Shri Swami Vivekanand Shikshan Sanstha's

Vivekanand College, Kolhapur (Empowered Autonomous).

Department of Physics

Date: 18/03/2025

Internal Examination Notice

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

No.	Class and Sem	Paper Code.	Title of the paper	Date and time
1.	M.Sc. I, SEM II	DSC12PHY21	Quantum Mechanics	27/03/2025 12:00 to 01:00 pm
2.	M.Sc. I, SEM II	DSC12PHY22	Condensed Matter Physics	28/03/2025 12:00 to 01:00 pm
3.	M.Sc. I, SEM II	DSE12PHY21	Solid State Physics-II (Semiconductor Physics)	29/03/2025 12:00 to 01:00 pm
4.	M.Sc. II, SEM IV	DSC12PHY41	Electrodynamics	27/03/2025 12:00 to 01:00 pm
5.	M.Sc. II, SEM IV	DSC12PHY42	Nuclear and Particle Physics	28/03/2025 12:00 to 01:00 pm
6.	M.Sc. II, SEM IV	DSE12PHY41	Physical Properties of Solids	29/03/2025 12:00 to 01:00 pm

Nature of question paper

- **For M.Sc. I and II**

Total Marks (for each paper) = 20

Q: 1) Select correct alternative (02 marks)

Q: 2) Short answer question (any **ONE** out of two) (12 marks)

Q: 3) Short answer question (any **ONE** out of two) (06 marks)

(M.Sc. Co-ordinator)

HOD

HEAD
DEPARTMENT OF PHYSICS
VIVEKANAND COLLEGE, KOLHAPUR
(EMPOWERED AUTONOMOUS)

"Education for Knowledge, Science and Culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe
Shri Swami Vivekanand Shikshan Sanstha, Kolhapur

Vivekanand College, Kolhapur (Empowered Autonomous)

M.Sc. Part- I (Sem-II) Internal Examination: 2025

Course Code: DSE12PHY41

Electrodynamics

Day: Thursday
Date: 27-03-2025

Time: 12.00 PM-01.00 PM
Marks: 20

Instructions:

1) All the questions are compulsory.
2) Figures to the right indicate full marks.
3) Draw neat labelled diagrams wherever necessary.
4) Use of log table/calculator is allowed.

Q. 1) Select the correct alternative **(02 marks)**

1. Which of the following Maxwell's equations describes the existence of displacement current?

a) Gauss's law for electric fields

b) Gauss's law for magnetic fields

c) Faraday's law of electromagnetic induction

d) Ampère's law with Maxwell's correction

2. In a waveguide, Transverse Electric (TE) mode means:

a) The electric field is completely longitudinal

b) The electric field has no longitudinal component

c) The magnetic field is purely transverse

d) Both electric and magnetic fields are transverse

Q. 2) Short answer question (any one out of two) **(12 marks)**

1. Discuss the propagation of TE and TM modes of EM waves in a rectangular waveguide. Draw a diagram to represent the electromagnetic fields of TE_{10} and TM_{11} modes.

2. Derivation of the electromagnetic wave equation in the waveguide of an arbitrary cross-section.

Q. 3) Short answer question (any one out of two) **(6 marks)**

1. Starting from Maxwell equations in Microscopic form, develop EM Wave Equations in free space.

2. Fresnel's equations for parallel and perpendicular polarization.

ESTD JUNE 1984

Name :- Anjali Bhagwan Kamble. M.Sc II

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥
– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

18/20

VIVEKANAND COLLEGE, KOLHAPUR.
(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	Kamble
Seat No. :	1606
Seat No. in words :	one six zero six
Suppliment No. :	1
	47619
Centre -	Vivekanand college

प्र. क्र. Q. No.	
1.	
1.	d) Ampere's law with Maxwell's correction. 1
2.	b) The electric field has no longitudinal component. 1

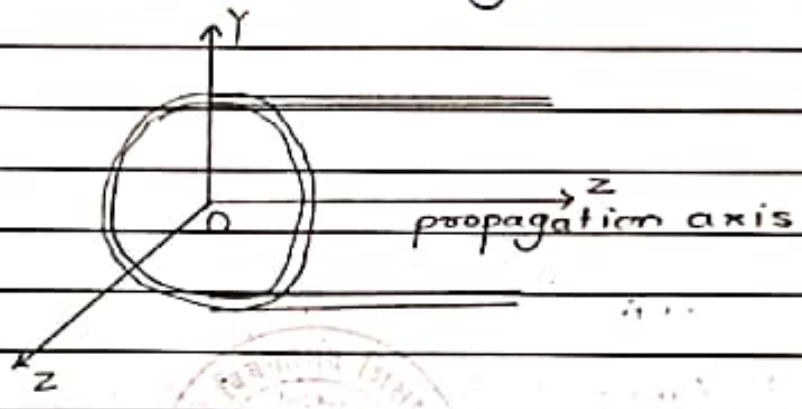
VIVEKANAND COLLEGE KOLHAPUR (Empowered Autonomous) ESTD JUNE 1964

2 Section | Q. No. | Marks

प्र. क्र. Q. No. 2.

2.

→ Waveguide of an arbitrary cross section.



- The waveguides are the hollow metallic structure that flows the energy in the form of electric and met magnetic medium without loss of energy.
- In waveguide the electric field is perpendicular to the walls of waveguide.
- Above fig. shows the arbitrary coss-section of waveguide.
- In above cross section wave are flows in the direction of z. without looses its energy. from the centre.

Now,

$$\left[\nabla^2 - \frac{1}{c}\frac{\partial}{\partial t}\right]\vec{E} = 0 \quad \text{——(1)}$$

Here,

$$\vec{E} = E_0 \cdot e^{i(kz - \omega t)} \quad \text{——(2)}$$

Section	Q. No.													03
	Marks													

प्र. क्र. Q. No.

2. Now,

2. $$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

$$\nabla^2 = \nabla_1^2 + \frac{\partial^2}{\partial z^2}$$

where,

$$\nabla_1^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \quad \text{——— (3)}$$

put eqn (3) in eqn (1) ∴

Hence,

$$\left[\nabla_1^2 + \frac{\partial^2}{\partial z^2} - \frac{1}{c}\frac{\partial}{\partial t}\right]\vec{E} = 0 \quad \text{——— (4)}$$

Now, consider 2nd term of eqn (4)

$$\therefore \frac{\partial^2}{\partial z^2} = \frac{\partial^2 \vec{E}}{\partial z^2}\left(\frac{\partial \vec{E}}{\partial z^2}\right)$$

$$= \partial^2 E_0 . e^{i(kz - \omega t)}$$

$$\frac{\partial^2}{\partial z^2} = -k_g \cdot \omega t \quad \text{——— (5)}$$

Now consider 3rd term of eqn (4)

$$\therefore \frac{\partial}{\partial t} = \frac{\partial \vec{E}}{\partial t}\left(\frac{\partial \vec{E}}{\partial z^2}\right)$$

$$= \partial E_0 . e^{i(kz - \omega t)}$$

$$= -\omega t \quad \text{——— (6)}$$

Section | Q. No. | Marks

2. put eqn (5) & (6) in eqn (4)

$$\left[\nabla_1^2 - \mu_0 \varepsilon_0 \frac{\partial^2}{\partial t^2}\right] \vec{E} = 0 \quad \text{---(7)}$$

Now,

$$\vec{E} = \hat{e}_x \frac{\partial}{\partial x} + \hat{e}_y \frac{\partial}{\partial y} + \hat{e}_z \frac{\partial}{\partial z} \quad \text{---(8)}$$

$$E = E_1 + E_2$$

Similarly,

$$E = B_1 + B_2.$$

Here,

E_1 & E_2 are for the electric ~~trans~~ transverse wave. similarly we can write for the magnetic waves i.e. B_1 & B_2.

Name :- Anjali Bhagwan Kamble. M.Sc II

॥ ज्ञान, विज्ञान आणि सुंसस्कार यासाठी शिक्षण प्रसार ॥
- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारमुक्त स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.
(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	Kamble
Seat No. :	1606
Seat No. in words :	one six zero six.
Suppliment No. :	2
	47625
Centre	Vivekanand college.

VIVEKANAND COLLEGE KOLHAPUR (E) ESTD JUNE 1964

3.

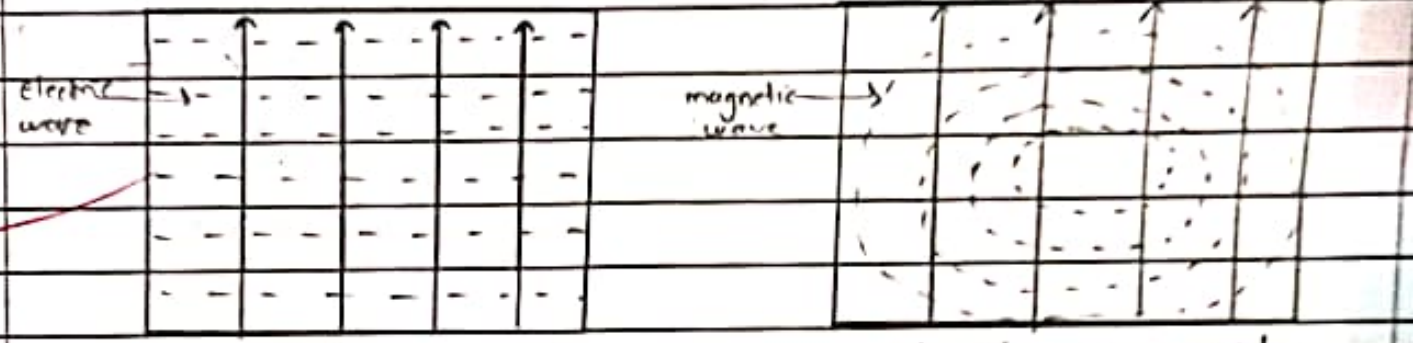
1.

TE mode	TM mode.
1) The electric (E) wave Field. is perpendicular and parallel to the propagation of waveguide.	1) The magnetic (H) field is perpendicular and parallel to the propagation of waveguide.
2) The magnetic field is parallel and coexist to walls of waveguide	2) The electric field is parallel and coexist to walls of waveguide.
3) The lines of electric field is in straight line. and are in the rectangular waveguide.	3) The lines of magnetic field is in the curve i.e. in the circular waveguide.
4) In TE_{01} mode, $m=0$ & $n=1$	In, TM mode, TM_{11} $m=1$ $n=1$

&

ction	Q. No.												
	Marks												

5.
No.



Rectangular waveguide

circular waveguide.

Name - Vedaja Ajay Yadav. Date: 27-03-25 Subject: Electrodynamics

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥

- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

18/20

VIVEKANAND COLLEGE, KOLHAPUR.
(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	Yadav
Seat No. :	1609
Seat No. in words :	One six zero nine.
Suppliment No. :	1
	47652
Centre	

प्र. क्र.
Q. No.

Q.1.

1) ~~a)~~ d) Ampere's law with Maxwell's correction 1

2) b) The electric field has no longitudinal component. 1

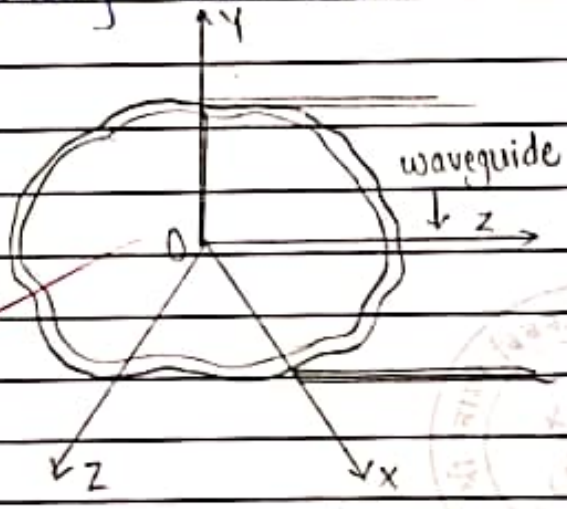
(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE KOLHAPUR (E.A.) ESTD JUNE 1964

ction	Q. No.												
	Marks												

क्र. No.

2) Electromagnetic wave equation in the waveguide of an arbitrary cross section -



Consider a long, hollow waveguide. Let the walls of waveguide are filled with free space.

Then the Electromagnetic wave is introduced to the walls of waveguide at the end of cross section area point.

We know that, the wave eqn is given by,

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right) E = 0 \quad \text{---(1)}$$

where $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$ ---(2)

$$\therefore \nabla^2 = \nabla_t^2 + \frac{\partial^2}{\partial z^2} \quad \text{---(3)}$$

where $\nabla_t^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ ---(4)

From eqn (4) eqn (1) becomes

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right) E = 0$$

$$\left(\nabla_t^2 + \frac{\partial^2}{\partial z^2} - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right) E = 0 \quad \text{---(5)}$$

क्र. No.

Then,

$$\nabla_1^2 E + \left(\frac{\partial^2 E}{\partial z^2} - \frac{1}{c^2} \frac{\partial^2 E}{\partial t^2} \right) = 0 \quad \text{---} \quad (6)$$

Now consider the 2nd term of eqn (6) we get,

$$\frac{\partial^2 E}{\partial z^2} = \frac{\partial}{\partial z} \left[\frac{\partial E}{\partial z} \right]$$

$$= \frac{\partial}{\partial z} \left[\frac{\partial}{\partial z} E_0 e^{i(kgz - \omega t)} \right]$$

As $E = E_0 e^{i(kgz - \omega t)}$

$$\therefore = \frac{\partial}{\partial z} \left[E_0 e^{i(kgz - \omega t)} (ikg) \right]$$

4

$$\frac{\partial^2 E}{\partial z^2} = E_0 e^{i(kgz - \omega t)} (ikg)^2$$

$$= -kg^2 E_0 e^{i(kgz - \omega t)}$$

$$= -kg^2 E \quad \text{---} \quad (7)$$

Now consider third term of eqn (6) we get,

$$\frac{\partial^2 E}{\partial t^2} = \frac{\partial}{\partial t} \left[\frac{\partial E}{\partial t} \right]$$

$$= \frac{\partial}{\partial t} \left[\frac{\partial}{\partial t} E_0 e^{i(kgz - \omega t)} \right]$$

04 Section | Q. No. | Marks

प्र. क्र. Q. No.

$$= \frac{\partial}{\partial t}\left[E_0 e^{i(kgz-\omega t)}(-i\omega)\right]$$

$$= E_0 e^{i(kgz-\omega t)}(-i\omega)(-i\omega)$$

$$= -\omega^2 E_0 e^{i(kgz-\omega t)}$$

$$= -\omega^2 E \quad \text{——} (8)$$

From eqn (7) and (8) we can write eqn (6) as,

$$\nabla_t^2 E + \left[(-kg^2)E + -\frac{1}{c^2}(-\omega^2 E)\right] = 0$$

$$\nabla_t^2 E + \left[-kg^2 E + \frac{\omega^2}{c^2}E\right] = 0 \quad \text{——} (9)$$

Since, $$kc^2 = -kg^2 + \frac{\omega^2}{c^2} \quad \text{——} (10)$$

Then from eqn (10) eqn (9) becomes,

$$\nabla_t^2 E + kc^2 E = 0 \quad \text{——} (11)$$

$$(\nabla_t^2 + kc^2)E = 0$$

$$(\nabla_t^2 + kc^2) E_0 e^{i(kgz-\omega t)} = 0 \quad \text{——} (12)$$

We can also write,

$$\vec{E} = \hat{e}_x E_0 e^{i(kgz-\omega t)} + \hat{e}_y E_0 e^{i(kgz-\omega t)} + \hat{e}_z E_0 e^{i(kgz-\omega t)}$$

$$\vec{E} = \hat{e}_x E_x + \hat{e}_y E_y + \hat{e}_z E_z$$

$$\vec{E} = E_x + E_y + E_z$$

$$\vec{E} = \vec{E_1} + \vec{E_z} \quad \text{——} (13)$$

Similarly, $$\vec{B} = \vec{B_1} + \vec{B_z} \quad \text{——} (14)$$

where, $\vec{E_1}$ and $\vec{B_1}$ are the transverse components and $\vec{E_z}$ and $\vec{B_z}$ are the longitudinal components of field.

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥
- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदान स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.
(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	Alodas
Seat No. :	1609
Seat No. in words :	One six zero nine
Suppliment No. :	47626
Centre	

प्र. क्र.
Q. No.

Q.3. 1) The Maxwell's eqn in Guassian unit are written as,

1) $\nabla \cdot E = 4\pi\rho$ [Gauss law of electrostatics]
2) $\nabla \cdot B = 0$ [Gauss law of magnetostatics]
3) $\nabla \times E = \frac{-1}{c}\frac{\partial \vec{B}}{\partial t}$ [Modified Faraday's law]
4) $\nabla \times B = \frac{4\pi}{c}\vec{J} + \frac{1}{c}\frac{\partial \vec{E}}{\partial t}$ [Modified Ampere's law]

The microscopic forms of above eqn are written when charge density and current density are zero. i.e. $J=0$ & $\rho=0$

2) Then the microscopic form of above eqns is :

1) $\nabla \cdot E = 0$
2) $\nabla \cdot B = 0$
3) $\nabla \times E = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$
4) $\nabla \times \vec{B} = \frac{1}{c}\frac{\partial \vec{E}}{\partial t}$

02 Section | Q. No. | Marks

प्र. क्र.
Q. No.

Derivation of EM wave equations in free space -

We know the Maxwell's eqn in mirrorscople form are,

1) $\nabla \cdot \vec{E} = 0$ —(1)

2) $\nabla \cdot \vec{B} = 0$ —(2)

3) $\nabla \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$ —(3)

4) $\nabla \times \vec{B} = \frac{1}{c}\frac{\partial \vec{E}}{\partial t}$ —(4)

Now on taking curl of eqn (3) it becomes,

$$\nabla \times (\nabla \times E) = -\nabla \times \frac{1}{c}\frac{\partial \vec{B}}{\partial t}$$

$$\nabla(\nabla \cdot E) - \nabla^2 E = \frac{-1}{c}\frac{\partial}{\partial t}(\nabla \times \vec{B}) \quad —(5)$$

Using eqn (1) and eqn (4) in eqn (5) we get.

$$-\nabla^2 E = \frac{-1}{c^2}\frac{\partial \vec{E}}{\partial t}$$

$$\therefore \nabla^2 E - \frac{1}{c^2}\frac{\partial \vec{E}}{\partial t} = 0$$

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial}{\partial t}\right)E = 0 \quad —(6)$$

Now on taking curl of eqn (4) we get,

$$\nabla \times (\nabla \times \vec{B}) = \nabla \times \frac{1}{c}\frac{\partial \vec{E}}{\partial t}$$

$$\nabla(\nabla \cdot B) - \nabla^2 B = \frac{1}{c}\frac{\partial}{\partial t}(\nabla \times E) \quad —(7)$$

ESTD JUNE 1984

Section | Q. No. | Marks

Now using eqn (2) and (3) eqn (7) becomes,

$$-\nabla^2 B = -\frac{1}{c^2}\frac{\partial \vec{B}}{\partial t}$$

$$\nabla^2 B = \frac{1}{c^2}\frac{\partial \vec{B}}{\partial t}$$

$$\nabla^2 B - \frac{1}{c^2}\frac{\partial \vec{B}}{\partial t} = 0$$

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial}{\partial t}\right)\vec{B} = 0 \quad \text{——(8)}$$

We can write eqn (6) and (8) jointly as,

$$\left(\nabla^2 - \frac{1}{c^2}\frac{\partial}{\partial t}\right)\psi = 0 \quad \text{——(9)}$$

Where ψ is either E or B

The general wave eqn of eqn (9) is,

$$\psi_0 = \psi_0 e^{i(kz-\omega t)} \quad \text{——(10)}$$

Eqn (9) represents the wave equations in free space.

"Education for Knowledge, Science and Culture"
-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 (2024-25)

Electrodynamics

Paper code: DSC12PHY41

Date: - 27/03/2025 Time: - 12:00 – 01:00 pm

Day: - Thursday Total Marks: 20

Attendance Sheet

Sr. No.	Name of the students	Roll Number	Sign
1)	Dhiraj Prakash Bhirgasdeve	1601	
2)	Suyash Sanjay Dongare		
3.	Devkule Nishigandha. N.		
4.	Anjali Bhagwan Kamble	1606	
5.	Vedaja Ajay Yadav	1609	
6	Mahek S. Jamadar	1605	
(7)	AKASH B. KAVAITHEKAR		
8.	Gouri B. Gavade		

VIVEKANAND COLLEGE KOLHAPUR (Autonomous) ESTD JUNE 1964

"Education for Knowledge, Science and Culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe
Shri Swami Vivekanand Shikshan Sanstha, Kolhapur

Vivekanand College, Kolhapur (Empowered Autonomous)

M.Sc. Part- II (Sem-II) Internal Examination: 2025

Course Code: DSE12PHY42

NUCLEAR AND PARTICLE PHYSICS

Day: Friday | Time: 12-1 pm

Date: 28/03/2025 | Marks: 20

Instructions:

1) All the questions are compulsory.

2) Figures to the right indicate full marks.

3) Draw neat labeled diagrams wherever necessary.

4) Use of log table/calculator is allowed.

Q. 1) Select the correct alternative. **(02 marks)**

1) Which of the following potentials is commonly used to model nucleon-nucleon interactions?

a) Coulomb potential b) Square well potential

c) Lennard-Jones potential d) Gravitational potential

2) In low-energy n-p scattering, the scattering length is a measure of----------

a) The energy of the neutron b) The effective range of interaction

c) The relative velocity of nucleons d) The magnetic moment of the proton

Q. 2) Short answer question (any one out of two). **(12 marks)**

1. Give a classification of fundamental forces.

2. Explain in detail the internal conversion. What are the momentum and parity selection rules?

Q. 3) Short answer question (any one out of two). **(6 marks)**

1. Write a note on Yukawa's theory of nuclear force.
2. Write a note on Deuteron.

VIVEKANAND COLLEGE KOLHAPUR (Autonomous) ESTD JUNE 1964

Mahek S. Jamodar

19/20

॥ ज्ञान, विज्ञान आणि सुंसस्कार यासाठी शिक्षण प्रसार ॥

– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदान स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.

(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	
Seat No. :	1605
Seat No. in words :	one six zero five
Suppliment No. :	01
	1035
Centre	

प्र. क्र.
Q. No.

1)

1) b) Square well potential.

2) b) The effective range of interaction

2

VIVEKANAND COLLEGE KOLHAPUR (Autonomous) ESTD JUNE 1964

Section	Q. No.	02											
	Marks	11											

प्र. क्र.
Q. No.

2)

1. There are four basic foundamental forces in nature in terms of which we can explain natural processes. The four interactions are:

1) Strong interaction
2) Electromagnetic interaction.
3) Weak interaction.
4) Gravitational interaction

1) Strong interaction:

(a) Strong interaction acts on quarks and hadrons.

(b) The relative strength of strong interaction is 1.

(c) The range of strong interaction is nearly equal to nuclear size (i.e 10^{-15} fm) in between nuclear forces.

(d) Strong interaction is higher than that of all three interactions.

(e) The force carriers or exchange particles in strong interaction are gluons on quarks and π pions on hadrons.

(f) Role of strong interaction in universe is gluons holds quarks together to form nucleus, π pions holds together to form an atom.

5.
o.

(g) The characteristic time of strong interaction is 10^{-22} to 10^{-23} sec.
(h) The exchange particles in strong interaction have large mass and its spin is 1.

2) Electromagnetic interation:
(a) Electromagnetic interaction acts on every charged particle.
(b) The force of electromagnetic interaction can be given as

$$f = \frac{k q_1 q_2}{r^2}$$

where q_1 and q_2 → charge of two particles.
r → the distance between two particles
(c) The range of electromagnetic interaction is infinite.
(d) The strength of electromagnetic interaction is 10^{+3} times weaker than strong interaction.
(e) The characteristic time of electromagnetic interaction is 10^{-14} to 10^{-20} sec.
(f) The force carriers or exchange particle in electromagnetic interaction is photon.
(g) Electromagnetic interaction may be attractive or repulsive.
(h) Electromagnetive interaction are also known as frictional forces.
(i) Role of electromagnetic interaction in univese

प्र. क्र. Q. No.

is to study the structure of atoms, molecules solids and liquids.

(j) The spin of the particles is equal to 1.

3) Weak interaction:

(a) Weak interaction is responsible for decay process also responsible for radioactive decay process.

(b) Weak interaction acts on quarks and leptons.

(c) The relative strength of weak interaction is 10^{+13} times weaker than strong interaction.

(d) The force carriers or exchange particle in weak interaction is vector Bosons.

(e) The characteristic time of weak interaction is 10^{-8} to 10^{-14} sec.

(f) The mass of exchange particle is 10^{-15} MeV and spin is equal to 1.

(g) Role of weak interaction in universe is to mediate transformation of quarks and leptons.

4) Gravitational interaction:

(a) Gravitational interaction acts on every particle. so it is also known as universal interaction.

(b) The force of Gravitation interaction can be given as.

$$f = \frac{G m_1 m_2}{r^2}$$

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥
- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.
(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	Sawant
Seat No. :	1605
Seat No. in words :	one six zero five
Suppliment No. :	
	1016
Centre	

क्र.
No.

where m_1 and m_2 → mass of two particles.
r → distance between two particles.
G → gravitational constant.

(c) The range of gravitation interaction is infinite.

(d) The force carriers or exchange particles in gravitational interacting is graviton.

(e) Gravitons are uncharged, massless particles having spin equal to 2.

(f) Gravitation interaction is attractive force.

(g) The characteristic time of gravitational interaction is years.

(h) Role of gravitational interact in universe is to assemble planets, stars and galaxies

02 Section	Q. No.	3
	Marks	06

प्र. क्र.
Q. No.

3)

2.

(a) Deuteron is a nucleus of one proton and one neutron

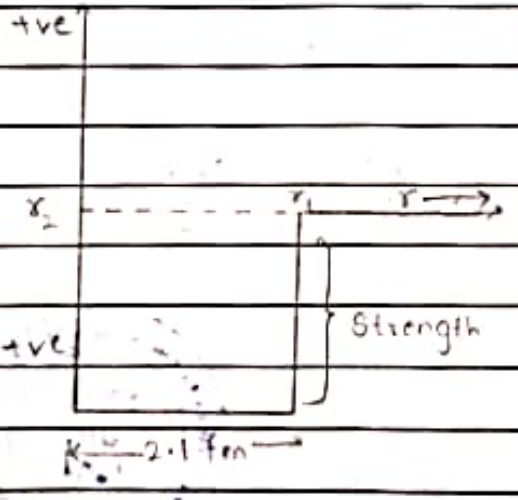
(b) Deuteron is a nucleus of one proton and one neutron having bound system.

(c) As the experimental list, known parameters of deuteron is binding energy.

Binding energy of deuteron is 2.225 Mev and binding energy per nucleon is 1.113 Mev.

(d) As binding energy per nucleon is 1.113 Mev it is weakly bounded system having range of 2.1 fm.

(e) How strong is n-p potential is given by the depth of the potential well.



Q. No.													
Marks													

(f) Due to one proton deuteron has positive charge.

(g) The spin of the deuteron is 1.

(h) Deuteron has even parity i.e. positive parity

(i) The mass of deuteron is 2.014735 amu.

(j) Electric Quadrapole moment of deuteron is $2.82 \times 10^{-31} m^2$ or 0.00282 barn.

(k) It obeys B.E statistics i.e., it is bosons and it has no excited state.

(l) The total effective charge is -2.225 Mev. The (-ve) sign represents force of attraction between them.

(m) The central potential is a potential function of $V(\vec{r}) = V(\vec{r})$ and does not depend on θ.

In classical mechanics the physical term is $m = \frac{m_1 m_2}{m_1 + m_2}$ where m is the reduced mass.

By energy eigen function and time independent Shrodinger equation,

$$H\psi(r) = E\psi(r)$$

$H \Rightarrow$ Hamiltonian.

$\psi(r) =$ wave function.

Hamiltonian $H = \frac{-\hbar^2}{2m} \nabla^2 + V(r)$

$$\therefore \left[\frac{-\hbar^2}{2m} \nabla^2 + V(r)\right] \psi(r) = E\psi(r).$$

Name : Vedaja Ajay Yadav.

19/20

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥

– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारमंडल स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.

(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	Yadav
Seat No. :	1609
Seat No. in words :	One six zero nine
Suppliment No. :	1
	1036
Centre	

प्र. क्र.
Q. No.

Q.1.

1) b) square well potential. 1/1

2) b) the effective range of interaction. 1/1

2/2

VIVEKANAND COLLEGE KOLHAPUR
ESTD JUNE 1964

02 Section	Q. No.	02
	Marks	12

प्र. क्र.
Q. No.

.2.

1) Classification of fundamental forces:

There are four basic fundamental forces or interaction from which we can study the various laws of nature. They are as follows: ~~and are also~~

1) Strong interaction
2) Electromagnetic interaction
3) Weak interaction
4) Gravitational interaction.

I] Strong interaction:

1) Strong interaction usually acts on quarks and hadrons.
2) The range of strong interaction is almost equal to size of nucleus ie. 10^{-15} m.
3) And the relative strength of strong interaction is 1.
4) The force carriers or exchange particles in ~~electromag~~ strong interaction are ~~leptons~~ gluons in quarks and pions in hadrons. And here pions are π-mesons.
5) The characteristic time of strong interaction is given by 10^{-22} to 10^{-23} sec.
6) Strong interaction has spin which is equal to 1.
7) Strong interaction is mainly seen in nucleus of an atom.
8) The universal role of Strong interaction is that, ~~quarks~~ gluons combine quarks together and hadron combines a nucleus to form an atom.
9) Relative strength of strong interaction is higher than

Q. No.

other three interactions.

II] Electromagnetic Interaction:

1) Electromagnetic force/interaction is also called as frictional forces.
2) Except gravitational interaction, all three interactions are electromagnetic interactions.
3) In our daily life we can experience only two interactions and they are electromagnetic interaction and gravitational interaction.
4) The electromagnetic interaction is given by.

$$F = \frac{K \cdot q_1 q_2}{r^2}$$

where q_1 and q_2 are charges and r is the distance between them where k is force constant.

5) The electromagnetic interaction acts on every charged particle
6) The range of electromagnetic interaction is infinite (∞)
7) The relative strength of electromagnetic interaction is 10^3 times weaker than the strong interaction.
8) The charge/force carriers or exchange particles in electromagnetic interactions are photons
9) The characteristic time of electromagnetic interaction is 10^{-14} to 10^{-20} sec.
10) The spin of EM interaction is equal to 1
11) And in electromagnetic interactions mass of exchange particles is equal to zero
12) The universal role of electromagnetic interactions is to study atomic, molecular structure and also to study solids and liquids

04	Section	Q. No.												
		Marks												

प्र. क्र.
Q. No.

III] Weak interaction:

1) Weak interaction is generally responsible for radioactive decay.
2) Weak interaction acts on quarks and leptons.
3) The range of strong interaction is equal to 10^{-18} m.
4) The relative strength of ~~strong~~ weak interaction is 10^{13} times weaker than that of strong interaction.
5) The force carriers or exchange particles in weak interactions are vector bosons.
6) The characteristic time of weak interaction is equal to or is in between 10^{-8} to 10^{-13} sec.
7) The weak interaction has spin which is equal to 1
8) The mass of exchange particles / energy is equal to 10^{-5} MeV.
9) The universal role of weak interaction is to mediates transformation of quarks and leptons.

IV] Gravitational interaction:

1) Gravitational interaction is based on Newton's law of gravitation and it is given by.

$$F = G \frac{m_1 m_2}{r_2}$$

where G = gravitational constant = 6.67×10^{-11} $N m^2 kg^{-2}$
$m_1 m_2$ = masses of two particles
r = distance between that two particles i.e. m_1 and m_2.

2) Gravitational interaction is the weakest interaction among all four interactions.

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥
- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारमंडल स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.
(Empowered Autonomous)

SUPPLIMENT

Jr. Supervisor's Sign. :	
Students Sign. :	Yadav
Seat No. :	1609
Seat No. in words :	One six zero nine.
Suppliment No. :	2
	1015
Centre	

प्र. क्र.
Q. No.

1) 3) The gravitational interaction acts on every particle in nature.

4) The range of gravitational interaction is ∞. i.e. It can occur between particles ~~pair~~ which can be at infinite distance.

5) The relative strength of gravitational interaction is 10^{39} times weaker than that of the strong interaction.

6) The force carriers or exchange particles in gravitational interaction are gravitons.

7) The characteristic time of gravitational interaction is years. Means it can take many years.

8) The spin of gravitational interaction is equal to 2

9) As the particles in gravitational interaction are massless since there is no exchange of mass.

10) The universal role of gravitational interaction is to assemble stars, galaxies, planets in a specific manner.

11) There are two types of gravitational interactions-
   i) Astronomical gravitational interaction - which is in between moon and earth & other stars
   ii) Terrestrial gravitational interaction - which is seen on earth.

ESTD JUNE 1964

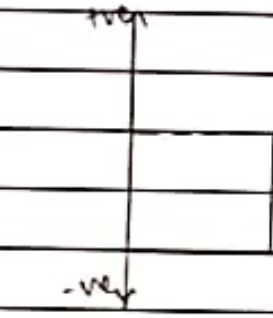
12

02 Section | Q. No. 03 | Marks 05

प्र. क्र.
Q. No.

Q.3. 2) Deuteron:

1) A deuteron is made up of one nucleus of proton and one nucleus of neutron.
2) It does not contains two nucleus of protons and two nucleus of neutrons as it does not form bound system.
3) Hence, from above statement/sentence, deuteron has bound system.
4) The expert parameters of deuteron are calculated experimentally which tells that the B.E. of deuteron is equal to 2.5 MeV i.e. 2.25 MeV and B.E of deuteron per nucleon is equal to 1.113 MeV.
5) The strength of deuteron is 2.1 Fm.



6) As the B.E. of deuteron per nucleon is 1.1 MeV it is weakly bound system.
7) The charge of deuteron is positive due to charge of proton.
8) The mass of deuteron is equal to 2.014735 amu
9) The spin of deuteron is equal to 1.
10) Deuteron has even parity i.e. positive parity.
11) The quadrupole moment of deuteron is given by,

Section | Q. No. | Marks

क्र. No.

$Q_d = 2.82 \times 10^{-31}$ Fm

$= 0.0028$ barn.

12) Deuteron does obeys B.E. statistics i.e. bosons and deuterons have no excited states.

"Education for Knowledge, Science and Culture"
-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 (2024-25)

Nuclear and Particle Physics

Paper code: DSC12PHY42

Date: - 28/03/2025
Day: - Friday

Time: - 12:00 – 01:00 pm
Total Marks: 20

Attendance Sheet

Sr. No.	Name of the students	Roll Number	Sign
1)	Suyash Sanjay Dongare	1603	
2)	Dhiraj Prakash Bhirgasdeve	1601	
3)	Anjali Bhagwan Kamble.	1606	
4)	Devkule Nishigancha N.	1602	
5)	Vedaja Ajay Yadav	1609	
6)	Mahek S. Jamadar	1605	
(7)	AKASH B. KAVATHEKAR	1607	
(8)	Gauri Gavade		

VIVEKANAND COLLEGE KOLHAPUR (Autonomous) ESTD JUNE 1964

"Education for Knowledge, Science and Culture"
-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
Physical Properties Of Solids

Date: 29/03/2025
Day: Saturday

Total Marks: 15
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) **(08)**

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

Q.2 Long Answer Question (Any one)

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

VIVEKANAND COLLEGE KOLHAPUR
ESTD JUNE 1964

Mahek S. Jamadar

॥ ज्ञान, विज्ञान आणि सुंसस्कार यासाठी शिक्षण प्रसार ॥

– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.

(Empowered Autonomous)

SUPPLIMENT 19/20

Jr. Supervisor's Sign. :	
Students Sign. :	Mahek
Seat No. :	1605
Seat No. in words :	One six zero five
Suppliment No. :	
	47276
Centre	

प्र. क्र. Q. No.	
	1

1. (d) Phonons

2. (a) $\chi < 0$

)2 Section | Q. No. | Marks

प्र. क्र.
Q. No. 2.

1 The velocity of wave packet is called as group velocity.

We ~~Kam~~ know $\omega = 2\left(\frac{C_1}{M}\right)^{1/2} \left|\sin\frac{ka}{2}\right|$

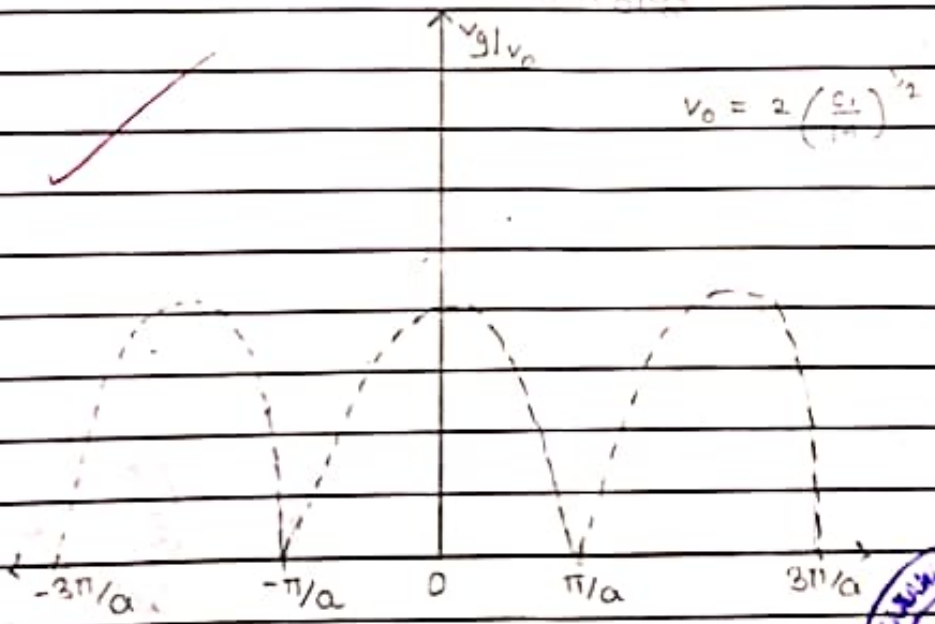
$v_g = \frac{d\omega}{dk} = \left(\frac{C_1}{M}\right)^{1/2} \cos\frac{ka}{2} \cdot a$

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

If $k = \pm\frac{\pi}{2}$

$\therefore \cos\pm\frac{\pi}{2} = 0$

$\therefore v_g = \frac{d\omega}{dk} = 0$ at edge of zone



06

Section	Q. No.													03
	Marks													

प्र. No.

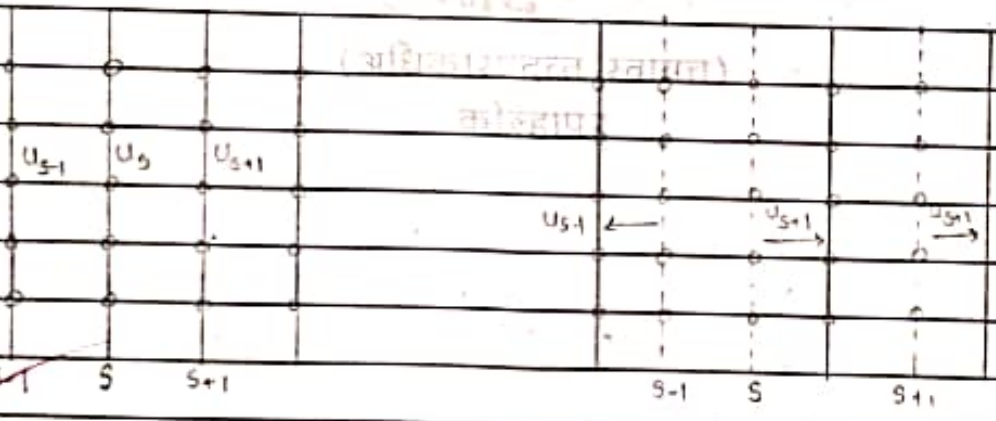
2.

1. Vibrational motion:

When any external force or heat energy is applied to an atom, then it begins to vibrate about its mean position. This motion is called vibrational motion.

Expression of monoatomic lattice.

Consider a one dimensional problem system having all atoms of planes are identical. Suppose polarization direction is either transverse or longitudinal.



Fig(a): Without external energy

(b) Displacement of atom on applied external force.

Consider the force on plane labelled 's' due to the displacement of plane labelled s±p:

The force of plane 's' is proportional to

difference of displacement. It is given by.

$$f_s = \sum_p c_p [u_{s+p} - u_s] \quad \text{——} (1)$$

This is in linear displacement and in the form of Hooke's law. c_p is force constant.
It is convenient to regard f_s and c_p is the force acting on one atom of the plane.
The equation of motion of force acting on one atom of the plane is,

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

Where M ⟶ the mass of single atom
p ⟶ summation of all +ve and -ve integers.

The solution of equation (2) is,

$$u_s = U_{(\omega)} e^{i[ska - \omega t]} \quad \text{——} (3) \text{.....} (k \rightarrow \text{wave vector})$$

Similarly for plane 's+p'

$$u_{s+p} = U_{(\omega)} e^{i[(s+p)ka - \omega t]} \quad \text{——} (4)$$

Differentiate equation (3) we get.

$$\frac{du_s}{dt} = U_{(\omega)} e^{i[ska - \omega t]} \cdot -i\omega.$$

Again differentiate above equation,

$$\frac{d^2 u_s}{dt^2} = U_{(\omega)} e^{i[ska - \omega t]} \cdot -\omega^2.$$

$$\therefore \frac{d^2 U_s}{dt^2} = -\omega^2 U_{(0)} e^{i[ska-\omega t]} \quad \text{---(5)}$$

using equation (5) in equation (2), we get,

$$M(-\omega^2) U_{(0)} e^{i[ska-\omega t]} = \sum_p C_p \left[U_{s+p} - U_s\right]$$

Put the values of equation (3) and (4) in above equation

$$-M\omega^2 U_{(0)} e^{i[ska-\omega t]} = \sum_p C_p \left\{ U_{(0)} e^{i[(s+p)ka-\omega t]} - U_{(0)} e^{i[ska-\omega t]} \right\}$$

$$\therefore -M\omega^2 U_{(0)} e^{i[ska-\omega t]} = \sum_p C_p U_{(0)} e^{i[ska-\omega t]} e^{[ipka-1]}$$

$$\therefore -M\omega^2 = \sum_p C_p \left[e^{ipka-1}\right]^p$$

for Integers greater than 0

$$-M\omega^2 = \sum_{p>0} C_p \left[e^{ipka} + e^{-ipka} - 2\right] \quad \text{---(6)}$$

We know that,

$$\frac{e^{ipka} + e^{-ipka}}{2} = \cos pka \quad \ldots\ldots \left(\because \frac{e^{i\theta} + e^{-i\theta}}{2} = \cos\theta\right)$$

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

Therefore equation (6) becomes.

$$-M\omega^2 = \sum_{p>0} C_p \left[2\cos pka - 2\right]$$

$$\omega^2 = \frac{-2}{M} \sum_{p>0} C_p \left[\cos pka - 1\right]$$

$$\omega^2 = \frac{2}{M} \sum_{p>0} C_p \left[1 - \cos pka\right] \quad \text{---} \quad (7)$$

Equation (7) gives the dispersion relation of monoatomic lattice.

for plane $s=1$ $p=1$.

$$\omega^2 = \frac{2}{M} C_1 \left[1 - \cos ka\right]$$

By $1 - \cos\theta = 2\sin^2\theta/2$

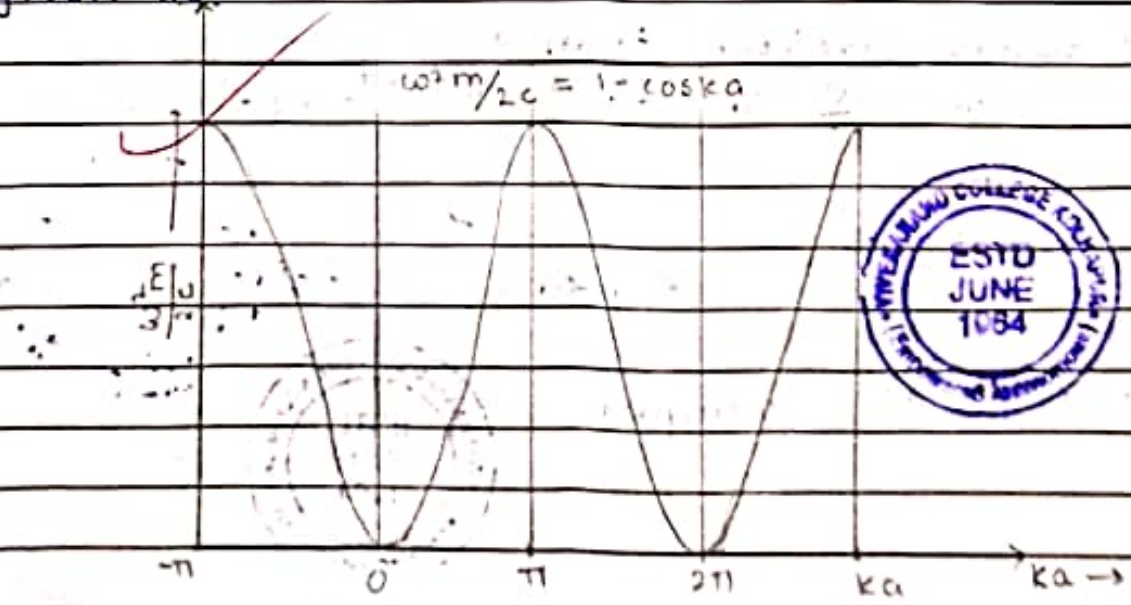
$$\omega^2 = \frac{2}{M} C_1 \left[2\sin^2 \frac{ka}{2}\right]$$

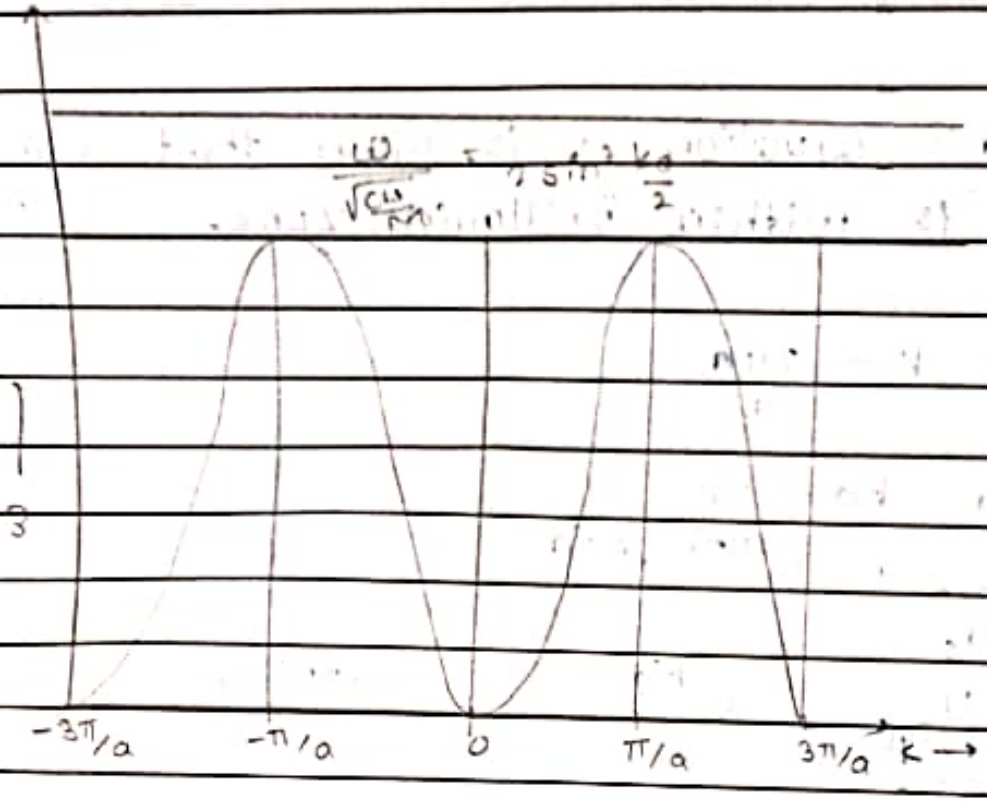
$$\omega^2 = \frac{4C_1}{M} \sin^2 \frac{ka}{2}$$

$$\omega = \left(\frac{4C_1}{M}\right)^{1/2} \sin \frac{ka}{2}$$

First Brillouin zone.

The graph of ω^2 vs ka and ω vs K is given as





$$\omega^2 = \frac{2}{\left(\frac{C_1}{M}\right)^{1/2}} \sin^2 \frac{ka}{2}$$

$$2\pi\nu = 2\sqrt{\frac{C_1}{M}}$$

$$\nu_{max} = \frac{1}{\pi}\sqrt{\frac{C_1}{M}}$$

The maximum frequency is ν_{max} which acts as low passing filter can transmit frequency of maximum zero.

The ratio of two successive displacement is

$$\frac{U_{s+p+1}}{U_{s+p}} = \frac{U_0 e^{i[(s+p+1)ka - \omega t]}}{U_0 e^{i[(s+p)ka - \omega t]}}$$

$$\frac{U_{s+p+1}}{U_{s+p}} = e^{i(ka)}$$

Now $-\pi \leq ka \leq +\pi$

$-\pi a \leq k \leq \pm \pi/a$

$k = \pm \pi/a$.

from this equation it is clear that wave vector is within Brillouin zone.

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

$$k'a = ka - 2\pi$$

$$\frac{U_{s+p}}{U_s} = e^{2\pi ni} e^{ik'a}$$

$$\frac{U_{s+p}}{U_s} = e^{ik'a} \quad \ldots e^{2\pi ni} = 1$$

It is proved that displacement is same for wave vector k and k'.

Name : Vedaja Ajay Yadav.

॥ ज्ञान, विज्ञान आणि सुसंस्कार यासाठी शिक्षण प्रसार ॥

– शिक्षणमहर्षी डॉ. बापूजी साळुंखे

(अधिकारप्रदत्त स्वायत्त)
कोल्हापूर

VIVEKANAND COLLEGE, KOLHAPUR.

(Empowered Autonomous)

SUPPLIMENT 19/20

Jr. Supervisor's Sign. :	
Students Sign. :	Yadav
Seat No. :	1609
Seat No. in words :	One six zero nine
Suppliment No. :	1
	47275
Centre	Vivekanand College, Kop

प्र. क्र. Q. No.	
Q.1.	
1)	d) phonons
2)	a) $\varepsilon < 0$

ESTD JUNE 1964

02	Section	Q. No.												
		Marks												

प्र. क्र.
Q. No.

Q.2.

1) Group velocity and phase velocity:

The velocity of wave packet is called as group velocity. Group velocity is denoted by V_g.

Let us consider a eqⁿ,

$$\omega = \left(\frac{c}{M}\right)^{1/2} \sin\frac{ka}{2} \quad \text{—(1)}$$

Taking derivative of eqⁿ (1)

$$\frac{d\omega}{dt} = \left(\frac{c}{M}\right)^{1/2} \cos\frac{ka}{2}$$

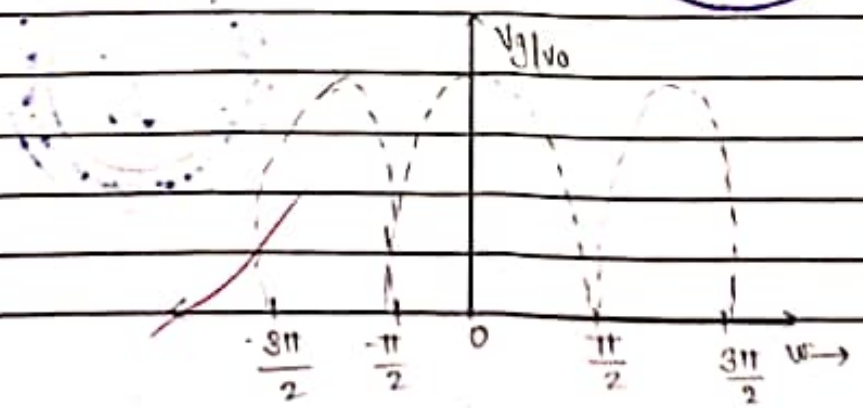
$$\therefore \frac{d\omega}{dt} = V_g = \left(\frac{c}{M}\right)^{1/2} \cos\frac{ka}{2}$$

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

$$\therefore \cos\frac{\pi}{a}\cdot\frac{a}{2} = \frac{\pi}{2}$$

$$\because \cos\frac{\pi}{2} = 0$$

$$\therefore \frac{d\omega}{dt} = V_g = 0$$



1) Vibrational motion:

When an external force or heat energy is given to an atom then it starts to vibrate along its mean position and this is called as vibrational motion of an atom.

Expression of monoatomic lattice :-

Consider a problem system which has atoms and they are identical. Let the ~~propagation~~ polarization be longitudinal or transverse.

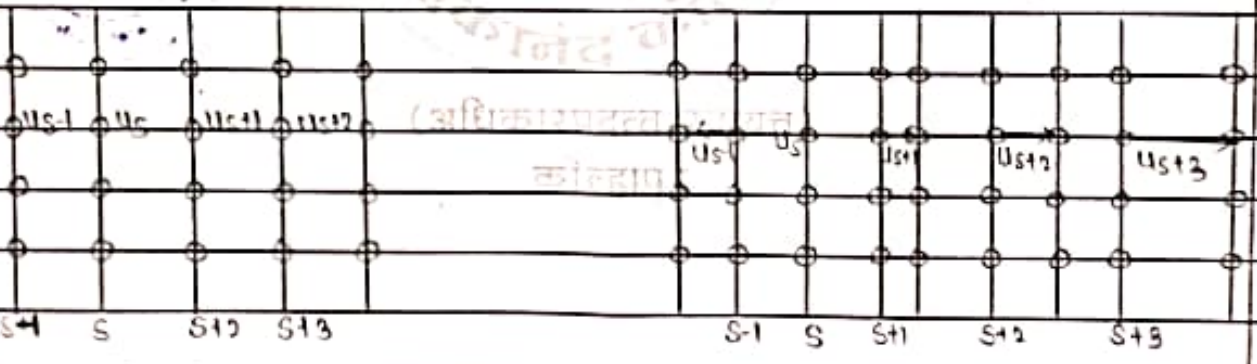


fig a: without external energy

fig b: Displacement of atoms due to external field

Let us consider that the plane force acting on plane labelled as 's' is due to the displacement of plane labelled 's+p'. Hence the total force can be calculated by taking difference of there displacements.

$$\therefore F_s = \sum_p C_p [u_{s+p} - u_s] \quad \text{— (1)}$$

04	Section	Q. No.											
		Marks											

प्र. क्र.
Q. No.

We know that the eqn of motion is

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

The solution of above eqn is given as,

$$u_s = u_0 \cdot e^{i(ska - \omega t)} \quad \text{— (3)}$$

Differentiate eqn (3) wit we get

$$\frac{du_s}{dt} = u_0 e^{i(ska - \omega t)} (i\omega)$$

Again differentiate above eqn.

$$\frac{d^2 u_s}{dt^2} = u_0 e^{i(ska - \omega t)} (i\omega)^2$$

$$\frac{d^2 u_s}{dt^2} = u_0 e^{i(ska - \omega t)} i^2 \omega^2 \quad \ldots (i^2 = -1)$$

$$\frac{d^2 u_s}{dt^2} = -u_0 e^{i(ska - \omega t)} \omega^2 \quad \text{— (4)}$$

Similarly, by as eqn (3) we can also write,

$$u_{s+p} = u_0 e^{i[(s+p)ka - \omega t]} \quad \text{— (5)}$$

So, on substituting values of eqn (3), eqn (4) and eqn (5), eqn (2) becomes,

$$M(-\omega^2) u_0 e^{i(ska - \omega t)} = \sum_{p \neq 0} c_p \{ [u_0 e^{i[(s+p)ka - \omega t]}] - [u_0 e^{i(ska - \omega t)}] \}$$

Name: Yedaje Ajay Yadav

॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

27985

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature of Supervisor	

Suppliment No. : 2

Roll No. : 1609

Class : M.Sc II.

Subject : Physical Properties of Solids

Test / Tutorial No. : Internal Examination

Div. :

D) $-M\omega^2 u_0 e^{i(ska-\omega t)} = \sum_{p<0} c_p \cdot u_0 e^{i(ska-\omega t)} \left[e^{ipka} - 1 \right]$

$\therefore -M\omega^2 = \sum_{p<0} c_p \left(e^{ipka} - 1 \right)$

$M\omega^2 = -\sum_{p<0} c_p \left(e^{ipka} - 1 \right)$ — (6)

Now consider,

$M\omega^2 = -\sum_{p<0} c_p \left(e^{ipka} + e^{-ipka} - 2 \right)$ — (7)

We know that,

$\cos\theta = \frac{e^{i\theta} + e^{i\theta}}{2}$

i.e. $\cos pka = \frac{e^{ipka} + e^{-ipka}}{2}$ $\quad \because \sin\theta = \theta$

$\therefore \cos pka = 1 - 2\left(\frac{pka}{2}\right)^2$

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

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

Now eqn (7) becomes,

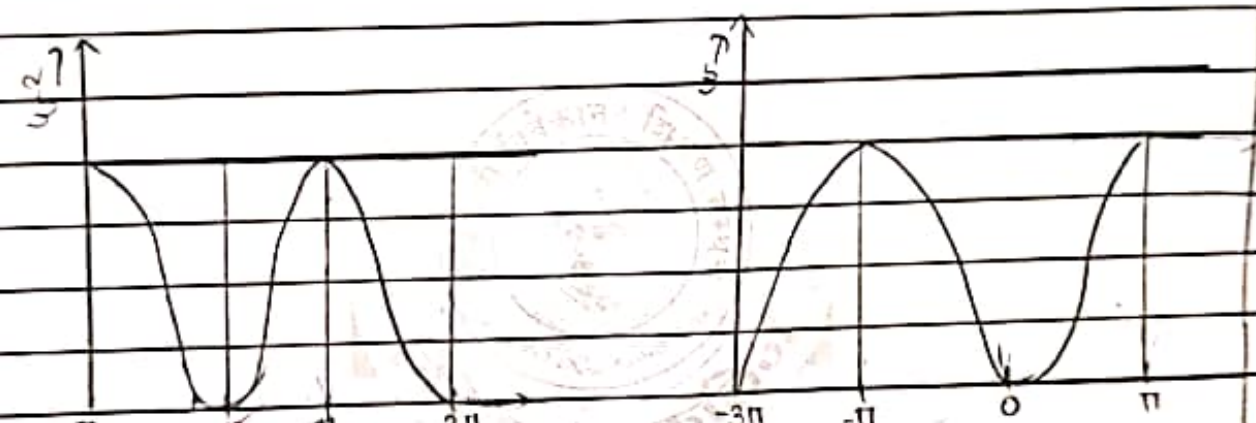
$$M\omega^2 = -\sum_{p<0} C_p (2\cos pka - 2)$$

$$\omega^2 = \frac{-2}{M} \sum_{p<0} C_p (\cos pka - 1)$$

$$\therefore \omega^2 = \frac{2}{M} \sum_{p<0} C_p (1 - \cos pka) \quad \text{—(8)}$$

Eqn (8) is called as expression of monoatomic lattice.

1st Brillouin zone:



In the above graphs fig. (a) represents the graph of ω^2 Vs ka and fig (b) represents the graph of ω Vs k.

The ratio of successful displacement is,

$$\frac{U_{s+p+1}}{U_{s+p}} = \frac{-U_0 e^{i[k(s+p+1)a - \omega t]}}{U_0 e^{i[k(s+p)a - \omega t]}}$$

$$\frac{U_{s+p+1}}{U_{s+p}} = e^{i(ka)} \quad \text{—(9)}$$

Now $-\pi \leq ka \leq \pi$

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

Then for k'

$$\frac{U_{s+p+1}}{U_{s+p}} = e^{i(k'a)} \quad \text{—(10)}$$

From eqn (9) and (10) it is clear that atom within the Brillouin zone and outside the Brillouin zone has same displacement.

OR

From eqn (9) and (10) it is clear that, the ~~vect~~ wave vector k and k' is same and displacement is also same

"Education for Knowledge, Science and Culture"
-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 (2024-25)

Physical Properties of Solid

Paper code: DSE12PHY41

Date: - 29/03/2025 Time: - 12:00 – 01:00 pm

Day: - Friday Total Marks: 20

Attendance Sheet

Sr. No.	Name of the students	Roll Number	Sign	
1	Suyash S. Dongare	1603		15
2)	Dhiraj P. Bhingasdeve	1601		15
3.	Gauri B. Gavade	1605		17
4.	Anjali Bhagwan Kamble.	1606		18
5.	Devkule Nishigandha. H.	1602		14
6.	Vedaja Ajay Yadav	1609		19
7.	Mahek S. Jamadar.	1605		19
8	Akash B. Kavathekar			15

VIVEKANAND COLLEGE KOLHAPUR (Autonomous) ESTD JUNE 1964