

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

Vivekanand College, Kolhapur (Empowered Autonomous)

Department of Physics

Notice

Date: Tuesday, 10th October 2023

It is hereby informed to the students of M.Sc. – I and II, that First Term Internal Evaluation Examination is scheduled between 25th to 26th October 2023 in the Department of Physics.

Instructions:

- 1) Nature of question paper for M.Sc. – I: 05 MCQ's (05 Marks), 01 Short Answer Questions (05 Marks), 01 Long Answer Questions (10 Marks)
- 2) Nature of question paper for M.Sc. – II: 05 MCQ's (05 Marks), 01 Short Answer Questions (05 Marks), 01 Long Answer Questions (10 Marks)
- 3) Students should present before 15 minutes of the examination.
- 4) Answer sheets will be provided by the Department.
- 5) Strictly mention the Full Name and Roll number on Answer Sheet correctly.
- 6) All students should remain present for the Internal Examination as the examination will not be conducted afterwards in any case.

Sr. No.	Date	Class	Name of the Paper	Time
01	25/10/2023	M. Sc. – I	(01) Mathematical Physics	12 – 01 PM
			(02) Classical Mechanics	02 – 03 PM
02	25/10/2023	M. Sc. – II	(01) Nuclear and Particle Physics	12 – 01 PM
			(02) Thin Film Deposition and other Techniques	02 – 03 PM
03	26/10/2023	M. Sc. – I	(01) Research Methodology	12 – 01 PM
			(02) Solid State Physics – I	02 – 03 PM
04	26/10/2023	M. Sc. – II	(01) Solid State Physics – I	12 – 01 PM
			(02) Solid State Physics – II	02 – 03 PM

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Head

Head of the
Department of Physics
Vivekanand College, Kolhapur



(M.Sc. Co-ordinator)

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Shri Swami Vivekanand Shikshan Sanstha, Kolhapur
Vivekanand College, Kolhapur (Autonomous)
Department of Physics

M.Sc. Part-I SEM I Internal Examination
Mathematical Method in Physics
Paper code:CC-1100A

Date: - 25/10/2023
Day: - Wednesday

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

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 most correct alternative

(05)

- i) The product of Eigen values of matrix is equal to it's
a) Trace b) Determinant c) Eigen vector d) Characteristics equation
- ii) Every matrix satisfies it's
a) Characteristic equation b) Eigen values
c) Eigen vector d) All of above
- iii) If the determinant of matrix is zero then the matrix is called as
a) Singular matrix b) Identity matrix
c) Equal matrix d) Periodic matrix

iv) The sum and product of the eigen values of the matrix $A = \begin{bmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{bmatrix}$ are respectively...

(a) 7 and 7 (b) 7 and 5 (c) 7 and 6 (d) 7 and 8

v) Multiplication of matrices is

a) commutative b) not commutative c) not associative d) determinant

Q.2) Attempt any One

(10)

i) Find the inverse of following matrix

$$A = \begin{bmatrix} 3 & -3 & 4 \\ 2 & -3 & 4 \\ 0 & -1 & 1 \end{bmatrix}$$

ii) Find the Eigen values of the matrix

$$A = \begin{bmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{bmatrix}$$

Q.3) Attempt any One

(5)

- i) State and prove Cayley-Hamilton theorem
- ii) Explain inner product and outer product of matrix with suitable example.





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Date: 25/10/2023

Name - Mahak Jamadar

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Q.1. Select most correct alternative

i) characteristic equation Determinants

ii) characteristic equation

iii) Identity matrix

iv) 745

v) Commutative.

① 5



Q.2.

$$-A = \begin{bmatrix} 3 & -3 & 1 \\ 2 & -3 & 1 \\ 0 & -1 & 1 \end{bmatrix}$$

Now let us use following equation

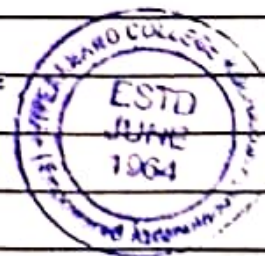
$$-A = I A$$

$$\begin{bmatrix} 3 & -3 & 4 \\ 2 & -3 & 4 \\ 0 & -1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} A, \frac{1}{3} R_1 \quad \begin{bmatrix} 1 & -1 & \frac{4}{3} \\ 2 & -3 & 4 \\ 0 & -1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} A$$

$$R_2 - 2R_1 \quad \begin{bmatrix} 1 & -1 & 4/3 \\ 0 & -1 & 4/3 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ -2 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad A - R_2 \quad \begin{bmatrix} 1 & -1 & 4/3 \\ 0 & 1 & -4/3 \\ 0 & -1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 2/3 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$R_1 + R_2 \rightarrow \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -\frac{4}{3} \\ 0 & 0 & -\frac{1}{3} \end{bmatrix} \sim \begin{bmatrix} 1 & -1 & 0 \\ \frac{2}{3} & -1 & 0 \\ \frac{4}{3} & -1 & 1 \end{bmatrix} \xrightarrow{A \cdot 3R_3} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -\frac{4}{3} \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & -1 & 6 \\ \frac{2}{3} & -1 & 0 \\ -2 & 3 & -1 \end{bmatrix}$$



$$R_2 + \frac{4}{3} R_3$$

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & -1 & 0 \\ -2 & 3 & -4 \\ -2 & 3 & 3 \end{bmatrix} A$$

$$\therefore I = PA$$

$$P = A^{-1}$$

$$A^{-1} = \begin{bmatrix} 1 & -1 & 0 \\ -2 & 3 & -4 \\ -2 & 3 & 3 \end{bmatrix}$$

ii) Eigen values :-

$$A = \begin{bmatrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{bmatrix}$$

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The characteristic equation of given matrix is

$$\begin{vmatrix} 2-\lambda & 2 & 1 \\ 1 & 3-\lambda & 1 \\ 1 & 2 & 2-\lambda \end{vmatrix} = 0$$

$$2-\lambda \left[(3-\lambda) \cdot (2-\lambda) + 2 \right] + 2 \left[(2-\lambda) + 1 \right] + 1(3-\lambda) + 2$$

$$(2-\lambda) \left[6 - 3\lambda - 2\lambda + \lambda^2 + 2 \right] + 4 - 2\lambda + 6 - \lambda$$



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$$(2-\lambda) [\lambda^2 - 5\lambda + 6] + 3\lambda - 10$$

$$(2-\lambda) \quad (3-\lambda) \quad (-\lambda)$$

$$(2-\lambda) [\lambda^2 - 5\lambda + 6 + 2] + [4 - 2\lambda + 2] + 3 - \lambda + 2$$

$$(2-\lambda) [\lambda^2 - 5\lambda + 8] + 2\lambda - 6 + \lambda - 5$$

~~$$2\lambda^2 - 10\lambda + 16 - \lambda^3 + 5\lambda^2 - 8\lambda + 3\lambda - 11$$~~

~~$$-\lambda^3 + 7\lambda^2 - 15\lambda + 5 = 0$$~~

~~$(\lambda - 1)(\lambda - 1)(\lambda - 5)$~~

∴ Freq (वैद्यमान) $\lambda = 1.115$

Q.3) Calc Hamilton theorem.

$$\Delta_f |I - \lambda I| = (-1)^n (\lambda^n + q_1 \lambda^{n-1} + q_2 \lambda^{n-2} + \dots + q_n)$$

~~characteristic polynomial~~ of $n \times n$ matrix $A = (a_{ij})$

$$\therefore x^n + a_1 x^{n-1} + a_2 x^{n-2} + \dots + a_n x = 0$$

$$\therefore A^n + a_1 A^{n-1} + a_2 A^{n-2} + \dots + a_{n-1} I = 0$$





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Proof.

$$\text{Adj}(A - \lambda E) = B_0 \lambda^{n-1} + B_1 \lambda^{n-2} + \dots + B_{n-1}$$

Where, $B_0, B_1, \dots, B_{n-1}$ are $n \times n$ matrix &

their elements being polynomial in λ .

$$(A - \lambda E) \text{Adj}(A - \lambda E) = |A - \lambda E| E$$

$$(A - \lambda E) (B_0 \lambda^{n-1} + B_1 \lambda^{n-2} + \dots + B_{n-1}) = (-1)^n (\lambda^n + a_1 \lambda^{n-1} + \dots + a_n)$$

equating coefficients of the power of λ on both sides

$$-B_0 = (-1)^n E$$

$$AB_1 - EB_1 = (-1)^n a_1 E$$

$$AB_2 - EB_2 = (-1)^n a_2 E$$

$$AB_{n-1} = (-1)^n a_{n-1} E$$





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प्रश्न ५.

$$\text{Adj}(A - \lambda I) = B_0 \lambda^{n-1} + B_1 \lambda^{n-2} + \dots + B_{n-1}$$

Where, $B_0, B_1, \dots, B_{n-1}$ are $n \times n$ matrix &

their elements being polynomial in λ .

$$(A - \lambda I) \text{Adj}(A - \lambda I) = |A - \lambda I| I$$

(अधिकारप्रदत्त स्वायत्त)

$$(A - \lambda I) (B_0 \lambda^{n-1} + B_1 \lambda^{n-2} + \dots + B_{n-1}) = (-1)^n (\lambda^n + a_1 \lambda^{n-1} + \dots + a_n)$$

equating coefficients of like power of λ on both sides

$$-2B_0 = (-1)^n I$$

$$AB_1 - IB_1 = (-1)^n a_1 I$$

$$AB_2 - IB_2 = (-1)^n a_2 I$$

$$AB_{n-1} = (-1)^n a_{n-1} I$$



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Department of Physics

M.Sc. Part-I SEM Internal Examination (2023-24)
Paper- Mathematical Physics

Day: - Wednesday
 Date: - 25/10/2023

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

Attendance

Sr. No.	Name of the students	Sign
1	Vedaja Yadav	<u>Vedaja</u>
2	Dakyle Nishigamha	<u>Dakyle</u>
3	Biradar Shubhangi b.	<u>Biradar</u>
4	Anjali B. Kamble	<u>Akamble</u>
5	Gaursi B. Gaude	<u>Gaursi</u>
6	Mahek S. Jamadar	<u>Mahek</u>
7	Akash Kavathekar	<u>Akash</u>
8	Suryesh S. Dongare	<u>Suryesh</u>
9	Biradar Dhiraj P. Bhingardae	<u>Biradar</u>
10		
11		
12		
13		
14		
15		



Classical Mechanics

Date: 25/10/2023

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 A) Select most correct alternative.

(05)

1. Any restriction on the motion of system is known as _____ and the force responsible is called _____.

- a) Degrees of freedom, constraint b) Constraint, Degrees of freedom
c) Constraint, force of constraint d) Degrees of freedom, force of constraint

2. The equation of constraints containing time as an explicit variable are called **nonholonomic** constraint.

- a) scleronomous b) rheonomous
c) holonomic d) non-holonomic

3. If the total external force on the system is zero, its total _____ is constant of motion.

- a) linear momentum b) angular momentum
c) torque d) energy

4. If the total external torque on the system is zero, its total _____ is constant of motion.

- a) linear momentum b) angular momentum
c) force d) energy

5. The equation of constraints that are not explicitly dependent on time are called holonomic constraint.

- a) scleronomous b) rheonomous
c) holonomic d) non-holonomic

Q.2) Long answer questions

(10)

Derive Lagrange's equation of motion from D'Alembert's principle.

OR

Derive conservation theorem of energy.

Q.3) Short answer questions

(05)

Write note on Degrees of freedom

OR

Derive equation of motion of simple pendulum using Lagrange's equation of motion.



Name :- Anjali Bhagwan Kamble.

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Subject : classical Mechanics

Test / Tutorial No. : 1

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Suppliment No. : 1

Roll No. :

Class : M.Sc I

- Any restriction on the motion of system is known as _____ and the force responsible is called _____.
→ c) Constraint, force of constraint.
- The equation of constraints containing time as an explicit variable are called _____ constraint.
→ b) rheonomous.
- If the total external force on the system is zero, its total _____ is constant of motion.
→ a) linear momentum.
- If the total external torque on the system is zero, its total _____ is constant of motion.
→ b) angular momentum.
- The equation of constraints that are not explicitly dependent on time are called _____ constraint.
→ a) Scleronomous.



Note on Degrees of Freedom —

- If the particle is in free space it has 3 direction known as (x, y, z) direction. i.e. the particle has three degrees of freedom.
- If the particle is in circular direction its co-ordinates are (r, ϕ, θ) .
- a single particle has 3 degrees of freedom. & two particles have 6 degrees of freedom.

i.e. (x_1, y_1, z_1) & (x_2, y_2, z_2)

- If a system has n no. of particles then their degrees of freedom is $3N$.
- In cartesian system the co-ordinates are (x, y, z) .



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c) Constraint Force of Constraint

b) Rheonomous Constraint

d) energy a) Linear momentum

b) angular momentum

a) scleronomous constraint



2>

→

Conservation theorem of energy:

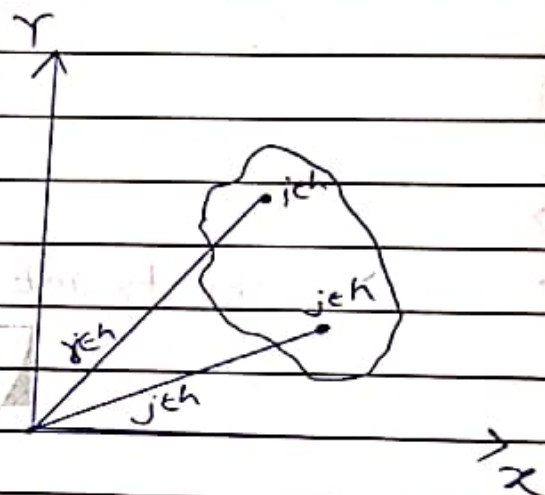
If the external and internal force acting on the system are conservative then the total energy of system is remaining conserved.

Consider a system of n particles. From Workdone of Force.

$$W_{12} = \sum_{i=1}^N \int \vec{F}_i \cdot d\vec{r}_i \quad \text{--- ①}$$

but

$$\vec{F}_i = \vec{F}_i^e + \sum_{j=1}^n \vec{F}_{ij}$$



$$W_{12} = \sum_{i=1}^n \int \left[\vec{F}_i^e + \sum_{j=1}^n \vec{F}_{ij} \right] \cdot d\vec{r}_i$$

According to the Newton's III Law

$$\vec{F}_{ij} = -\vec{F}_{ji}$$

then

$$\vec{F}_{ij} + \vec{F}_{ji} = 0$$

then

$$\sum_{i=1}^n \vec{F}_{ij} = 0$$



We get

$$W_{12} = \sum_{i=1}^n \int \vec{F}_i \cdot d\vec{r}_i$$

but

$$F_i = \frac{dp_i}{dt} \Rightarrow \frac{d}{dt} (m_i v_i) \rightarrow \text{2nd law}$$

$$W_{12} = \sum_{i=1}^n \int_1^2 \frac{dp_i}{dt} \cdot d\vec{r}_i$$

$$= \sum_{i=1}^n \int_1^2 \frac{d v_i}{dt} \cdot d\vec{r}_i$$

$$= \sum_{i=1}^n m_i \int_1^2 \frac{d v_i}{dt} \cdot \frac{d\vec{r}_i}{dt} dt = \sum_{i=1}^n m_i \int_1^2 v_i \cdot v_i dt$$

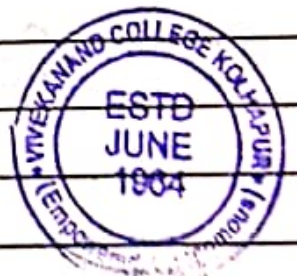
$$= \sum_{i=1}^n m_i \left[\frac{v_i^2}{2} \right]_1^2$$

$$W_{12} = \sum_{i=1}^n m_i \frac{v_i^2}{2} - \sum_{i=1}^n m_i \frac{v_i^2}{2}$$

we get

$$W_{12} = T_0 - T_1 \quad \text{--- (2)}$$

Again we using eqn (1)



$$W_{12} = \sum_{i=1}^n \int_1^2 \vec{F}_i \cdot d\vec{r}_i$$

but

$$\vec{F}_i = \vec{F}_{ie} + \sum_{j=1}^n \vec{F}_{ij} = 0$$

then

$$W_{12} = \sum_{i=1}^n \int_1^2 \vec{F}_i \cdot d\vec{r}_i$$

So, we consider $\vec{F}_i = -\nabla V_i$

then

$$W_{12} = \sum_{i=1}^n \int_1^2 -\nabla V_i \cdot d\vec{r}_i$$

Now,

$$-\nabla V_i = \frac{dV_i}{dr}$$

then

$$\sum_{i=1}^n \int_1^2 \frac{dV_i}{dr} \times dr \Rightarrow - \sum_{i=1}^n \int_1^2 dV_i \Rightarrow$$

$$\sum_{i=1}^n \left[V_i^2 \right]_1^2 \Rightarrow - \sum_{i=1}^n V_i \Big|_1^2$$



Dhishaj . P. Bhingardere

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we get

$$V_1 - V_2 \quad \text{③}$$

From eqn ② & ③

$$T_2 - T_1 = V_2 - V_1$$

$$T_2 + V_2 = T_1 + V_1$$

$$T + V = 0$$

$$T + V = \text{Constant}$$

so, above eqn represents the
Conservation theorem of energy



Q.3

1>

→ Degrees of Freedom:-

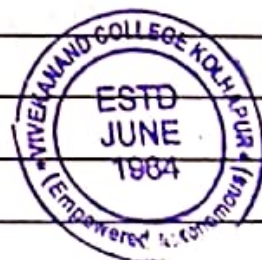
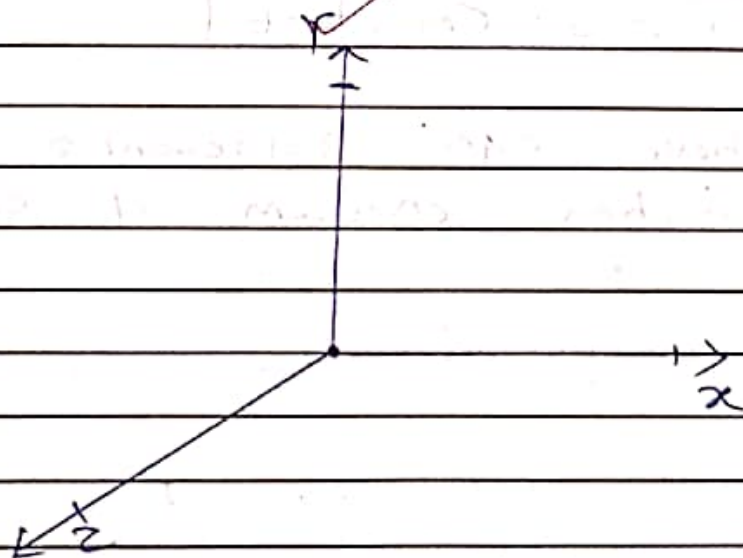
the no. of independent co-ordinates necessary to specify the position or configuration of system completely then it's called as degrees of Freedom.

there are two types of degrees of Freedom.

$$3N - K$$

1> Monoatomic:-

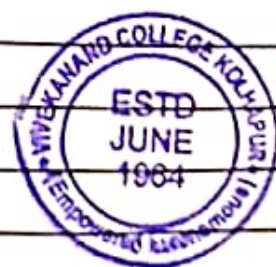
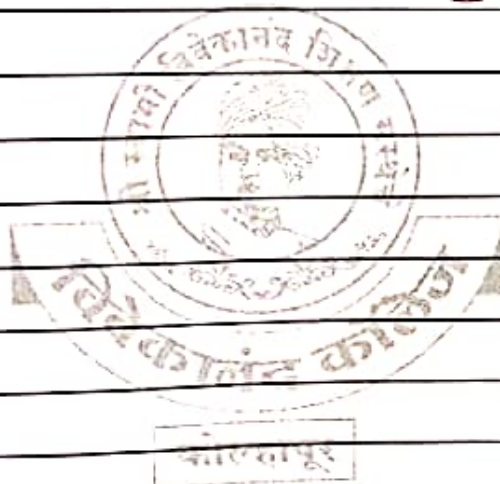
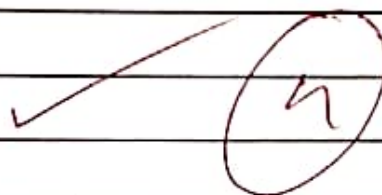
a small atom allowed to move on the x, y, z axis the movement is translation motion and therefore the degrees of Freedom is most monoatomic.



2) Diatomic -

Diatomic molecules like O_2 and N_2 are the movement of Translation motion and the molecules are rotate along the centre of mass i.e. consist two rotational motion and add two degree's of Freedom

$$3N - K$$



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Test / Tutorial No. : Internal Exam SEM-I

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1] A]

1 c) Constraint , force of constraint. ✓

2 b) rheonomous ✓

3 a) linear momentum ✓

4 b) angular momentum. ✓

5 a) scleronomous ✓



3]

Degrees of freedom:

Consider a free particle. This particle can freely move in a space. The coordinates can be Cartesian coordinates (x, y, z) and Spherical polar coordinates (r, θ, ϕ) .

Particle can move freely in any one dimension having independent coordinates. If we have a system of N particles then the degrees of freedom of motion of a system is $3N$.

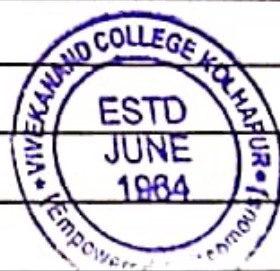
If the system is free of any constraint the particle can move in one dimension along three coordinates. Therefore for N number of particles we have degrees of freedom $3N$.

If a holonomic constraint which is expressed by k is applied the equation of constraint is given by eliminating k from degrees of freedom.

So degrees of freedom, when holonomic constraint is applied is given as $3N - k$.

Thus, the degrees of freedom is defined as, the number of ways in which a mechanical system can move without violating any constraint which is imposed on it is called degrees of freedom.

3



Q2]

We have D'Alembert's principle,

$$\sum_{i=1}^N (\vec{f}_i - \vec{p}_i) \cdot \delta \vec{r}_i = 0$$

$$\sum_{i=1}^N \vec{f}_i \cdot \delta \vec{r}_i = \sum_{i=1}^N \vec{p}_i \cdot \delta \vec{r}_i \quad \text{--- (1)}$$

We have to transform $\vec{r}_i$ into $\vec{q}_j$ as generalised coordinates.

The equation is given as,

$$\vec{r}_i = \vec{r}_i(q_1, q_2, \dots, q_n, t) \quad \text{--- (2)}$$

Then for infinitesimally small virtual displacement the equation is written as

$$\delta \vec{r}_i \frac{\partial \vec{r}_i}{\partial \vec{q}} = \frac{\partial \vec{r}_i}{\partial q_1} dq_1 + \frac{\partial \vec{r}_i}{\partial q_2} dq_2 + \dots + \frac{\partial \vec{r}_i}{\partial q_n} dq_n$$

$$\therefore \delta \vec{r}_i \frac{\partial \vec{r}_i}{\partial \vec{q}} = \sum_{j=1}^n \frac{\partial \vec{r}_i}{\partial q_j} dq_j \quad \text{--- (3)}$$

Above equation is independent of time. Hence virtual displacement is constant in time.

∴ velocity of the i^{th} particle is

$$\vec{v}_i = \frac{d\vec{r}_i}{dt}$$

Diffⁿ w.r.t t we get.

$$\frac{\partial \vec{r}_i}{\partial t} = \frac{\partial \vec{r}_i}{\partial q_1} \frac{dq_1}{dt} + \frac{\partial \vec{r}_i}{\partial q_2} \frac{dq_2}{dt} + \dots + \frac{\partial \vec{r}_i}{\partial q_n} \frac{dq_n}{dt} + \frac{\partial \vec{r}_i}{\partial t}$$

$$\frac{\partial \vec{r}_i}{\partial t} = \sum_{j=1}^n \frac{\partial \vec{r}_i}{\partial q_j} \frac{dq_j}{dt} + \frac{\partial \vec{r}_i}{\partial t}$$

$$\frac{\partial \vec{r}_i}{\partial t} = \sum_{j=1}^n \frac{\partial \vec{r}_i}{\partial q_j} \dot{q}_j + \frac{\partial \vec{r}_i}{\partial t}$$



where $\dot{q}_j = \frac{dq_j}{dt}$ generalised velocities

Using eqn (3) in (1) we get.

$$\begin{aligned}\sum_{i=1}^N \vec{f}_i \cdot d\vec{r}_i &= \sum_{i=1}^N \vec{f}_i \cdot \sum_{j=1}^N \frac{\partial \vec{r}_i}{\partial q_j} dq_j \\ &= \sum_{j=1}^N \left(\sum_{i=1}^N \vec{f}_i \cdot \frac{\partial \vec{r}_i}{\partial q_j} \right) dq_j \\ &= \sum_{j=1}^N Q_j dq_j \longrightarrow (5)\end{aligned}$$

where $\sum_{i=1}^N \vec{f}_i \cdot \frac{\partial \vec{r}_i}{\partial q_j} = Q_j$

Consider the equation

$$\begin{aligned}\vec{p}_i &= m_i \vec{v}_i \\ \vec{p}_i &= m_i \dot{\vec{r}}_i\end{aligned}$$

$$\therefore \sum_{i=1}^N \vec{p}_i \cdot d\vec{r}_i = \sum_{i=1}^N m_i \dot{\vec{r}}_i \cdot d\vec{r}_i \longrightarrow (6)$$

Consider,

$$\begin{aligned}\frac{d}{dt} \left(m_i \dot{\vec{r}}_i \cdot \frac{\partial \vec{r}_i}{\partial q_j} \right) &= \frac{d}{dt} (m_i \dot{\vec{r}}_i) \cdot \frac{\partial \vec{r}_i}{\partial q_j} + m_i \dot{\vec{r}}_i \cdot \frac{d}{dt} \left(\frac{\partial \vec{r}_i}{\partial q_j} \right) \\ &= m_i \ddot{\vec{r}}_i \cdot \frac{\partial \vec{r}_i}{\partial q_j} + m_i \dot{\vec{r}}_i \cdot \frac{d}{dt} \left(\frac{\partial \vec{r}_i}{\partial q_j} \right)\end{aligned}$$

$$m_i \dot{\vec{r}}_i \cdot \frac{\partial \vec{r}_i}{\partial q_j} = \frac{d}{dt} \left(m_i \dot{\vec{r}}_i \cdot \frac{\partial \vec{r}_i}{\partial q_j} \right) - m_i \ddot{\vec{r}}_i \cdot \frac{\partial \vec{r}_i}{\partial q_j} \longrightarrow (7)$$

Consider

$$\frac{d}{dt} \left(\frac{\partial \vec{r}_i}{\partial q_j} \right) = \frac{\partial}{\partial q_j} \left(\frac{d\vec{r}_i}{dt} \right) = \frac{\partial \dot{\vec{r}}_i}{\partial q_j} \longrightarrow (8)$$

we have

$$\vec{v}_i = \frac{\partial \vec{r}_i}{\partial t}$$

$$\frac{\partial \dot{\vec{r}}_i}{\partial t} = \frac{\partial \vec{r}_i}{\partial t} \longrightarrow (9)$$



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using eqn (8) and (9) in eqn (7)

$$\begin{aligned}
 m_i \vec{r}_i \frac{\partial \vec{r}_i}{\partial q_j} &= \frac{d}{dt} \left(m_i \vec{r}_i \frac{\partial \vec{r}_i}{\partial \dot{q}_j} \right) - m_i \vec{r}_i \frac{\partial \dot{q}_j}{\partial t} \\
 &= \frac{d}{dt} \left(\frac{m_i}{2} \vec{r}_i^2 \right) - \frac{m_i}{2} \frac{\partial \vec{r}_i^2}{\partial t} \\
 \therefore \vec{r}_i \frac{\partial \vec{r}_i}{\partial t} &= \frac{1}{2} \frac{\partial \vec{r}_i^2}{\partial t}
 \end{aligned}$$

putting in eqn (6)

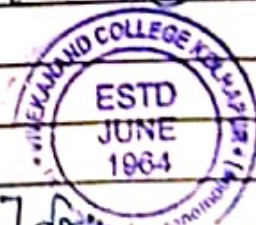
$$\sum_{i=1}^N \vec{p}_i \cdot d\vec{r}_i = \sum_{i=1}^N \left[\frac{d}{dt} \left(\frac{1}{2} m_i \vec{r}_i^2 \right) - \left(\frac{1}{2} m_i \vec{r}_i^2 \right) \right] d\vec{r}_i$$

$$\therefore \sum_{i=1}^N \vec{p}_i d\vec{r}_i = \left[\frac{d}{dt} \left(\sum_{i=1}^N \frac{1}{2} m_i \vec{r}_i^2 \right) - \sum_{i=1}^N \frac{1}{2} m_i \vec{r}_i^2 \right] d\vec{r}_i$$

$$= \sum_{i=1}^N \left[\frac{d}{dt} \left(\frac{\partial T}{\partial \dot{q}_j} \right) - \frac{d}{dt} \left(\frac{\partial T}{\partial \dot{q}_j} \right) \right] d\vec{r}_i \rightarrow (10)$$

using eqn (10) and (5)

$$\sum_{i=1}^N Q_i dq_j = \sum_{i=1}^N \left[\frac{d}{dt} \left(\frac{\partial T}{\partial \dot{q}_j} \right) - \frac{d}{dt} \left(\frac{\partial T}{\partial \dot{q}_j} \right) \right] d\vec{r}_i$$



$$Q_j = -\frac{\partial v}{\partial t}$$

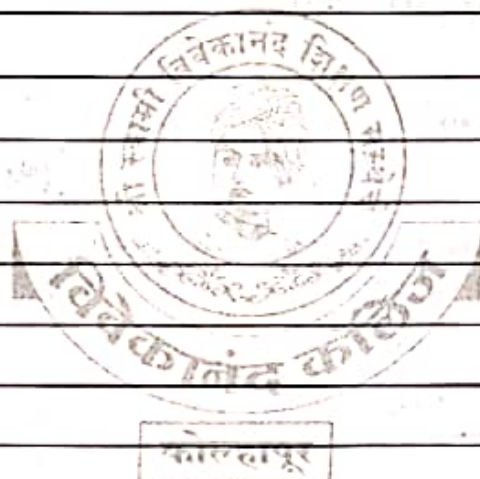
$L = T - v$ is Lagrangian

$$\left[\frac{d}{dt} \left(\frac{\partial T}{\partial \dot{q}} \right) - \frac{\partial T}{\partial q} - \frac{\partial (-v)}{\partial q} \right] = 0$$

$$\frac{d}{dt} \left(\frac{\partial (T-v)}{\partial \dot{q}} \right) - \frac{\partial (T-v)}{\partial q} = 0$$

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

9



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Department of Physics

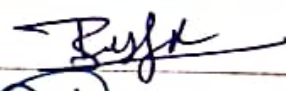
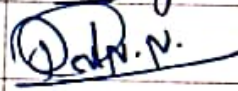
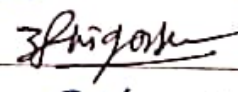
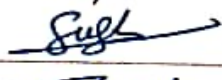
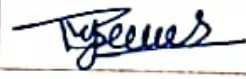
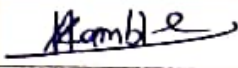
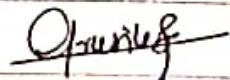
M.Sc. Part-I SEM Internal Examination (2023-24)

Paper- classical Mechanics

Day: - Wednesday
Date: - 25/10/2023

Time: - 2.00 pm- 03.00 pm
Total Marks:20

Attendance

Sr. No.	Name of the students	Sign
1	Biradar Shubhangi B.	
2	Devkule Nishigandha	
3	Dhiraj P Bhingardeve	
4	Suyash S. Dongare	
5	Mahek S. Tamadar	
6	Anjali B. Kamble	
7	Graceli B. Gravaale	
8	Akash Kavathekar	
9	Vedaja Yadav	
10		
11		
12		
13		
14		
15		



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Vivekanand College, Kolhapur (Empowered Autonomous)
Department of Physics

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

Research Methodology

Paper code: MIN12PHY11

Date: - 26/10/2023

Time :- 12.00 noon- 1.00 pm

Total Marks: 20

Day: - Thursday

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) In types of research researcher has to make more critical evolution of the materials.
(a) descriptive (b) applied ~~(c) analytical~~ (d) fundamental
- ii) Intypes of the research approaches researcher has greater control over research environment.
(a) inferential ~~(b) experimental~~ (c) simulation (d) qualitative
- iii) is called as focal point of research.
~~(a) Research hypothesis~~ (b) Research problem
(c) Literary Survey (d) Research design
- iv) Which of the following is not a principle of experimental design.
(a) principle of replication (b) principle of randomization
(c) principle of local control ~~(d) principle of minimization~~
- v) To measure the scattering of values from average values we use methods of data analysis.
(a) statistical average ~~(b) dispersion~~ (c) asymmetry (d) relationship

Q.2 Attempt any one

(10)

- i) Define the meaning and objectives of research. Explain the types of research in detail.
- ii) Give detailed account of research designs with research approaches.

Q.3 Attempt any one

(5)

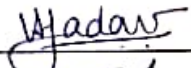
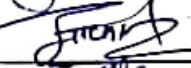
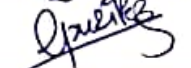
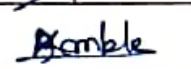
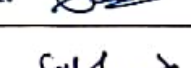
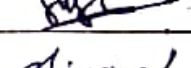
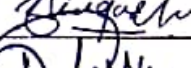
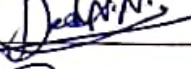
- i) Explain various methods of data collection in research with significance of research.
- ii) Define simple regression, multiple correlation and partial correlation methods in detail.



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Vivekanand College (Autonomous), Kolhapur.
 Department of Physics
 M.Sc. I Internal Examination Oct-2023
 Research methodology

Day and Date: Thursday, 26/10/2023

Time: 12-1pm

Roll No	Name of Students	Sign	Marks
	Vedaja Yadav		14
	Akash kavathekar		13
	Gouri B Gavade		17
	Anjali B. Kamble		19
	Mahek S. Jamadar		15
	Suyash S. Dongare		14
	Dhisey. P. Bhingorli		16
	Devuade Nishiganta		09
	Dixadar. shubhangi. l.		03



Name :- Anjali Bhagwan Kamble.

॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

- शिक्षणमहर्षी डॉ. बापूजी साळुंखे

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Class : M.Sc I

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19/2/2023
[Signature]

Subject : Research Methodology.

Test / Tutorial No. : Internal Exam.

Div. :

i. In — types of research researcher has to make more critical evolution of materials.

→ c) analytical.

ii. In — types of the research approaches researcher has great control over research environment.

→ b) experimental.

iii. — is called focal point of research.

→ a) Research hypothesis

iv.

→ b) principle of randomization.

v. To measure the scattering of values from average values we use — method of data analysis.

→ b) dispersion.



i. There are various methods in data collection in research.

A) Primary data collection method.

- In this method ~~rese~~ of research researcher has start his/her research from the primary sources like Books, newspaper, documentaries. which are already available in the publication.
- It is also called as the generalisation method because he/she only use the material which are already available.
- It has another two types inferential and descriptive method.
- In descriptive method researcher should present his/her research in detail on the basis of the topic which is taken.
- On the other hand in inferential research method researcher can present his/her work in short. ~~as~~ is

B) Secondary Data Collection method.

- In this method of research researcher have to go outside the box and thinking about the topic.
- In this way of research the information is not already or easily available. ~~so~~
- So researcher's duty is to collect the data by himself/herself by going out.

1) Interview method

It consists is very widely used method to collect the data.

It consists of two types personal / face to face interview & telephone interview.

a) personal interview - In this type researcher have to go to the place where interview stay and then they



give the interview. ~~it is~~ it is quite difficult method or way because it consists of time & money.

b) Telephone interview - It is very simplest method to collect the data & finding the information which is important to the research.

- The researcher can ask question to the interview through telephone and it doesn't costs money or ~~very~~ very much time.
- It is widely used method.

2) Through Questionerion -

- In this method researcher have to make list of questions which hel/she have to ask.
- Questioneries is also a simple method because we already know what we have to ask.
- Researcher make the list of questions on the basis of his/her topic of research.

3) Through local control -

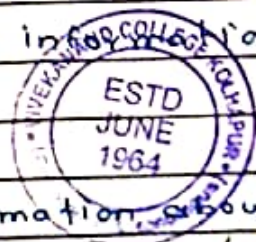
- In this method researcher has to go to local place to collect the data about research.
- The information given by the people can use as response or comment for the research.

4) Through Generalisation -

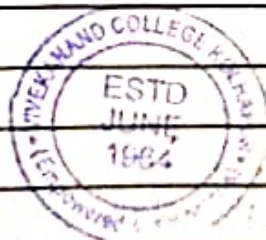
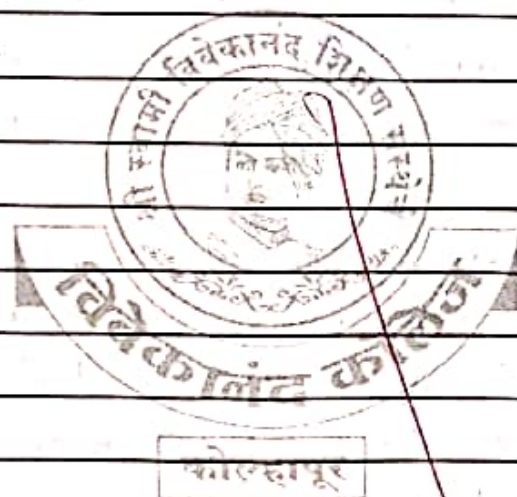
- In this type researcher can get the reference from the Biography, Books, Newspaper and government if the related information is available.
- If the topic was related to the population or on the basis of globalisation, researcher can ask to the help to the government survent to collect the information.

• Significance of research. -

- The research helps to us to collect information about every small section or topic.
- It helps to government to get more data in his office.



- It helps to citizen to awareness about each and every detail.
- It gives information to the normal people who is not in the city or to develop itself.
- It is very useful to youth like us to develop our knowledge.
- It also help to government to develop country.



Name :- Anjali Bhagwan kamble .

॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

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Subject : Research Methodology .

Test / Tutorial No. : Internal Exam .

Div. :

→ Meaning of research - It is the possible / simple way to collect the data about every topic.

- The research is based on the popular issues done around us.

- So researcher has to select the topic related to that incidence.

- Objectives in research -

- Researcher should give time as well as money to the research.

- It help to finding the more information about each & every thing.

- It increases the informational data in our stationary.

Types of research .

- 1) clinical research - The researcher can research in the field of clinical based topic.

- The information is available about the clinical is in books, or we can get it from the people who worked in that field.

- 2) Personal research -

In this type the research to the researcher should research about the particular person who is slightly different

From other.

3) Governmental research —

The researcher can study or research about the government issues.

4) local research —

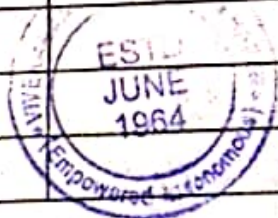
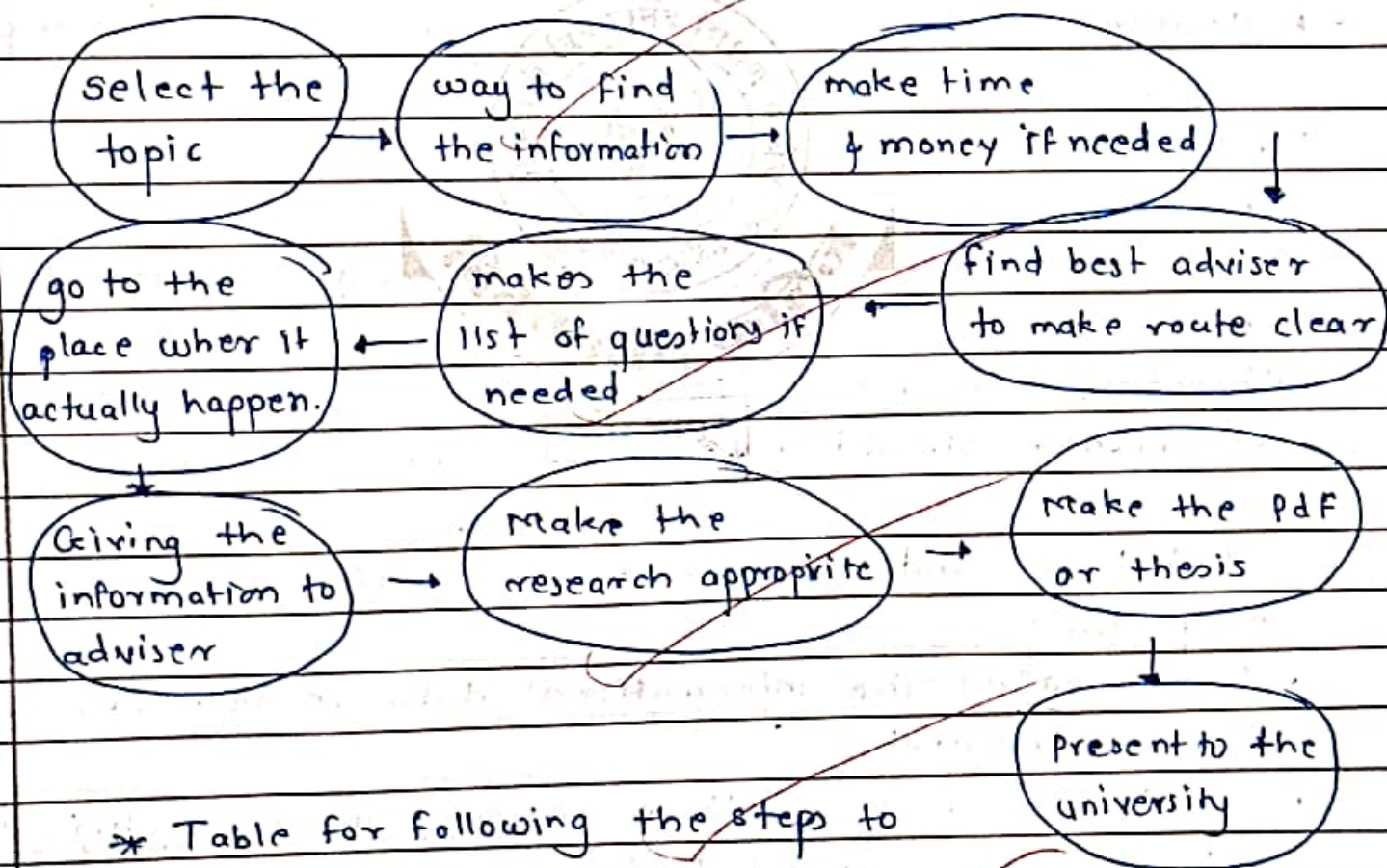
The research can be based upon ~~local~~ local ~~prop~~ problems.

5) Global research —

The researcher can research on the global ~~his~~ issues.

6) Scientific research —

This research is based on the topic of science. which is main part of research methodology.



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Class: Plac-I

1) ⑥ Applied.

2) ⑥ Experimental.

3) ⑥ Research hypothesis

4) ⑥ principle of local control

5) ⑥ Dispersion



② Research Design :-

Important ^{Parts} Concept of Research Design :-

1) sampling of Design :-

It involve or In this design to observed atom for given study.

2) observation of design :-

To observe given sample.

3) statistical design :-

To ~~analyze~~ analyse the atom over observed

information and data gathered

4) operational design :-

In this desi operational design carried out sampling, observational and statistical design

Need of Research Design :-

1) To make research as effective as possible yielding maximum information with



minimum expenditure of time, money and efforts



Features of Good Research Design -

- ① Good Research design is characterised by adjectives like flexible, Appropriate and effective.
- ② It should be minimum bias and maximum reliability of data collections & measures.
- ③ It should gives smallest experimental error.
- ④ It provides maximum opportunities to various research problems.

Some Important concepts of Research Design.

dependent and independent variable

Treatment

confounded relationship

Research Hypothesis

concept of Research Design

control.

experimental & non experimental units

experimental & non experimental hypothesis

Types of Research Design :

① In case of Exploratory Research Design :

- ① it is basically formulated research problem
- ② The main basic purpose of this design is formulating research problem for precise investigation, or, of developing the research, working of hypothesis for research.

There are some concepts of exploratory research design.

- ① survey of considering literature
- ② Experience survey
- ③ Insight stimulating.

Survey of considering literature is simple and fruitful processes.

In Experience survey, the survey of people who have had practical experience of given research problem.

Insight stimulating is useful for research in suggesting hypothesis for research.

② In case of Descriptive Research Design :

In this research the research describing characterisation of particularly individual group or describing characteristics



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Diagnostic Research :

In this research, researcher determine the frequency of give problem, and researcher know what he wants to measure.

③ Experiment Testing of hypothesis :

In this method researcher can test the hypothesis of for research.

Research Approaches.

① Quantitative Approach

② Qualitative Approach

① Indrational Approach

②

③ Experimental Approach



Quantitative Approach :

In this approaches researcher gathered quantitative information

can be subjected for quantitative analysis

① Infredional Approach :

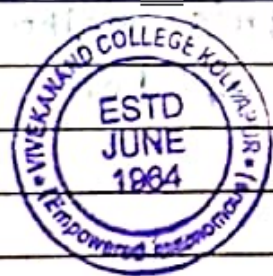
in this approach to make data bases and to form relationship certain extend

② Experimental Approach ::

In this method researchers have total control on Research experiment and variables. Researcher can be manipulated variable

③ Qualitative Approaches

In this research approach mainly concern with investigation results and human behaviour



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Department of Physics
M.Sc. Part-I SEM I internal Examination (2024-25)
Course Code: DSE12PHY11
Solid State Physics-I

Date: 26/10/2023

Day: Thursday

Total Marks: 20

Time: 2.00 to 3.00 pm

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:

(08)

✓. ----- is a coating process that uses thermally induced chemical reactions at the surface of a heated substrate, with reagents supplied in gaseous form.

- (a) CBD (b) CVD (c) Diffusion (d) Spray pyrolysis

✗. ----- breakdown occurs because of the high electric field.

- (a) Voltage b) Avalanche c) Zener d) none of these

Q.2 Attempt any one

(12)

1. What is mean by work function? Explain the formation of graded junction and Schottky barriers.
- ✗. Explain the effect of temperature and doping on mobility. Explain the terms Drift and resistance.

Q.3 Attempt any one

(06)

- ✓. Explain Direct recombination of electrons and holes, Indirect recombination and trapping.
2. Give the construction and working of tunnel diode



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: Msc Physics

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Subject : solid state physics

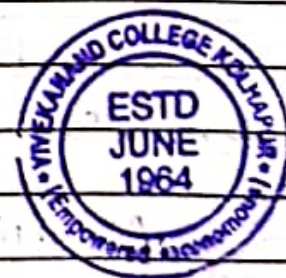
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Effect of temperature and Doping on Mobility

① CVD is coating process that uses thermally induced chemical reactions at the surface of a heated substrate, with reagents supplied in gaseous form.

② Zener breakdown occurs because of the electric field



22. (2). Effect of temperature and doping on Mobility

- The mobility of charge carriers is essentially a measure of the ease with which carriers can move under the influence of an electric field

- Mobility is determined by scattering of carriers

Two basic types of scattering mechanism are there.

Lattice Scattering

It occurs due to vibrations of lattice atom

Impurity Scattering

It occurs because carriers are scattered or deflected because of interaction with impurity atoms

① Lattice Scattering :- The lattice scattering is also known as phonon scattering.

The vibrating atoms create acoustic waves in the crystals. These acoustic particles are known as phonons.

So, we can calculate energy of these phonons such as:

$$E_{\text{phonon}} = \hbar \omega$$

Let K be the wave vector or propagation vector. So, $K = \frac{2\pi}{\lambda}$

Acoustic particles - phonons.

$E_{\text{phonon}} = \hbar \omega$ & wave vector, $K = \frac{2\pi}{\lambda}$

$\uparrow$ - Freq. of lattice vibration increases.



if Temperature increases mobility decreases.

$$\mu_n = \frac{q\tau}{m n^*} \quad (1) \quad \tau \rightarrow \text{Mean time b/w Scattering events.}$$

Lattice Scattering :-

Probability that a carrier will be scattered by mechanism i within a time period dt is.

$\frac{dt}{\tau} \rightarrow$ mean time b/w scattering events.

Therefore probability that a carrier will be scattered by any mechanism can be written as.

$$\frac{1}{\tau} = \frac{1}{\tau_1} + \frac{1}{\tau_2} \quad (2)$$

$$\frac{1}{\mu} = \frac{1}{\mu_1} + \frac{1}{\mu_2} + \dots \quad (4)$$

Impurity Scattering :-

when carriers are charged then ionized impurity also charged.

It means carrier passing through the ionized impurity will get deflected.

Here in this case photon are the scatter carriers.

So as the temperature increases then the frequency of lattice vibration increases.

But exactly opposite.

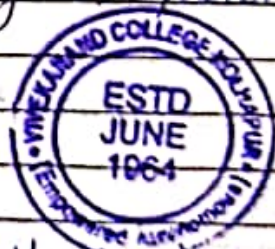
As temperature increases then the mobility of photons decreases. & it can be written as

$$\mu = \frac{q\tau}{m n^*}$$

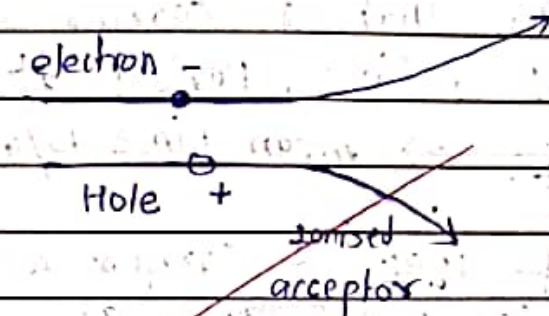
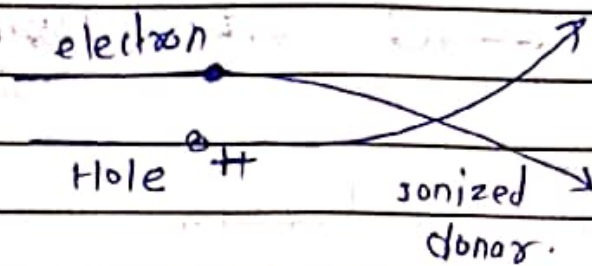
where μ = mobility

τ = mean time between scatt. events

$m n^*$ = effective mass



mobility $N_D + N_A$.



06

3.

① Direct Recombination of electrons & Holes.

Excess of carriers (electron & holes) can be created into a semiconductor therefore conductivity increases.

When excess carriers arise from optical luminescence the resulting conductivity is known as photoconductivity.

In the process of electron hole recombination an excess electron in conduction band falls to the valence band.

This electron now occupies the vacancy representing holes.

This transition of electron can be direct or indirect.



" ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार "

-शिक्षणमहर्षी डॉ. बापूजी साळुंखे

Shri Swami Vivekanand Shikshan Sanstha Kolhapur's

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

SUPPLIMENT

Signature
of
Supervisor

Subject : Solid state physics

Test / Tutorial No. :

Div. :

Suppliment No. : 1

Roll No. : 1301

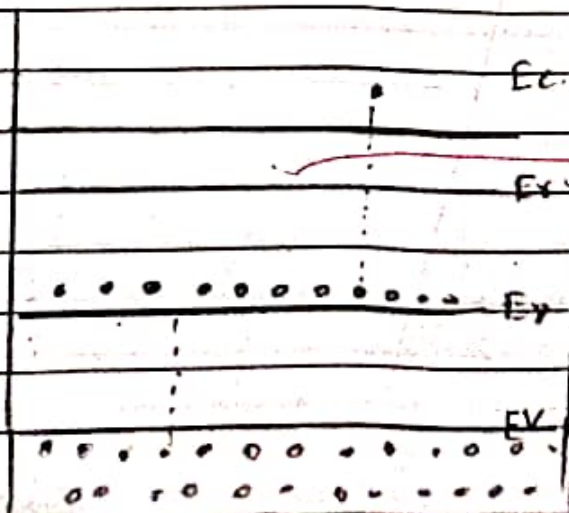
Class : Msc - I

Indirect Recombination :- Trapping

The majority of the recombination event in indirect materials occurs via recombination levels within the band gap.

The resulting energy loss by recombining electron is usually given up to the lattice as heat rather than by the emission of photons.

Any impurity or lattice defect can serve as a recombination centre if it is applicable of receiving one type of carrier and subsequently capturing the opposite type of carrier



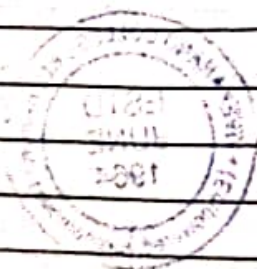
Carrier lifetime.

The carrier lifetime resulting from direct recombination is more applicable than is the case for indirect recombination.

Reason is unequal times required for capturing each type of carrier.

Temporary trapping :-

When a carrier is trapped temporarily at a center and then is re-excited without recombination the process is known as temporary trapping.



॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

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02.09.20

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Supervisor

Subject: Solid State physics

Test / Tutorial No. :

Div. :

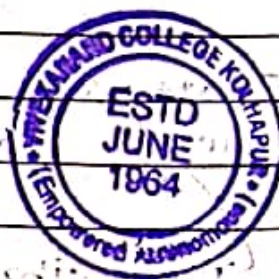
Suppliment No. : -1 + 2 = 3

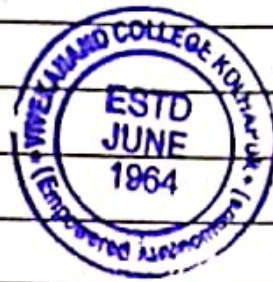
Roll No. : 1313

Class :

b) CVD

c) Zener.





The mobility of charge carriers is essentially a measure of the ease with which carriers can move under the influence of an electric field.

Two basic types of scattering mechanism are there

Lattice scattering

It occurs due to vibration of lattice atoms

Impurity scattering

It occurs because carriers are scattered or deflected because impurity atoms

Lattice Scattering : The lattice scattering is also known as phonon scattering

The vibration atoms create acoustic wave in the crystals. This quanta of acoustic wave is known as phonon

So, therefore we can calculate energy of that photons such as

$$E_{\text{photon}} = \hbar \omega$$

$\therefore$ let k be the wave vector or Propagation Vector so,

$$k = \frac{2\pi}{\lambda}$$

Acoustic Particles - Photons

$$E_{\text{photon}} = \hbar \omega \quad \text{wave vector}$$

$$k = \frac{2\pi}{\lambda}$$

$$\mu_h = qE$$

~~m_h~~

$E \Rightarrow$ Meantime b/w
Scattering events



Lattice Scattering

Probability that a carrier will be scattered by mechanism 'i' within a time period dt is

$\frac{dt}{\tau}$ means time b/w scattering events.

∴ Probability that a carrier will be scattered by any mechanism can be written as

$$\sum \frac{dt}{\tau_i}$$

$$\frac{1}{\tau} = \frac{1}{\tau_1} + \frac{1}{\tau_2} + \dots \quad (3)$$

$$\frac{1}{\mu} = \frac{1}{\mu_1} + \frac{1}{\mu_2} + \dots \quad (4)$$



॥ ज्ञान, विज्ञान आणि सुसंस्कार यांसाठी शिक्षण प्रसार ॥

- शिक्षणमहर्षी डॉ. बापूजी साखुंबे

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Class :

Impurity / Scattering

When Carriers are charged then
ionized impurity also charged.

It means carrier passing through the
ionized impurity will get retracted.

Here in this temp. increases then Frequency
of lattice vibration increases.

But exactly opposite

as temp. increased then the mobility of Photons
decreases & it can be written as



$$\mu = \frac{qE}{m_n v}$$

where

μ = mobility

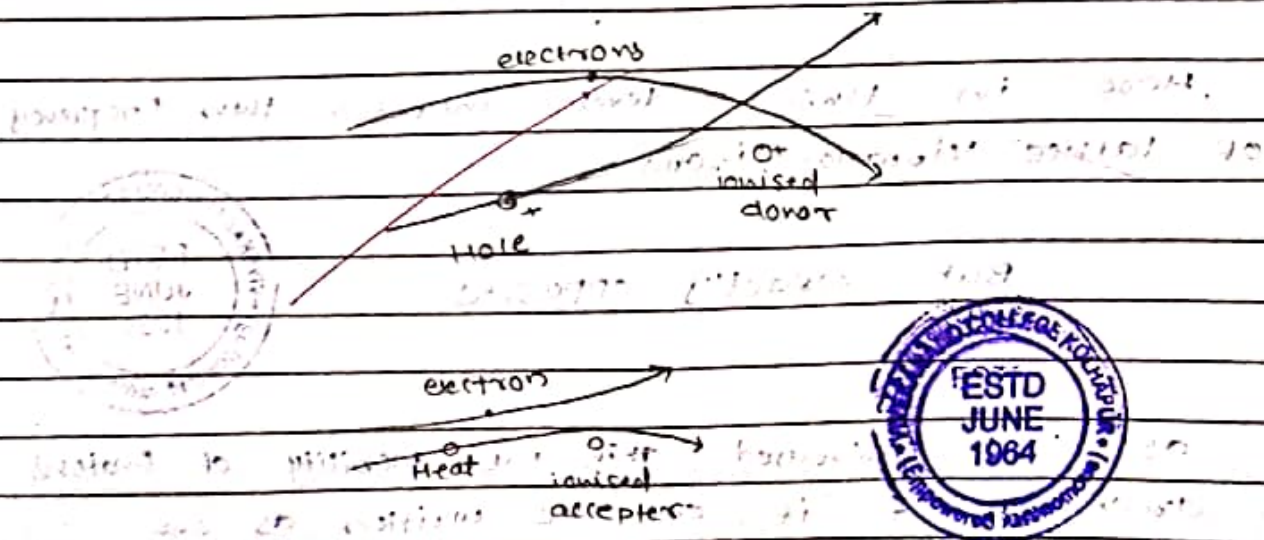
τ = mean time betⁿ scattⁿ event

m_n = effective mass

the mobility of electrons is $\propto$ to the mean time between scattⁿ event (τ) & inversely proportional to carrier thermal velocity (v_{th})

$$\mu \propto \tau \propto \frac{1}{v_{th}}$$

$$\mu \propto \frac{1}{v_{th}} \propto \frac{1}{\sqrt{T}}$$



mobility Not N_A

they are deflected by +ve & -ve dopants
like

4 Case 1 - carrier deflected by ionic red donors
atoms

2> Case 2 - carrier deflected by ionized acceptor
atoms

It means mobility μ depends on
total R doping

It means

$$\mu = \mu_0 \left(\frac{N_0}{N_0 + N_A} \right)$$

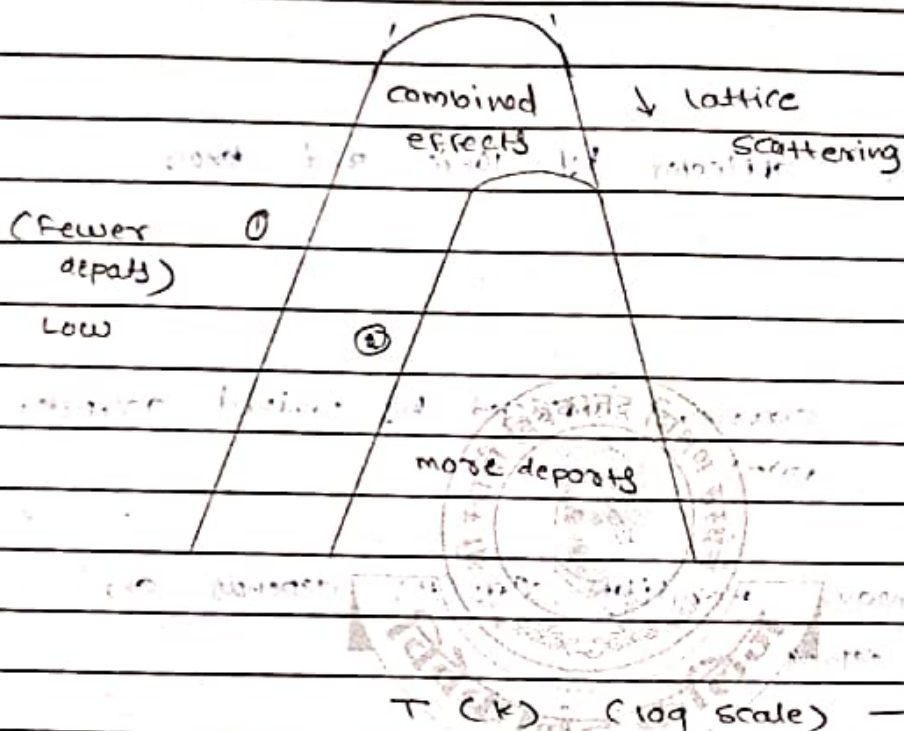
mobility (μ) increase only low impurity
Concentrations: if impurity concentration is low



Impurity
Scattering

Photons
Scattering

Mobility (log scale)



In this fig it is seen that
on x-axis temp (T) taken & on y-axis

mobility (μ) taken it is in log scale.



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Suppliment No. : 2

Roll No. :

Class :

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of
Supervisor

Subject :

Test / Tutorial No. :

Div. :

8.8.4

Direct recombination of electric & holes

- Excess of carriers can be created into a semiconductor therefore conductivity increases.

When excess carriers are created from optical irradiance, the resulting conductivity is known as Photoconductivity.



In optical absorption electron hole pair are created

In the process of electron hole recombination an excess electron in conduction band falls to the valance band.

This electron now occupies the vacancy representing hole

this transition of electron can be direct or indirect.

Indirect recombination : trapping



The majority of the recombination events in indirect material occur via recombination level within the band gap

The resulting energy loss by recombining electron is usually given up to the lattice as heat rather than by the emission of photons.

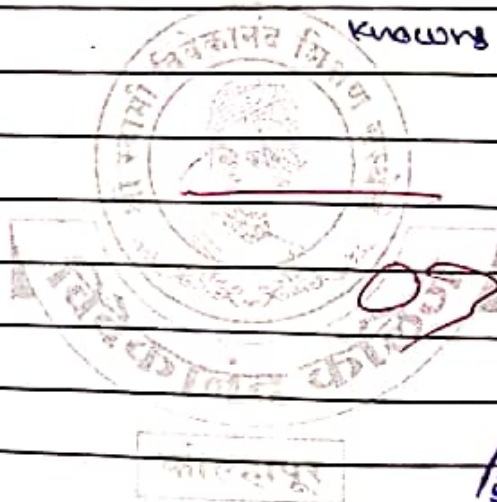
Indirect recombination; trapping

Carrier lifetime

the carrier lifetime resulting from direct recombination is more direct recombination

temporary trapping

when a carrier is trapped temporarily at a recombination center & thus is re-excited without recombination the process is known as temporary trapping



"Education for Knowledge, Science and Culture"

-Shikshanmaharshi Dr. Bapuji Salunkhe

Shri Swami Vivekanand Shikshan Sanstha, Kolhapur

Vivekanand College, Kolhapur (Empowered Autonomous)

Department of Physics

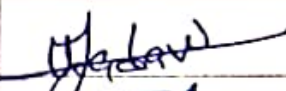
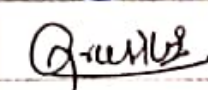
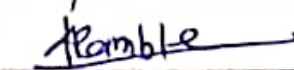
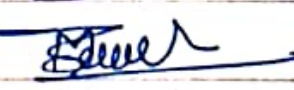
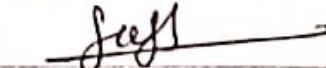
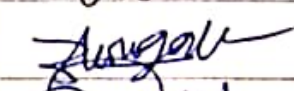
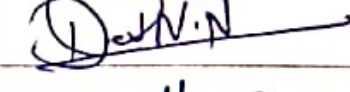
M.Sc. Part-I SEM-I Internal Examination (2023-24)

Paper- Solid State Physics-I

Day: - Thursday
Date: - 26/10/2023

Time: - 2.00 pm- 03.00 pm
Total Marks:20

Attendance

Sr. No.	Name of the students	Sign
1	Vedaja Yadav	
2	Akash Karathekar	
3	Guni B. Gaware	
4	Anjali B. Kamble	
5	Mahek S. Tamadar	
6	Swash S. Dongare	
7	Dhiraj P. Bhingardave	
8	Devuote Nishigandhe	
9	Biradar. Shubhangi. b.	
10		
11		
12		
13		
14		
15		

