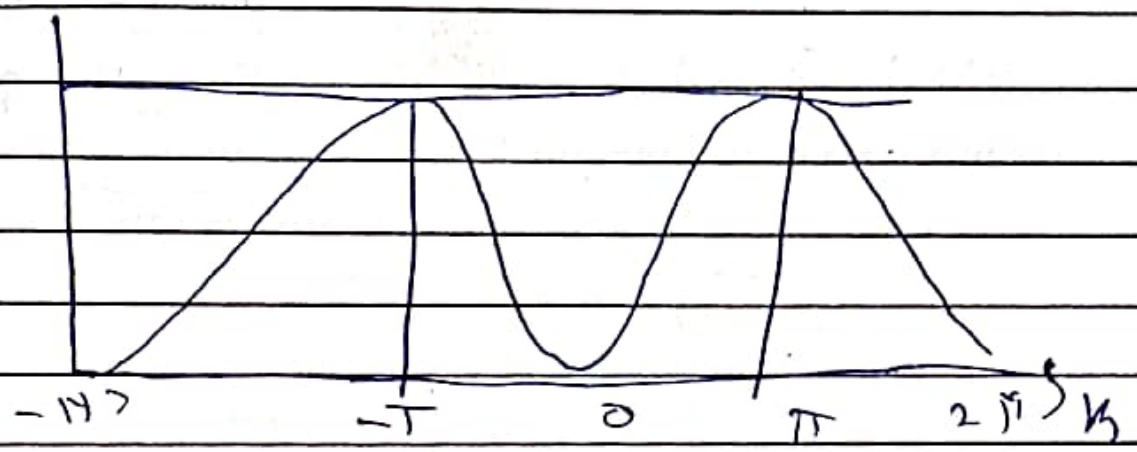

$$\omega = 2\sqrt{\frac{C}{m}}\sin\frac{ka}{2}$$

$$2\pi\nu = 2\sqrt{\frac{C}{m}}\sin\frac{ka}{2}$$

$$\nu = \frac{1}{\pi}\sqrt{\frac{C}{m}}\sin\frac{ka}{2} \qquad \frac{\pi a}{\lambda a}$$

$$\therefore \nu_{max} = \frac{1}{\pi}\sqrt{\frac{C}{m}}$$

Now relation displacement of two phases

$$\frac{u_{s+p+1}}{u_{s+p}} = \frac{u_0\, e^{i(k(s+p+1)a - \omega t)}}{u_0\, e^{i(k(s+p)a - \omega t)}}$$

$$\frac{u_{s+p+1}}{u_{s+p}} = e^{i(ka)} \quad \text{— (8)}$$

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we know that

$$-\pi < ka < \pi$$

$$-\frac{\pi}{a} < k < \frac{\pi}{a}$$

$$k_{max} = \pm\frac{\pi}{a}$$

so,

$$\frac{u_{s+p+1}}{u_{s+p}} = e^{ika}$$

But $k' = k - \frac{2\pi n}{a}$

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ka = कोशवर $- 2\pi n$

$$\therefore \frac{u_{s+p-1}}{u_{s+p}} = e^{2\pi n i} e^{ika}$$

Now Bragg's reflection condition

$$2d\sin\theta = n\lambda$$

$\theta = \pi/2$ $\quad d = a \quad k = \frac{2\pi}{a} n$ $\quad n = 1$

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$$2 \times a \times \sin \pi/2 = \frac{2\pi}{n} \times 1$$

$$\therefore \quad 2a = \lambda$$

$$\boxed{\therefore \quad \lambda = 2a}$$

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-Shikshanmaharshi Dr. Bapuji Salunkhe

Shri Swami Vivekanand Shikshan Sanstha, Kolhapur

Vivekanand College, Kolhapur (Empowered Autonomous)

Department of Physics

M.Sc. Part-II SEM IV Internal Examination (2023-24)

Paper- Solid State Physics-III

Day: - 14/03/2024 / Thursday

Date: - 14/03/2024

Time: - 12.00 pm- 01.00 pm

Total Marks:20

Attendance

Sr. No.	Name of the students	Sign
1	Shrusti Harish Jam	
2	Rajshree mahesh Randive	
3	shivani Dattatreyi Sagar	
4	Pranali Pradeep Shirke	
5	Gauri Sudar Mathani	
6	Dnyaneshwari P. Todalkar	
7	Snehal. N. Ahivale	
8	Anand N. Biradar	
9	Jaradi Sunil Kallappa	
10	shivraj c. Kavtagi	
11		
12		
13		
14		
15		

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Vivekanand College, Kolhapur (Empowered Autonomous).

Department of Physics

M.Sc. Part-II SEM IV
Internal Examination
Solid State Physics IV
Energy Conservation and storage devices

Date: 15/03/2024 Total Marks: 20
Day: Friday Time: 12:00-1:00pm

Instructions:

1) All questions are compulsory.
2) Figures to the right indicate full marks.
3) Use of log table and calculator is allowed.

Q.1 Select correct alternative **(2)**

1. In lattice vibration heat is generated called ----------.
   (a) Photons (b) Polarons (c) Plasmons (d) Phonons

2. The transverse electromagnetic wave propagates with phase velocity when ----------.
   (a) $\varepsilon < 0$ (b) ε = complex (c) $\varepsilon > 0$ (d) $\varepsilon = \infty$

Q.2 Short Answer Question (Any one) **(06)**

1. What is Group velocity and phase velocity?
2. What is transverse optical mode in plasmons?

Q.2 Long Answer Question (Any one) **(12)**

1. What is vibrational motion? And Derive expression of monoatomic lattice also 1st Brillouin zone.
2. Discuss dielectric function of an electron gas.

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Date: 15/03/2024

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥

– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

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SUPPLIMENT

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Suppliment No. :	—
	47349
Centre	Dept- of Physics

Energy conservation and storage devices.

प्र. क्र.
Q. No.

Q.1) Select Correct alternative

i) Phonons

ii) $E<0$

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Q. No.												
Marks												

(Q.2)

1) Group Velocity and Phase velocity

A) Group velocity :

It is the speed at which a specific phase of a wave travels.

B) Phase velocity :

The velocity at which phase of wave travels is called phase velocity.

Group & Phase velocity relation :

$$V_g = V_p + k \cdot \frac{dV_p}{dk}$$

V_g : group velocity

V_p : phase velocity

k - angular wave number

group velocity is directly proportional to the phase velocity

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· when group velocity increases, proportionally phase velocity is also increases & vice versa.

· Equation of phase velocity

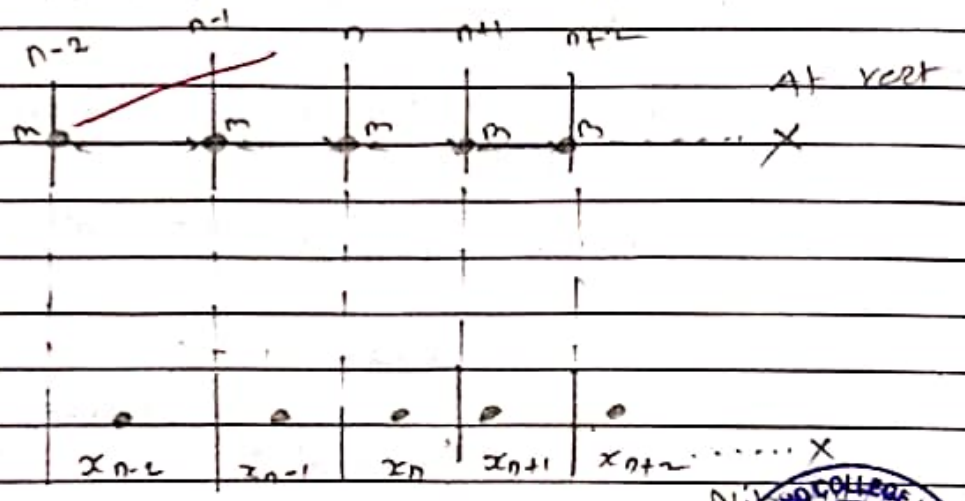
$$V_p = \frac{\omega}{k}$$

Similarly $V_g = \frac{d\omega}{dk}$

$$\boxed{\therefore \; V_g = V_p + K \cdot \frac{dV_p}{dk}}$$

D5

Q.2) Vibrational motion : vibration of atoms, molecules, lattice about its mean position after equal interval of time



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Section	Q. No.													
	Marks													

प्र. क्र.
Q. No.

Let us consider one dimentional infinite mono atomic lattice with atoms at rest. Let 'a' be the interatomic spacing. Let m be the mass of the each atom.

— In this case force of interaction will be betn neighbouring atoms only & also Hooke's law is followed.

Let us suppose a wave propagated along x direction of a monoatomic lattice

~~Under~~

Force of interaction on one atom due to another atom is directly proportional to the diff. of their displacement & is given as,

$$F = \beta(x_{n+1} - x_n) - \beta(x_n - x_{n-1})$$

$$F = \beta(x_{n+1} - x_n - x_n + x_{n-1})$$

$$m \cdot \frac{d^2x_n}{dt^2} = \beta(x_{n+1} + x_{n-1} - 2x_n) \quad \text{——— (1)}$$

let $x_n = A e^{i(\omega t - kna)}$

where $na = x$

$$\therefore \frac{dx_n}{dt} = A e^{i(\omega t - kna)} \, i\omega \quad \text{——— (2)}$$

diff. w.r.t t we get

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$$\frac{d^2 x_n}{dt^2} = -A\omega^2 e^{i(\omega t - kna)}$$

$$x_{n+1} = A e^{i[\omega t - k(n+1)a]} \quad \text{—(a)}$$

$$= x_n e^{-ika}$$

$$\text{—(b)}$$

$$\text{Sub. } x_{n-1} = x_n e^{ika}$$

Sub. above eqn in (1) we get,

$$-m\omega^2 A e^{i(\omega t - kna)} = P\left(x_n e^{+ika} + x_n e^{-ika} - 2x_n\right)$$

$$-m\omega^2 x_n = P x_n \left(e^{ika} + e^{-ika} - 2\right)$$

$$\therefore -m\omega^2 = P\left[2\cos ka - 2\right]$$

$$= \frac{2P}{m}\left[1 - \cos ka\right]$$

$$\omega^2 = \frac{2P}{m}\left[2\sin^2 \frac{ka}{2}\right]$$

$$\boxed{\therefore \omega = 2\sqrt{\frac{P}{m}}\,\sin\left(\frac{ka}{2}\right)} \quad \text{—(2)}$$

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Energy Conservation and Storage basics

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SUPPLIMENT

Date: 15/03/2024

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Centre	

प्र. क्र.
Q. No.

Q.1) Select correct alternative

i) phonons 1

ii) E/0 1

02

(अधिकारप्रदत्त स्वायत्त)
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Q. No.												
Marks												

* Group Velocity & phase velocity *

- **Phase velocity :**

  denoted by v_p

  - ration of angular frequency ω to $k = \frac{\omega}{k}$
  - velocity of phases of wave in a medium

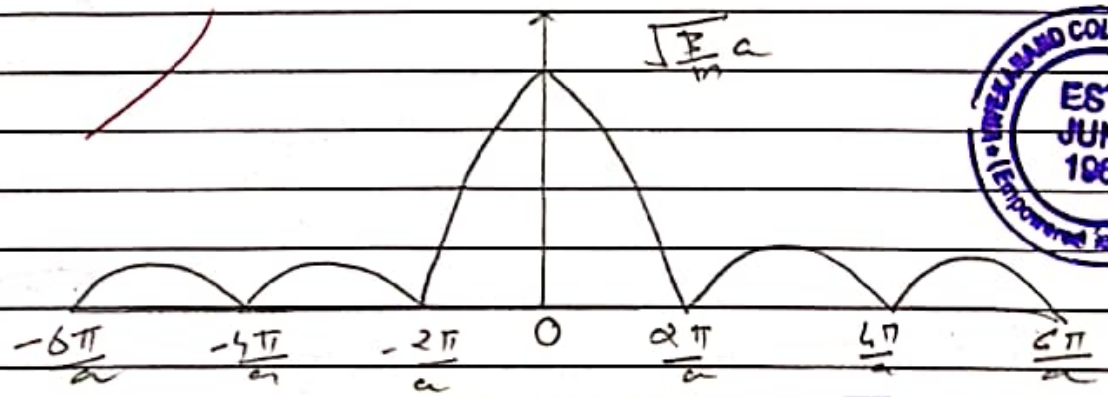
$$\therefore v_p = \frac{\omega}{k}$$

$$\therefore v_p = \frac{2\sqrt{\frac{T}{m}} \cdot \frac{ka}{2}}{k}$$

$$\therefore v_p = \sqrt{\frac{T}{m}}\, a = \text{constant}$$

$$c = \frac{T}{2}$$

It is a function of propagation constant



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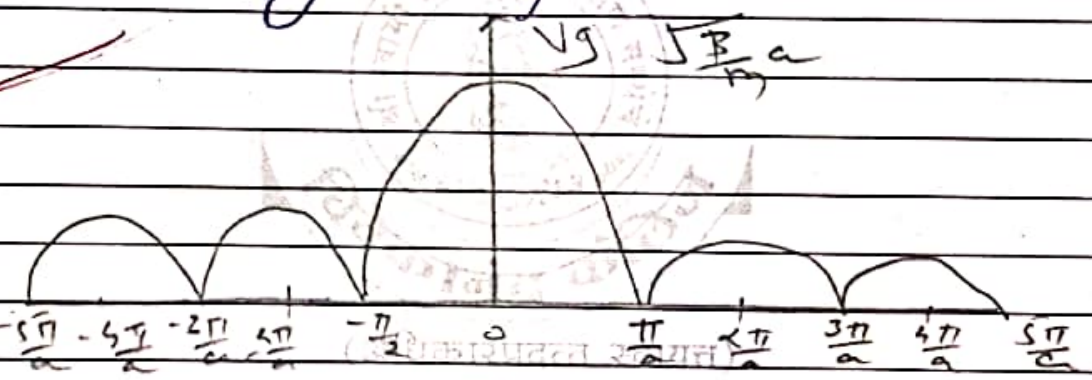
$$\boxed{\therefore v_p = \frac{dz}{dt} = \frac{\omega}{k}}$$

Group Velocity :

- denoted by V_g
- ration of $\frac{d\omega}{dk}$

- It is a maximum amplitude velocity of group of waves with diff. frequencies.

group velocity is function of k.



$$\therefore V_g = \frac{d\omega}{dk} = \frac{d}{dk}\left(2\sqrt{\frac{T}{m}} \sin \frac{ka}{2}\right)$$

$$\therefore V_g = \sqrt{\frac{T}{m}}\, a$$

$$\boxed{\therefore V_g = \sqrt{\frac{T}{m}}\, a = \text{constant}}$$

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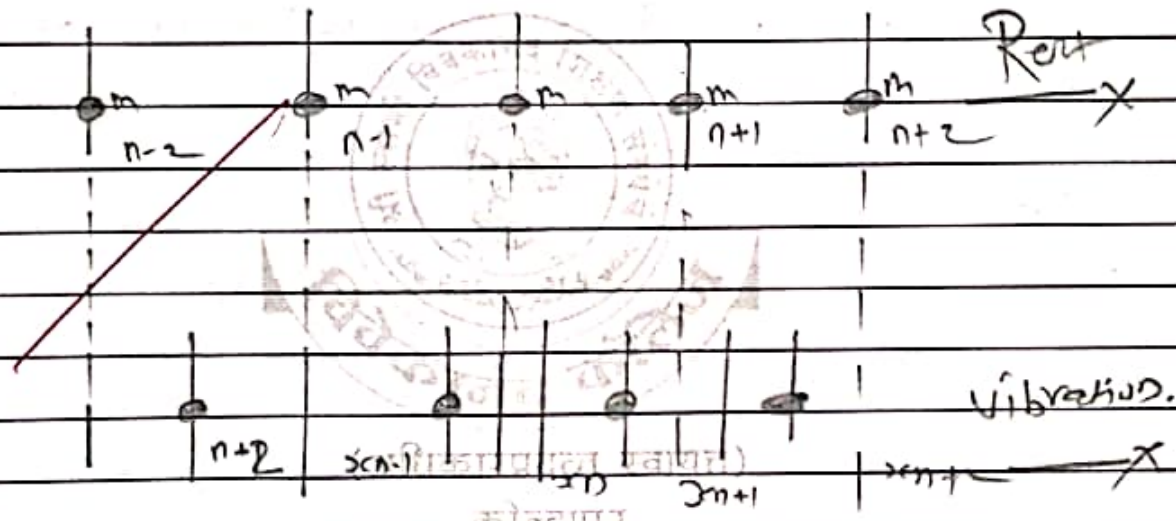
Section	Q. No.													
	Marks													

Q.2)

Vibrational motion :

It is oscillating motion of any matter with it's mean position after equal interval of time by gaining energy.



Force of attraction / of interaction of one atom due to another one is directly proportional to displacement.

So nth atom interacted with (n+1) & (n-1)th atom

$$\therefore F = \beta(x_{n+1} - x_n) - \beta(x_n - x_{n-1})$$

$$\therefore m\frac{d^2x_n}{dt^2} = \beta(x_{n+1} + x_{n-1} - 2x_n) \quad \text{--- (1)}$$

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let $x_n = A \cdot e^{i(\omega t - Kna)}$

$\therefore \frac{dx_n}{dt} = A \cdot e^{i(\omega t - kna)} (i\omega)$

diff. w.r.to t

$\frac{d^2 x_n}{dt^2} = -A\omega^2 e^{i(\omega t - kna)}$

$x_{n+1} = A \cdot e^{i(\omega t - kna)}$

$\cancel{\therefore x_{n+1} = x_n e^{ika}}$

$x_{n-1} = x_n e^{-ika}$

$\therefore$ eqn (1) becomes

$-m\omega^2 x_n = \beta x_n \left[e^{ika} + e^{-ika} - 2 \right]$

$\therefore -m\omega^2 = \beta (2\cos ka - 2)$

$\therefore -\omega^2 = \frac{2\beta}{m}(1 - \cos ka)$

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Q. No.												
Marks												

$$\therefore \omega^2 = \frac{4P}{m}\left(\sin^2 \frac{ka}{2}\right)$$

$$\boxed{\therefore \omega = 2\sqrt{\frac{P}{m}}\,\sin\left(\frac{ka}{2}\right)}$$

This is called the dispersion relation for one dimensional infinite monoatomic lattice

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Department of Physics

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Paper- Solid State Physics IV

Day: - Friday
Date: - 15/03/2024

Time: - 12.00 pm- 01.00 pm
Total Marks:20

Attendance

Sr. No.	Name of the students	Sign
1	Dnyaneshwari P. Todkar	Dnyaneshwari.
2	Shweta Sardar mithari	Smithari
3	Pranali Pradeep Shirke	Pshirke
4	Shivani Dattatrey Sagar	Shivani
5	Rajshree mahesh Randive	Rajshree
6	Shruti Harish Bam	Shruti.
7	Snehal N. Ahiwale	Snehal
8	Anand N. Biradar	Anand
9	Jarkali Smit Kallappa	Jkarkali
10	Shivraj C. Kavutagi	Shivraj
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