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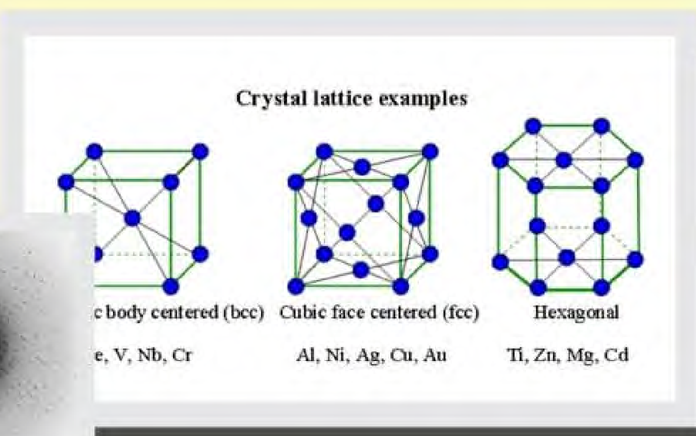
CBCS PATTERN

KAVAYITRI BAHINABAI CHAUDHARI
NORTH MAHARASHTRA UNIVERSITY

T.Y.B.Sc. • SEM V • PHY 502

SOLID STATE PHYSICS

Dr. R. M. Shewale



Prashant

PHYSICS

As per U.G.C. Guidelines and also on the basis of revised syllabus of **Kavayitri Bahinabai Chaudhari North Maharashtra University** with effect from June, 2020, Also useful for all Universities.

SOLID STATE PHYSICS

T.Y.B.Sc. (CBCS) | PHY - 502 | Sem V

- A U T H O R -

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Preface

I have great pleasure to place the book on "PHY– 502: SOLID STATE PHYSICS" in the hands of TYBSc students. The book is strictly written and complied according to the semester pattern syllabus framed by the Board of Studies in Physics, KBC NMU Jalgaon, for Third year BSc to be implemented from June 2020 and is written in lucid, simple language giving exhaustive details. Questions of various types are included at the end of each chapter. This will help in generating interest and thorough understanding of the subject. I hope, this book will be useful for the students and teachers.

I offer my sincere thanks to Mr. Rangrao Patil and Pradeep Patil, Prashant Publication Jalgaon for their co-operation and keen interest in publishing this book. Any constructive comments, suggestions and criticism from the faculty members and the students for further improvement of the subsequent edition will be highly appreciated and thankfully acknowledged.

- Author

Semester - V, PHY - 502 : Solid State Physics

Total lectures: 45 **Total Marks: 60**

Unit 1 : The Crystal Structure **(10 P, 14 M)**

Classification of solids, Lattice, Basis & crystal structure, translational vector, Unit cell, Primitive unit cell, symmetry operations, Types of lattices (2D & 3D), Miller indices, Interplaner spacing, Number of atoms per unit cell, co- ordination number, atomic radius and packing fraction for SC, BCC and FCC structures, Study of CsCl, NaCl and ZnS structures, Concept of reciprocal lattice and its properties with proofs.

Unit 2 : X-Ray Diffraction **(08 P, 10 M)**

Crystal as a grating for X-rays, Bragg's diffraction condition in direct lattice and reciprocal lattice, Ewald's construction, X-ray diffraction methods: Laue method, Rotating crystal method and Powder method, Analysis of cubic crystal by powder method, Brillouin zones (1D & 2D).

Unit 3 : Cohesive energy and Bonding in solids **(09 P, 12 M)**

Cohesive energy and formation of molecules, Definition of dissociation energy of molecule, Types of bonding, Ionic bond, Covalent bond, Molecular bond, Metallic bond and Hydrogen bond, Madelung energy, Madelung constant for one dimensional ionic crystal.

Unit 4 : Lattice vibrations and Thermal Properties **(09 P, 12 M)**

Lattice heat capacity, Classical theory of specific heat, Einstein's theory of specific heat, Vibrational modes in one dimension monoatomic lattice, Debye's model of specific heat of solids, Limitations of Debye model.

Unit 5 : Free electron theory of metals and Band theory of solids **(09 P, 12 M)**

Drude-Lorentz classical theory, Sommerfield's quantum theory: Free electron gas in 1-D and 3-D, Fermi level and fermi energy, Density of states, Formation of Energy band, Distinction between metals, semiconductors and insulators, Hall Effect, Hall co-efficient and mobility

Contents

UNIT 1

The Crystal Structure

Syllabus

Classification of solids, lattice, basis and crystal structure, translational vector, unit cell, primitive cell, symmetry operations, types of lattices (2D and 3D), Miller indices, inter planer spacing, number atoms per unit cell, co-ordination number, atomic radius and packing fraction for SC, BCC and FCC structures, study of CsCl, NaCl and ZnS structures, concept of reciprocal lattice and its properties with proofs.

(10 P, 14 M)

1.1 Classification of solids

1.1.1 Introduction: The crystal structure:

Matter is found to exhibit in the following four states:

1) The solid state
2) The liquid state
3) The gaseous state and
4) The plasma state.

The fourth state is quite unfamiliar state of matter. It is completely different from the first three states. The first three states consist of elements and they have stable atomic configurations. The atoms being formed from particles like electrons, protons and neutrons. The plasma state is totally an ionized state of matter.

Solids possess a definite shape, structure and volume, while liquid have only definite volume. Gases do not possess these properties at all. Microscopically it is observed that the nearest neighbor distance in liquids as well as solids is of the order of few angstroms. ($1A^0 = 10^{-8}$ cm) i. e. they contain 10^{28} to 10^{29} atoms/m^3. In case of gases, this is about 25 A^0 and above, i.e. they contain 1 X 10^{25} molecules/m^3.

Because of higher density compared to gases, there is some order and local irregularity in liquids and solids both. This is called short range order. There exist a regularity and repetition of pattern units in solids which is called as long range order. The liquids do not posses this long range order. We will study only solids which form a very significant branch of Physics namely “Solid State Physics”.

1.1.2 Classification of solids:

Solids are divided into three broad groups:

1) Crystalline solids
2) Amorphous solids
3) Poly crystalline solids

In crystalline solids the atoms are stacked together in a regular manner forming a three dimensional figure which is obtained by three dimensional repetition of certain pattern units but in amorphous solids, there is not any kind of an order in there atomic arrangements. In amorphous solids, arrangement is random in nature.

The periodicity of pattern units extends throughout a certain piece of material. It is called as a single crystal. Frequently the polycrystalline material may occur. It is formed by packing together many single crystals but in different orientations. These are called 'grains', such an assembly of grains together forms a polycrystalline solid. Periodicity is seen only locally and there is a hitch or interruption in the periodicity between two grains. The surface near which the grain symmetry breaks is called the grain boundary. Thus, in polycrystalline solids, there is only short range order.

We will study only the crystalline states of solids henceforth.

1.1.3 Lattice, basis and crystal structure:

Lattice: It is defined as a regular periodic arrangement of points in space. It is a mathematical abstraction which is infinite in extent.

Basis: The structure of all crystals is described in terms of a lattice with a group of atoms attached to each lattice point. This group is called the basis. It may be an atom or a collection of similar or different atoms. It may also be a molecule.

The crystal structure: It is formed only when a basis of atoms is attached identically to each lattice point. The logical relation is lattice + basis = crystal structure.

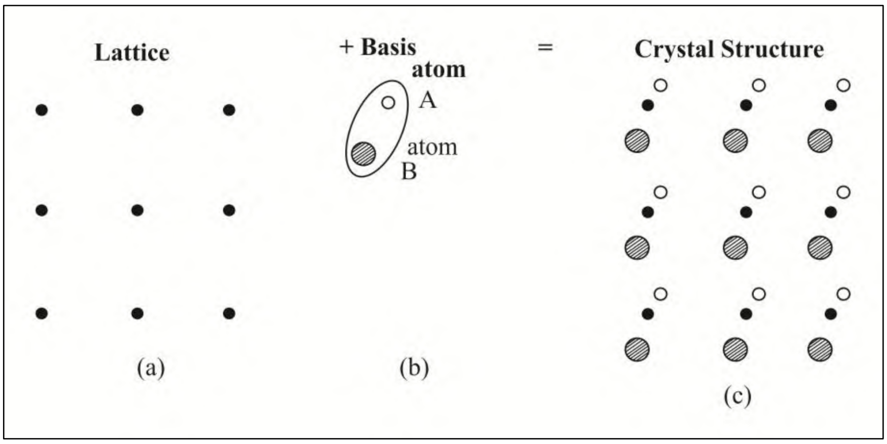
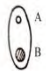
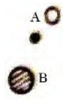


Fig. 1.1 (a) lattice work of points in two dimensions (b) typical basis (c) lattice + basis = crystal

Consider the basis:  A and B different atoms. For a typical lattice point,  the condition for attaching the basis to a lattice point is that if we fix how A and B should be oriented with respect to the lattice points and also fix their distances, we must attach the basis to the remaining lattice points in the same identical fashion. It should also be noted that it is immaterial where the typical atoms are situated with respect to the lattice points but it is important how the basis atoms are situated.

1.2 Translational Vectors

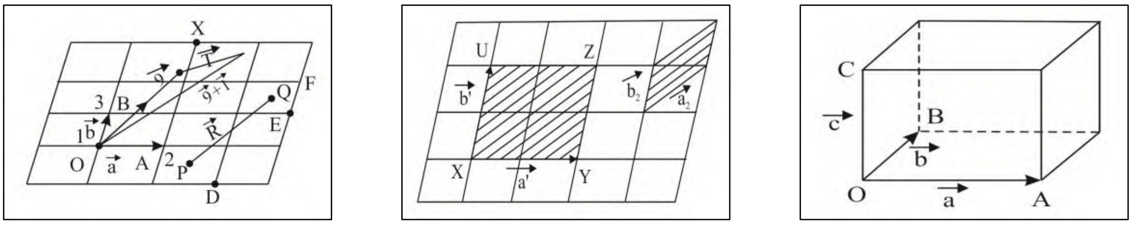


Fig. 1.2 (a) **(b)** **(c)**

Consider a typical lattice structure in two dimensions. Let us choose the point marked one (1) as the origin 'O' and denote A and B points by (2) and (3). Let us call $\overline{OA} = \vec{a}$ and. $\overline{OB} = \vec{b}$. We see that all other lattice points situated at such sites which are obtainable by starting from O and ending at the tip of a vectors $\vec{r}$ are such that $\vec{r} = m\vec{a} + n\vec{b}$; m, n being positive, negative or zero.

We could also have started from any other point P (not necessarily a lattice point) and undergone a further displacement $\vec{R} = \overrightarrow{PQ} = p\vec{a} + q\vec{b}$. p, q are integers.

The point Q is oriented with respect to F in exactly the same manner in which the point P is oriented with respect to D. We also have the position vectors $\vec{\rho}$ and $\vec{\rho} + \vec{T}$ where $\vec{T} = \text{an integer } (\vec{a}) + \text{an integer } (\vec{b})$.

Let us see that what happens from $\vec{\rho}$ to $\vec{\rho} + \vec{T}$. Physically we translate a vector that is $\text{an integer } (\vec{a}) + \text{an integer } (\vec{b})$. Hence $\vec{a}$ and $\vec{b}$ are said to form a set of translational vectors for the lattice. We have also two vectors $\vec{a}$ and $\vec{b}$ [see Fig. 1.2 (b)] which has a property that on translating through a vector $\vec{T}' = \text{an integer } (\vec{a}') + \text{an integer } (\vec{b}')$ we reach equivalent points.

Thus $\vec{a}'$ and $\vec{b}'$ also qualify to be lattice translational vectors. The above examples show that there are several choices of translational vectors. However, there exists a pair of translational vectors such that the elementary parallelepiped formed by them is of minimum area. These translation vectors are called primitive or fundamental lattice translation vectors. For this, there are various choices as shown in Fig.1.2 (b)

In 3 D space lattice, we have $\vec{a}$, $\vec{b}$ and $\vec{c}$ as primitive translation vectors and hence, lattice translation operation is defined by vector, $\vec{T} = m\,\vec{a} + n\,\vec{b} + p\,\vec{c}$, where m, n and p are all integers. An ideal crystal is constructed by regular repetition in space of identical structural units or building blocks usually termed as '*unit cells'*.

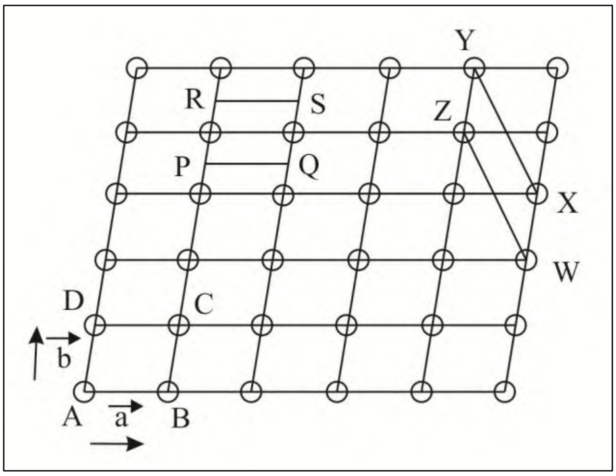


Fig. 1.3

In above Fig.1.3, parallelogram ABCD is called a unit cell. PQRS or WXYZ are also the unit cells. All the unit cells mentioned, contain only one atom each, since each atom situated at the corner belongs to four neighboring parallelogram and each atom located at an edge belongs to two parallelograms. Areas of all these unit cells containing one atom each are also equal.

When a unit cell is chosen such that the atoms are placed only at the corners, again when the sides of the parallelepiped are smallest, then that unit cell is called a '*primitive unit'* cell. If $\vec{a_1}$, $\vec{a_2}$, $\vec{a_3}$ we are the vectors representing the sides of primitive unit cell, then $\vec{a_1} \times \vec{a_2} \bullet \vec{a_3} = V$ where V = Volume of the cell.

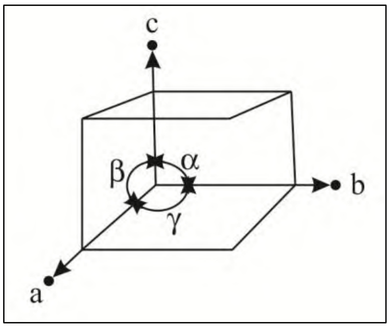


Fig. 1.4

1.3 Symmetry Operations

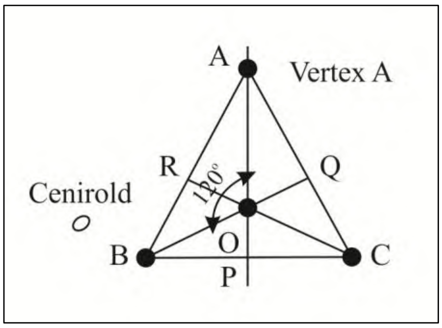
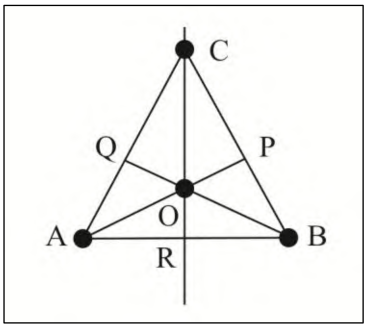
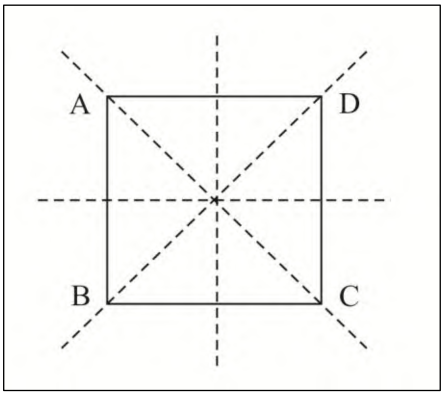


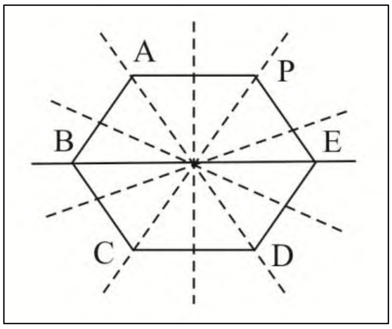
Fig. 1.5 : a)



b)



c)



d)

Consider an equilateral triangle ABC. [See Fig.1.5 (a)]. Suppose that there are identical atoms situated at the vertices. If we rotate this triangle by 120^0 in its plane about an axis perpendicular to the plane through centroid 'O', the triangle has then different orientations. [See Fig.1.5 (b)]. All atoms at A, B and C being identical in every respect, there is no difference between two triangles.

Let us suppose we had a perfect plane mirror polished on both sides and perpendicular to the plane of ΔABC and containing the altitude AC, then we would obtain upon reflection, a structure which exactly coincides with the initial one. Thus due to *mirror reflection* we have the same structure carried in to itself. Thus the above operations carry the structure in to itself be called ***'symmetry operations'*** and the structure is said to possess symmetry under that operations.

1.3.1 Types of Symmetry Operations :

1.3.1.1 Translational Symmetry :

Crystal lattices can be translated into itself by using any translation vector and we obtain exactly the same structure, then the type of structure is supposed to possess ***translational symmetry or translational invariance.***

It is a necessary and sufficient condition to form a crystal structure.

1.3.1.2 Point operations:

There are also some point operations like rotation and reflection. In some crystal structures, these operations are called point operations because we apply them only for lattice points instead of applying for a crystal as a whole. There is also a possibility of possessing two (or more) operations which carry the crystal into itself. These operations are called *compound symmetry operations.*

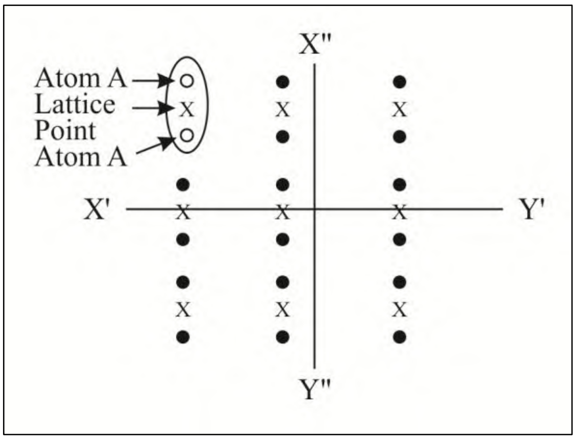
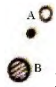


Fig.1.6

Consider a crystal structure as shown in Fig. 1.6. Cross marks are the lattice points. We can obtain the same structure after rotation through 180^0 about X'Y'. Hence the structure has rotational symmetry through 180^0 about X'Y' axis. The same structure does not have rotational symmetry through 180^0 about X''Y'' axis. Also if we have a basis of different atoms  instead of  then we do not have rotational symmetry through 180^0 about X'Y' axis. Thus, it depends upon the lattice, geometrical arrangement and nature of the basis with respect to the lattice.

If we consider an example of equilateral triangle, then it is seen that it possesses rotational symmetry of 120^0 or $(2\pi/3)^C$. Also it has rotational symmetry, if we rotate it through 240^0 or $(4\pi/3)^C$ and 360^0 or $2\pi^C$.

The square has rotational symmetry under $\pi/2$, up to rotations of 2π. There are four positions in which the structure merges into itself. Thus, we say that the equilateral triangle possesses a three - fold rotational symmetry, while a square possesses a four-fold rotational symmetry. A hexagon possesses a six fold symmetric rotation (i.e. a rotation of $\pi/3$). Hence we have 1, 2, 3, 4 or 6 fold rotational symmetries. The fold number can be found by the formula,

$$\text{Fold Number} = \frac{2\pi}{(\text{Minimum angle (non}-\text{zero angle) of rotation which leaves the structure invarient.})}$$

$$\text{Fold Number} = \frac{2\pi}{\theta} \ (\theta \text{is in radians}).$$

We cannot find a lattice that goes into itself under other rotations such as $2\pi/7$ or $2\pi/5$ radians i. e. we do not have five fold symmetry because what happens if we try to construct

Fig.1.7

a periodic lattice having five-fold symmetry, the pentagons do not fit together neatly showing that we cannot combine five-fold point symmetry with the required translational periodicity as shown in Fig 1.7.

1.3.1.2 Mirror reflection symmetry:

Consider an equilateral triangle ABC. It has reflection symmetry about vertical planes AP, BQ and CR. Also we have a reflection symmetry about vertical planes in case of square are hexagon.

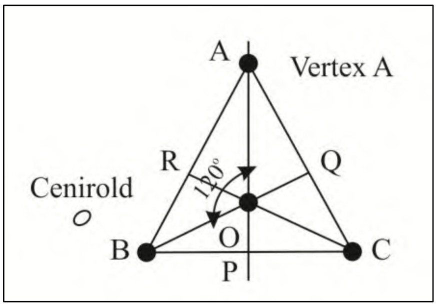
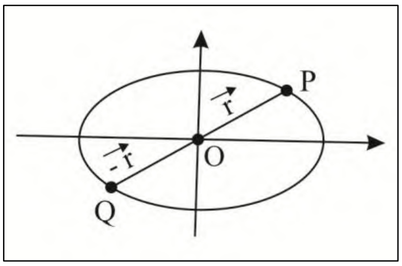


Fig.1.8

1.3.1.2 Inversion symmetry: This operation is made up of a rotation of π followed by the reflection in a plane normal to the rotation axis. The total effect is replace $\vec{r}$ by $-\vec{r}$.



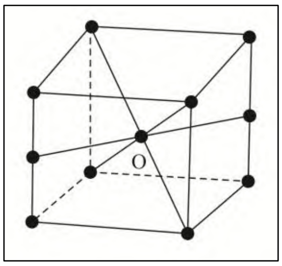


Fig. 1.9 (a) **(b)**

Consider an ellipse as shown in Fig. 1.9. Let P be any point on ellipse. Draw PO and produce it to Q such that PO = OQ then Q lies on ellipse in opposite quadrant. Thus, the entire ellipse goes over into itself. The same is the case in a rectangular parallelepiped about the point 'O'. Such that an operation is called inversion operation and the structure is said to possess symmetry under inversion about the centre of inversion 'O'.

1.4 Types of Lattices

Two and three dimensional lattice types: For studying any type of crystal structure we should have following four basic points:

i) The type of lattice

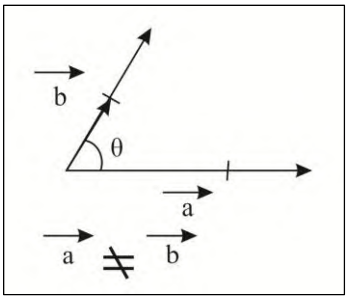
ii) The basis

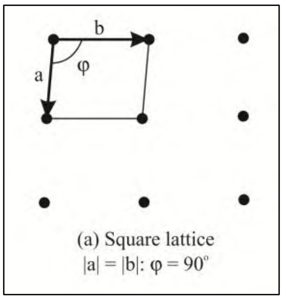
iii) The primitive translational vectors defining the primitive cell and

iv) The symmetry of the structure

1.4.1 Two Dimensional Lattice Types :

i) **Oblique Lattice:** It is a general 2D lattice in which the primitive lattice translational vectors $\vec{a}$ and $\vec{b}$ are different in magnitude and the angle between them is different from 90^0 or 120^0. It has rotational symmetry under π and 2π i. e. it has 2 and 1 fold rotational symmetry.





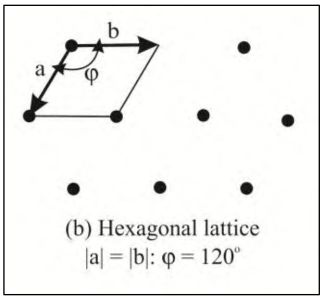


Fig. 1.10 (a) Oblique lattice **b) Square lattice** **c) Hexagonal lattice**

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KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY, JALGAON

S.Y.B.Sc. | PHY 403 | SEM IV

PRACTICAL PHYSICS

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PHYSICS

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PRACTICAL PHYSICS

S.Y.B.Sc. (CBCS) | PHY-403 | Sem IV

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PRACTICAL PHYSICS

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Preface

We are very glad to present the book "PHY– 403 : PRACTICAL PHYSICS" in the hands of SYBSc students. The book is strictly written and complied according to the semester pattern syllabus framed by the Board of Studies in Physics, KBC NMU Jalgaon, for Second year BSc to be implemented from June 2019 and is written in lucid, simple language giving exhaustive details. Questions of various types are included at the end of each chapter. This will help in generating interest and thorough understanding of the subject. We hope, this book will be useful for the students and teachers.

We offer our sincere thanks to Shri. Rangrao Patil of Prashant Publications, Jalgaon for his keen interest in publishing this book. We are also thankful to Mr. Sunil Pandhre for Typesetting. The thanks are also due to Mr. Pradip Patil for bringing out this book in time.

The constructive suggestions from students and faculty members for improving the quality of the book will be solicited.

- Authors

Semester - IV PHY- 403 : Practical Physics

(Credits: 02): (60 L, 100M (40 Internal + 60 External)

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda 2$ – T Law.
3. To study Lissajous Figures and demonstration of Lissajous figures by using C.R.O.
4. Study of acoustic resonance by using bottle as a resonator.
5. Determination of velocity of sound by using Kundt's tube.
6. Study of resonance using Kater's pendulum.
7. Log decrement
8. Damping coefficient
9. Study of acoustic resonance by using resonance tube.
10. To determine the Resolving Power of a Prism.
11. To determine the value of Cauchy Constants of a material of a prism.
12. To determine wavelength of sodium light using Fresnel Biprism.
13. To determine wavelength of sodium light using Newton's Rings.
14. To determine the refractive index of a liquid by using Newton's rings apparatus.
15. Determination of specific rotation α of optically active substance using Polarimeter.
16. Measurement of beam size of a LASER beam.
17. Measurement of beam divergence of a LASER beam.
18. To determine the wavelength of light from LASER source using Diffraction grating.
19. To determine wavelength of (1) Sodium & (2) spectrum of Mercury light using plane diffraction Grating
20. To determine the Resolving Power of a Plane Diffraction Grating.
21. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Contents

Practical No. 1

To Investigate the Motion of Coupled Oscillators.

Theory:

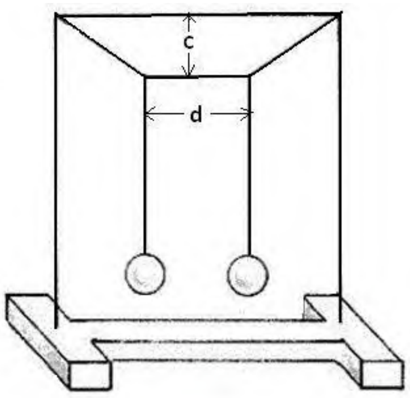
Coupled Oscillator is a useful apparatus for understanding the basic modes of coupling. Two pendulums are coupled though a compression spring and energy transfer takes place from one pendulum to other. To make both the pendulums oscillate with same frequency they are made identical.

Title: Motion of coupled oscillators.

Aim: To study a simple coupled system comprising of two simple pendulums.

Apparatus: Two simple Pendulums, Thread, Stopwatch, and Meter scale etc.

Diagram:



Observations:

Obs. No.	c cm	d cm	Time required for 50 oscillations during			$T_1 = \frac{1}{t_1}$	$T_2 = \frac{1}{t_2}$	$T_3 = \frac{1}{t_3}$	υ_1	υ_2	υ_3	$\lvert \upsilon_1 - \upsilon_2 \rvert$
			I	II	Mixed							
			t_1 sec	t_2 sec	t_3 sec							
1.												
2.												

Procedure:

1. Displace both the bobs by equal amount in the same direction and release. The system will go on oscillating with the displacement ratio always remaining in the ratio 1:1. This is one normal mode. Measure the period of oscillation T_1 by counting 50 or 100 oscillations.
2. Now displace the two bobs in opposite directions by equal amounts and release. The displacement ratio will now remains 1 : (-1). This is second normal mode. Measure the period of oscillation T_2 by counting 50 or 100 oscillations..
3. Now displace only one bob and release. This is mixed mode. Measure the time for 2 cycles of energy transfer back & forth. Let the period of oscillation be T_3. Let the corresponding frequencies for the three modes be,

   $$\upsilon_1 = \frac{1}{T_1}, \qquad \upsilon_2 = \frac{1}{T_2}, \quad \upsilon_3 = \frac{1}{T_3}$$
4. Find | υ_1 - υ_2 | and verify that it is equal to υ_3.
5. Now vary the parameter c & d and repeat the experiment.

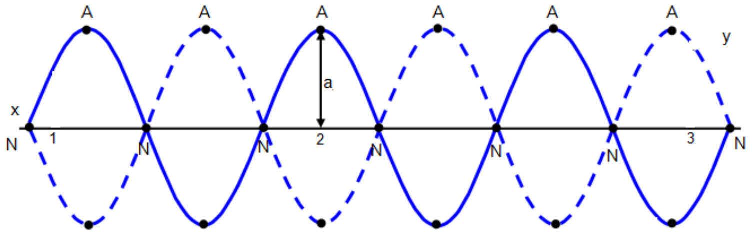
Result: Every time, | υ_1 - υ_2 | = υ_3

Practical No. 2

To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2- T Law.

Theory:

When a string under tension is set into vibrations, transverse harmonic waves propagate along its length. When the length of string is fixed, reflected waves will also exist. The incident and reflected waves will superimpose to produce transverse stationary waves in the string. The string will vibrate in such a way that the clamped points of the string are nodes and the point of plucking is the antinode.



The Envelope of standing

A string can be set into vibrations by means of an electrically maintained tuning fork, thereby producing stationary waves due to reflection of waves at the pulley. The loops are formed from the end of the pulley where it touches the pulley to the position where it is fixed to the prong of tuning fork.

(i) For the transverse arrangement, the frequency is given by,

$$n = \frac{p}{2l}\sqrt{\frac{T}{m}} = \frac{p}{2l}\sqrt{\frac{Mg}{m}}\, Hz$$

where 'l' is the length of thread in fundamental modes of vibrations, ' T ' is the tension applied to the thread and 'm' is the mass per unit length of thread. The above equation can be arranged as,

$$n = \frac{P}{2\sqrt{m}}\frac{\sqrt{Mg}}{l}\, Hz$$

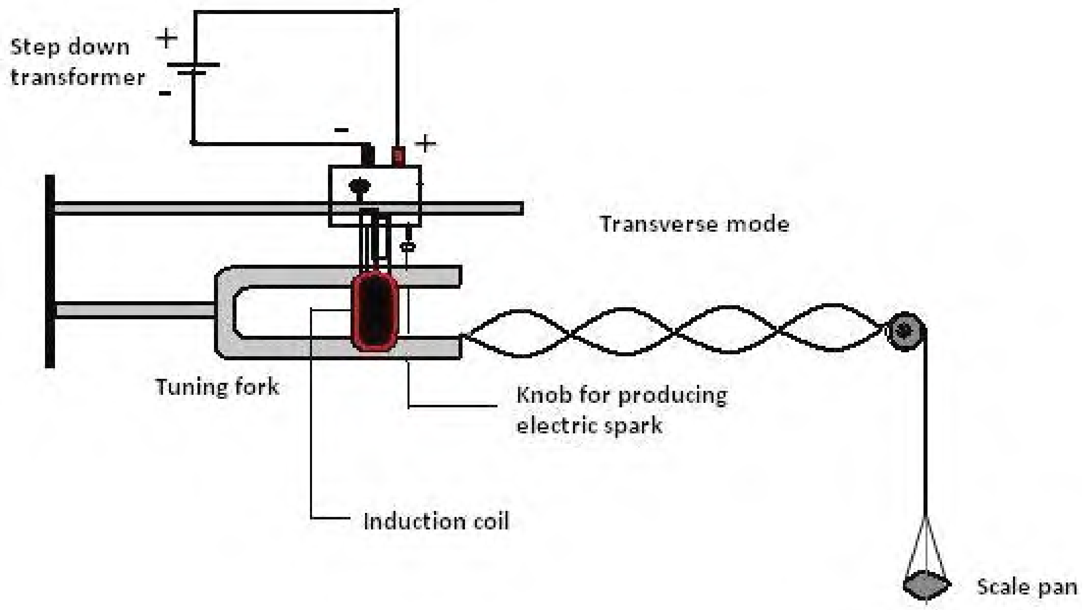
(ii) For the longitudinal arrangement, when 'p' loops are formed, the frequency is given by

$$n' = \frac{p}{l}\sqrt{\frac{T}{m}} = \frac{P}{\sqrt{m}}\frac{\sqrt{Mg}}{l}\ Hz$$

Title: Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2-T Law.

Aim: To determine the frequency of electrically driven Tuning fork by Melde's experiment and to verify λ^2-T Law.

Apparatus: Electrically maintained tuning fork, a stand with clamp and pulley, a light weight pan, a weight box, Analytical Balance, a battery with eliminator and connecting wires etc.



Procedure :

1. Find the weight of pan P and arrange the apparatus as shown in figure.
2. Place a load of 4 To 5 gm in the pan attached to the end of the string passing over the pulley. Excite the tuning fork by switching on the power supply.
3. Adjust the position of the pulley so that the string is set into resonant vibrations and well defined loops are obtained. If necessary, adjust the tensions by adding weights in the pan slowly and gradually. For finer adjustment, add milligram weight so that nodes are reduced to points.

4. Measure the length of say 4 loops formed in the middle part of the string. If '*l*' is the distance in which 4 loops are formed, then distance between two consecutive nodes is *l*/4.
5. Note down the weight placed in the pan and calculate the tension T.
   Tension, T= (wt. in the pan + wt. of pan) gm.
6. Repeat the experiment twice by changing the weight in the pan in steps of one gram and altering the position of the pulley each time to get well defined loops.
7. Measure one meter length of the thread and find its mass to find the value of m, the mass produced per unit length.

Observations:

1. Mass of the pan (w) = ……. gm.
2. Mass of 10 metre of thread (m") = ………gm=…… Kg.
3. Mass per metre of the thread (m) = ……Kg/m

a) For transverse arrangement

Sr. No.	Load Applied		No. of Loops 'P'	Length of thread '*l*'	Tension T= Mg	Frequency n Hz
	Load kept in the pan (W) Kg	Load M=W+w				
1.						
2.						
3.						

b) For longitudinal arrangement:

Sr. No.	Load Applied		No. of Loops 'P'	Length of thread '*l*'	Tension T= Mg	Frequency n' Hz
	Load kept in the pan (W) Kg	Load M=W+w				
1.						
2.						
3.						

Calculations:

i. Calculate the frequency, for the transverse arrangement by using the formula,

$$n = \frac{p}{2l}\sqrt{\frac{Mg}{m}} = \dots\dots\dots\dots..Hz$$

ii. Calculate the frequency, for the longitudinal arrangement by using the formula,

$$n' = \frac{p}{l}\sqrt{\frac{Mg}{m}} = \ldots\ldots\ldots..Hz$$

Result: Mean frequency, i) for the transverse arrangement = ……….Hz

ii) for the longitudinal arrangement = ……….Hz

Note :

When a string between the prong of a fork and the pulley is set into vibrations with maximum amplitude of an electrically maintained tuning fork, stationary waves are formed. If l is the total length of the thread, in which p loops are formed, then

In the transverse arrangement, the frequency is given by,

$$n = \frac{p}{2l}\sqrt{\frac{T}{m}} = \frac{1}{\lambda}\sqrt{\frac{T}{m}} = \ldots..Hz$$

$$\because\ \lambda = \frac{2l}{p}$$

$$\therefore \frac{\lambda^2}{T} = \frac{1}{n^2 m} = constant$$

However for, longitudinal arrangement,

$$\frac{\lambda^2}{T} = \frac{4}{n^2 m} = constant$$

Hence in order to verify, λ^2-T law, use the experimental set up and procedure explained in the above experiment and follow the observation table as below:

Mode of vibration	**No. of Loops 'P'**	**Length of Thread between two ends 'l' cm**	**Wavelength** $\lambda = \frac{2l}{p}$	**Mass in the pan W (Kg)**	**Tension** T= Mg	$\frac{\lambda^2}{T}$

Result: $\frac{\lambda^2}{T}$ is found to be constant

Practical No. 3

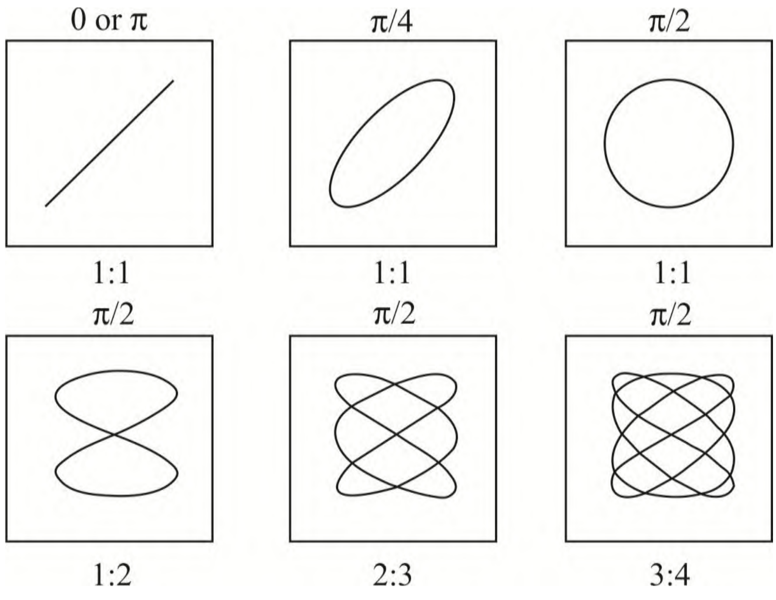
To Study Lissajous Figures and Demonstration of Lissajous Figures by Using C.R.O.

Theory:

When a particle is subjected to two mutually perpendicular directions, the resultant oscillatory path can be straight line, circle, ellipse, parabola etc. More complicated but beautiful figures are obtained by changing the ratio of frequencies of two S.H.M.'s. If the two frequencies are nearly equal, amplitudes are unequal and directions of S.H.M.'s are perpendicular, the particle follows a rotating ellipse. Such figures are known as Lissajous figures or curves.

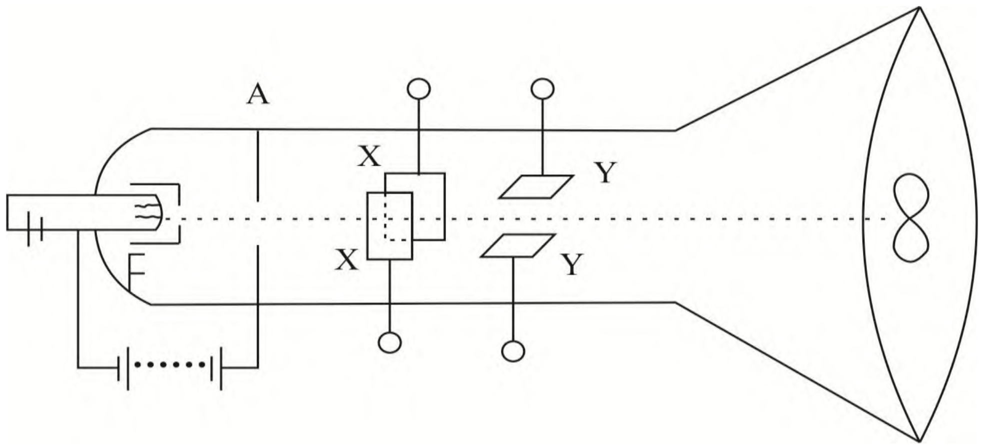
Lissajous figures are useful for two purposes:

1. They are used to determine the ratio of the two frequencies of component S.H.M.'s if one of them is known, other one can be determined.
2. Lissajous figure provides beautiful designs for printing in cloth industry.



Demonstration of Lissajous figures using electrical Method:

Lissajous figures are conveniently demonstrated with the cathode ray oscillograph (CRO). The cathode ray tube consists of a vacuum tube as shown in figure below. Its left part is narrow and cylindrical while the right part is broadened out to hold a fluorescent screen. The filament F is heated electrically so that electrons, emitted from the hot cathode, are attracted towards the anode A. It is maintained at a high positive potential with respect to the filament. The anode has a small hole at its centre. Electrons emerging from the hole form a narrow beam of cathode rays. These rays travel along the axis of the tube and fall on the screen. A fine fluorescent spot is seen on the screen at the point of impact.



X-X are two vertical plates which are fixed symmetrically with respect to the axis of the tube. When alternating e.m.f. is applied across the plates, the beam I set into S.H.M. in a horizontal plane. Y-Y are two horizontal plates which are fixed symmetrically with respect to the axis of the tube. When alternating e.m.f. is applied across the plates, the beam I set into S.H.M. in a vertical plane. When both the fields are applied the beam is subjected to two S.H.M.'s along two mutually perpendicular directions. As a result the spot follows the resultant oscillatory path. Thus a Lissajous figure is obtained. The shape of the figure depends upon the characteristics of the alternating e.m.f.'s.

Title: Study of Lissajous figures using C.R.O.

Aim: To obtain Lissajous figures using C.R.O. and to determine the frequency of an unknown signal using Lissajous figure.

Apparatus: Dual trace C.R.O., two function generator, CRO Probes, etc.

F.Y.B.Sc
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PHYSICS

PHY - 203

CBCS PATTERN

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