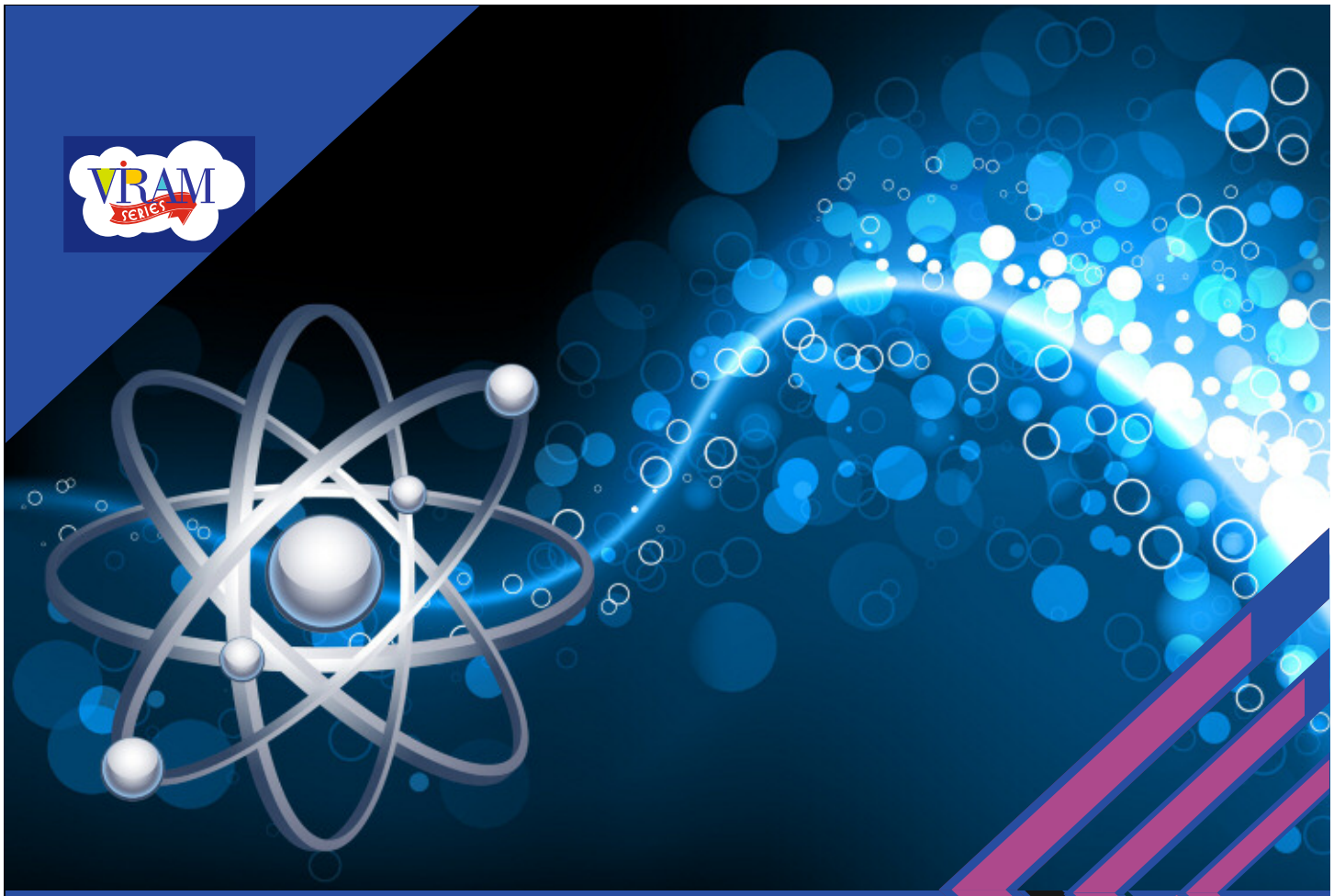

A Textbook of Engineering

PHYSICS-II

As per the Latest Syllabus of Diploma in Engineering Courses Under Jharkhand University of Technology, Ranchi

Dr. Pankaj Kumar

KHANNA PUBLISHERS

Investing in Learning

A Textbook of

Engineering Physics-II

As per Syllabus of 2nd Semester Diploma in Engineering Course under Jharkhand University of Technology, Ranchi

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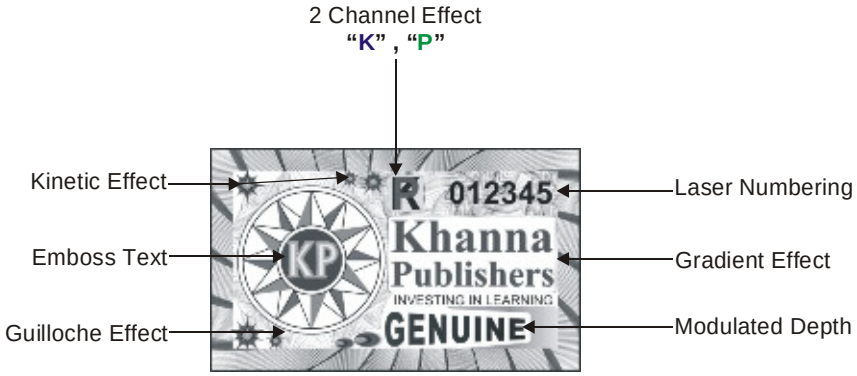

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First Edition : **2020**

Dedicated to my beloved
Mother and Father

Preface

This book, **A TEXTBOOK OF ENGINEERING PHYSICS-II** is especially written for the **2nd-Semester** of all branches of Diploma Engineering students. The organization and content of this book are methodically and systematically arranged, though this book follows the sequence of topics as prescribed in the latest syllabus of **Diploma in Engineering** under **Jharkhand University of Technology, Ranchi.** Also, the book fulfills the needs of N.B.A. New Delhi.

An important feature of this book is the inclusion of several numerical problems **(solved & unsolved)** which are designed to help students to recognize the physical concepts to strengthen their problem-solving ability.

Multiple Choice Questions (MCQs) with answers, Short and Long Type Questions also given at the end of each chapter are designed to probe student's grasp of concepts though out in the text.

Model question paper and previous year question paper of JUT Ranchi is given at the end of the book is one of the feature that the student will familiar with university questions.

The material covered in this book has been sourced from the knowledge acquired by the author as a result of reading through standard literature during the course of his profession. This opportunity is taken to express gratitude to the eminent authors and publishers of all those text.

Had I not got the encouragement, Support and Cooperation from a lot of people around me, my dream would have remained a dream alone. I am grateful to all of them.

I express my deep sense of regard and gratitude to Prof.(Dr.)Gopal Pathak, Vice-Chancellor of Jharkhand University of Technology, Ranchi, for his motivation and encouragement to bring out this Engineering Physics book. I oblige to him for his moral boost up and encouraging me to bring this book for 2nd semester students also. I express my gratitude for his highness to come to my work place, Govt. polytechnic, Kharsawan and release the 1st book **A TEXTBOOK OF ENGINEERING PHYSICS-I** in his busy schedule.

I express my deepest sense of regard and gratefulness to Dr. C. N. Mishra, Ex-Head (Retd.) University Department of Physics, Kolhan University, Chaibasa, Jharkhand for his constant inspiration, encouragement and priceless suggestions to complete this book as well as earlier book.

I would like to express my sense of appreciation to my bosom friend Prof. (Dr.) K.K. Singh, Professor, Department of Metallurgical Engineering, I.I.T.(BHU), Varanasi for his motivation, cooperation and repeatedly enquired about the progress of this work as well as earlier work.

I would like to express my sincere gratitude to Dr. Thakur Prasad Yadav, Scientist, Department of Physics, Banaras Hindu University, Varanasi, U. P. for reviewing the book. His suggestions are priceless to make this book more appealing.

I would like to express my sincere gratitude to Prof. (Dr.) H.L.Yadav, Professor, National Institute of Technology, Jamshedpur, Jharkhand for reviewing this book and his valuable suggestions to make the book more useful to the students.

I would like to express my sense of appreciation to my friend, colleague and well-wisher Prof. Aftab Alam, Senior lecturer and In-charge, Department of Engineering Physics, Al-Kabir Polytechnic, Jamshedpur for reviewing the book and important suggestions.

I would like to express my sense of appreciation to my youngest sister-in-law Dr. Priyambada Priydarshini, M.S. for her moral support and her eagerness how to become the book most popular with quality contents. I am heartedly oblige to her.

My special thanks to all my colleagues and friends for their creative suggestions.

Finally, I am indebted to my wife Ms. Renu Kumari and our son Harsh for extending their whole heartedly moral support towards timely completion of the project.

In spite of all precautions and care taken to produce a clear and accurate book, some errors and misprints might have been left inadvertently. The author will welcome comments and corrections with gratitude.

—Pankaj Kumar;
Ph.D.

Reveiw/Foreword

I had opportunity of reviewing the book "***A Textbook of Engineering Physics-II".*** Each topic is discussed in a simple, yet deeply penetrating fashion. The author has kept in mind the needs of those readers who wish to obtain a thorough knowledge of the subject without any guide. The student will find this book to be of great help in improving their knowledge of physics at **Diploma Engineering for 2nd Semester of Jharkhand University of Technology, Ranchi.** This book deserves to become popular and carries all the features to serve as a Textbook at the Diploma Engineering level.

Dr. C. N. Mishra
Ex-Head (Retd.)
University Department of Physics
Kolhan University, Chaibasa
West Singhbhum (Jharkhand)

A Textbook of Engineering Physics-II
By Dr. Pankaj Kumar

This book has been written keeping in mind the syllabus of Jharkhand University of Technology, especially for 2nd Semester Diploma Engineering course. It would serve as a useful textbook for the subject of Physics. There are a number of books available in the market on the Physics related to the Diploma Engineering course; however the treatment given in them is not in depth. To overcome this problem, this book looks a lucid style and presented the concept and necessary mathematical formulations in a comprehensive manner. In this book, the authors eternally analyzed the recent examples. The solutions were discussed as the route cause problems in detailed and the course of action for solutions were established. This is certainly the most critical aspect of the book. The author's style is fluent. The several universities are actively considering the Physics a course in Diploma Engineering. This book would be suitable for such a course since this is too general and detailed enough.

Dr. T. P. Yadav
Department of Physics
Institute of Science,
Banaras Hindu University,
Varanasi-221005

This book "**A Textbook of Engineering Physics-II"** written by Dr. Pankaj Kumar, Lecturer, Govt. Polytechnic, Kharsawan, under the Department of Higher, Technical Education and Skill Development, Govt. of Jharkhand, covers the entire syllabus of 2nd Semester Diploma in Engineering prescribed by Jharkhand University of Technology, Ranchi. Different books written on these topics by different authors have their own way of presentation; however, presentation by Dr. Pankaj Kumar is more fundamental and lucid. The simplicity of English language of this book is another nice aspect which makes most suitable for those students who join Diploma in Engineering after passing their 10th Board Examination from State Boards where medium of instruction is not English. Solution of the problems given in each chapter further clarifies the concept involved in that chapter. This book is also useful for other universities having similar syllabus.

I wish great success of this book.

H.L.Yadav
Ph.D. IIT Delhi
Professor, Department of Physics
N.I.T. Jamshedpur
Ex-Faculty,
Netaji Subhas Institute of Technology,
Delhi

It gives me immense pleasure to get the opportunity of reviewing the book ***A Textbook of Engineering Physics-II.*** It covers entire the syllabus of Diploma Engineering for 2nd Semester of ***Jharkhand University of Technology, Ranchi.*** I complement the author and appreciate his efforts to bring out this text book in a very simple language. The text is comprehensive and explanation of topics is commendable. Multiple Choice Questions and Numerical Problems with Answers, Short Type Questions and Long Type Questions at the end of each chapter and Modal Question Paper are designed to probe a student's grasp of concepts thought in the text. I understand that this book carries all the elements required for a good presentation.

AFTAB ALAM
M.Sc.; M.Tech.
Senior Lecturer & In-Charge,
Deptt. of Engg. Physics
Al-Kabir Polytechnic, Jamshedpur

Contents

Jharkhand University of Technology, Ranchi

Syllabus

Course Name : 03 Years Diploma Engineering
Semester : Second
Subject Title : Engineering Physics-II
Subject Code : 203/206

Teaching and Examination Scheme:

Teaching Scheme			Examination Scheme					
L	T	P	Full Marks.	External Exam Marks	Internal Exam Marks	External Pass Marks	Total Pass Marks	Duration of External Exams
03			100	80	20	26	40	3 Hrs
Practical		2	50	40	10	13	20	4 Hrs

NOTE:

Internal marks will be alloted on the basis of two snap tests and 2 assignment of equal marks to be conducted by the faculty teaching the subject.

RATIONALE:

Basic science forms the foundation of Engineering. In particular Physics provides fundamental facts, principles, laws, and proper sequence of events to streamline Engineering knowledge.

Objectives: The Student will be able to:

1. Analyze the basic properties of light.
2. Differentiate between field intensity and potential.
3. List the advantages of optical fibre.
4. Describe principle of working of optical fibre.
5. Differentiate between conductor, insulator and semi-conductor on the basis of band theory.
6. Know simple idea of Nano Technology.
7. Know simple idea of non-conventional source of energy.

Contents: Theory

Chapter	Name of the Topic	Hours	Marks
1.	**LIGHT** **Properties of light** Reflection, refraction, Snell's law, physical significance of refractive index, definition of dispersion of light along with ray diagram. **(Numericals on refractive index)**	03	06
2.	**Electric Field and Potential** **2.1 Electric field** Electric charge, Coulomb's inverse square law, Definition of unit charge, Electric field, Electric lines of force and their properties, Elect field intensity, Electric flux, Electric flux density. **(Numericals on Coulomb's law, Electrical Intensity)**	05	08
	2.2 Electric Potential Concept of potential, Definition and unit, Potential due to point charge using integration method, Potential difference between two points, Definition of dielectric strength and breakdown potential. **(Numericals on electric potential)**	05	08
	2.3 Capacity and Condensers Electrostatics capacity and its S.I. unit, Capacity of parallel plate condenser, Condenser in series and parallel (Formula only, no derivation), Uses of condensers. **(Simple problems)**	03	06
3.	**Current Electricity** Ohm's law, Resistance and its unit, Specific resistance, Factors affecting resistance, Kirohhoff's law and, its application to Wheat stone bridge circuit.	03	08
4.	**Fibre Optics** Introduction, Total internal reflection, critical angle, acceptance angle. Structure of optical fibre, Numerical Aperture, Fibre optic materials, Types of optical fibres, Applications in communication systesm. **(Numerical on critical angle, numerical aperture)**	05	08
5.	**Band Theory of Solids** Energy levels in solids, Valence and conduction bands, forbidden gap, Conductors, Semi-conductors and Insulators.	05	08
	Intrinsic and Extrinsic Semiconductors, *p*-type and *n*-type semiconductors, P-N junction diode-forward and reversed biased characteristics.		

6.	**MODERN PHYSICS.** **7.1 Photo electricity** Concept of photon, Plank's hypothesis, properties of photon, photo electric effect, Laws of photoelectric effect, work function, Einstein's photoelectric equation(no derivation), Basic Concept of Solar Energy. **(Numericals on Energy of photon, work function, photoelectric equation)**	03	06
	7.2 LASER Properties of laser, Characteristics and applications of Laser	01	04
	7.3 X-rays Introduction to X-rays, production of X-rays using Coolidge tube, minimum wavelength of X-rays, properties and applications. of X-rays **(Numericals on minimum wavelength of X-rays)**	02	06
7.	**Introduction to nanotechnology** Definition of nanoscale, nanometer & nanoparticle, applications of nanotechnology- electronics, automobiles, medical, textile, cosmetics, environmental, space and defence.	03	06
8.	**Non-Conventional Sources of energy** Introduction- Non Renewable and renewable (Alternate) energy sources, Examples- Solar Energy, Wind Energy, Tidal Energy, Geo-Thermal Energy and Bio-Mass. Advantages and disadvantages of renewable energy.	04	06
	Total	**42**	**80**

Practical:

Skills to be

Developed:

Intellectual

Skills:

- Proper selection of measuring instruments on the basis of range, least count, precision and accuracy required for measurement.
- To verify the principles, laws, using given instruments under different conditions.
- To read and interpret the graph.
- To interpret the results from observations and calculations.
- To use these results for parallel problems.

Motor

Skill:

- Proper handling of instruments.
- Measuring physical quantities accurately.

- To observe the phenomenon and to list the observations in proper tabular form.
- To adopt proper procedure while performing the experiment.

List of Experiment:

1. To represent simple harmonic motion with the help of vertical oscillation of spring to determine spring constant (K) (Stiffness Constant).
2. To determine time period of oscillation of compound bar pendulum and calculate acceleration due to gravity (g).
3. To calculate refractive index of material of prism using spectrometer device.
4. To determine effective capacitance of series and parallel combination of capacitors by calculating its reactance.
5. Verification of Ohm's Law.
6. To convert galvanometer into ammeter of required range using appropriate value of shunt.
7. To verify Total Internal Reflection (TIR) phenomenon for given glass slab and to calculate critical angle of incidence.
8. Determination of Energy Gap (Forbidden Gap) of a semi-conductor.
9. To determine I-V characteristics of P-N junction Diode.
10. To verify inverse square law by using photoelectric cell.

Learning :
Recourses :
Books :

Sr. No.	Author	Title	Publisher
01.	Arthur Beiser	Applied physics	Tata McGraw-Hill
02.	R.K.Gaur and S.L.Gupta	Engineering Physics	Dhanpatrai and Sons.
03.	Rensic and Halliday	Physics	Wiley publication
04.	Dr. S.K. Kulkarni	Nanotechnology-Principles and practices	Capital publishing company
05.	S.K.Gupta	ABC of Physics	Modern Publisher New Delhi
06.	A.S. Vasudeva	Senior Practical Physics	S.K.Kataria & Sons.
07.	Core Physics-II	A. Kumar	Bharti Bhavan
08.	Pradeep's Fundamental Physics-XII	K.L. Gomber & K.L Gogia	Pradeep Publication
09.	S. Chand's Principles of Physics-XII	V.K Mehta & Rohit Mehta	S. Chand Publication
10.	Dinesh New Millennium Physics-XII	S. K Sharma	Dinesh Publication

1

CHAPTER

Light

LEARNING OBJECTIVES

After reading this chapter, the student will able to

- To analyze the basic properties of light.
- To define the terms: Reflection, refraction, refractive index, dispersion of light.
- To understand the Snell's law, and the physical significance of refractive index.
- To explain the dispersion of light alongwith ray diagram.

OPTICS

Optics is the science which describes the behaviour and properties of light and the interaction of light with matter. Optics explains optical phenomena like, reflection, refraction, dispersion, interference, diffraction and polarisation. It is classified into three types:

(*i*) Ray optics or Geometrical optics (*ii*) Wave optics and

(*iii*) Quantum optics.

RAY OPTICS OR GEOMETRICAL OPTICS

Ray optics assumes that light consists of rays.

This assumption is useful in explaining phenomena like reflection, refraction and dispersion where a ray of light is the straight line path in going from one point to another. So, it is also known as **geometrical optics**.

PROPERTIES OF LIGHT

Reflection of Light

Light may be defined as the invisible radiant energy which produces in us the sensation of sight.

Light travels in a straight line. It can travel through vacuum with a speed of 3×10^8 ms^{-1}.

When rays of light fall on a surface, they are turned back into the same medium in accordance with definite laws.

The bouncing back of light from a smooth surface is called **reflection of light**.

Laws of Reflection

There are two laws of reflection of light:

(*i*) The incident ray, the reflected ray and the normal at the point of incidence, all lie in the same plane.

(*ii*) The angle of incident is always equal to the angle of reflection.

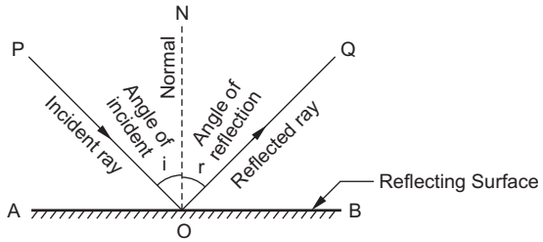


Fig. 1.1 Laws of reflection

Refraction of Light

Whenever light passes from one transparent medium to the other of different optical density, the change in speed of light occur and this sudden change causes the change in path of light. This phenomenon is known as **refraction of light**. *i.e.*,

"The bending of light when it passes from one transparent medium to another medium is called refraction of light".

Apparent distortion of objects that are submerged in water, is a nice example of refraction of light.

During the refraction of light, the speed and wavelength of light changes whereas, the frequency remains unchanged.

The refraction of light occurs with the change of optical densities of medium as follows:

(*i*) When a light ray passes from an optically rarer medium to an optically denser medium, the ray of light bends towards the normal as velocity of light decreases with increase in density of the medium.

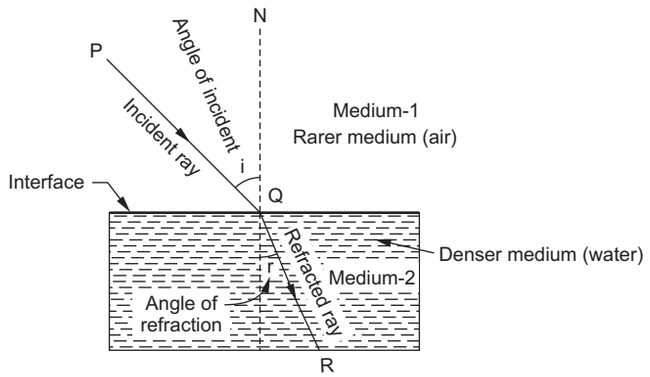


Fig. 1.2 Refraction of light (rarer to denser medium)

(*ii*) When a light ray passes from an optically denser medium to an optically rarer medium, the light ray bends away from the normal as the velocity of light increases with decrease in density of the medium.

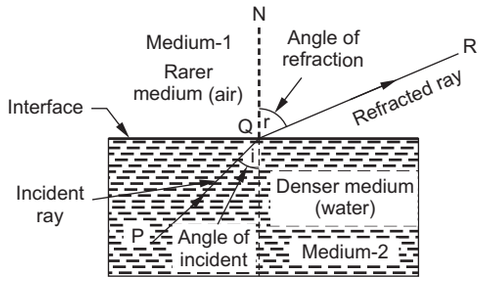


Fig. 1.3 Refraction of light (denser to rarer medium)

Laws of Refraction

The refraction of light takes place as per the following two laws:

(*i*) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

(*ii*) The ratio of the sine of angle of incidence to the sine of angle of refraction is constant for given pair of media.

Referring to Fig. 1.2. As per above laws, we have,

$$\frac{\sin i}{\sin r} = \text{constant} = \{_1{}^{n}{}_2\} \qquad ...(1)$$

Relation (1) is known as **Snell's law** and the constant n is known as **index of refraction** or **refractive index** of medium-2 with respect to medium-1.

The refractive index depends upon the nature of the two media and is different for different wavelength of light.

Absolute Refractive Index

The refractive index of substance is relative to a vaccum or air (a ray passes through vaccum to the given medium) is called the **"Absolute Refractive Index"** of the substance.

The relative refractive index for two media is equal to the ratio of their absolute refractive indices.

i.e., $$_1n_2 = \frac{n_2}{n_1} \qquad ...(2)$$

Referring to the Fig. 1.2., we find that

1. $_1n_2$ is the refractive index of medium-2 with respect to medium-1.
2. n_1 is the absolute refractive index of medium-1.
3. n_2 is the absolute refractive index of medium-2.

In refraction, as well as in reflection, light rays are reversible. Referring to the Fig. 1.2, the passage of a ray of light is going from medium-1 to medium-2 is reversible. It follows the same path in going from R to P as when going from P to Q.

Physical Significance of Refractive Index

The refractive index of a medium gives the following informations:

(*i*) The refractive index of a medium gives the information about the bending of refracted light *i.e.*, whether the ray will bend towards or away from the normal.

(*ii*) It gives the information that how much speed of light increases of decreases when passes from one medium to other.

If refractive index of a medium is given, then we can find the speed of light in that medium.

For example, refractive index of glass is 1.5, then speed of light is in the glass,

i.e., $$v_g = \frac{c}{n}$$

or $$v_g = \frac{3 \times 10^8}{1.5} = 2 \times 10^8 \text{ ms}^{-1}.$$

i.e., the speed of light decreases in glass with respect to air.

Dispersion of Light

White ray of light is made up with seven colours. They are: (*i*) Red, (*ii*) Orange, (*iii*) Yellow, (*iv*) Green, (*v*) Blue, (*vi*) Indigo and (*vii*) Violet.

"The phenomenon of splitting of white light into its constituents seven colours is known as dispersion of light".

When a white ray of light incidents on a prism, refraction takes place.

(*i*) **Due to refraction:** On entering the prism, white ray of light deviates from original path.

(*ii*) **Due to dispersion:** We find, on entering the prism, white ray splits up into its constituents seven colours. This is known as **"Dispersion of light"**.

Dispersion of light is the dependence of the refractive index of a material on the wavelength of light. Light rays of different colours have different wavelengths. The incident white ray on entering the prism splits up in different colours, which are refracted through different angles by the prism. On the screen, which is placed behind the prism, seven colours are seen which are arranged in the following order:

1. Red
2. Orange
3. Yellow
4. Green
5. Blue
6. Indigo
7. Violet.

On the screen, this set of seven colours is called **"spectrum"** which is **"visible"**.

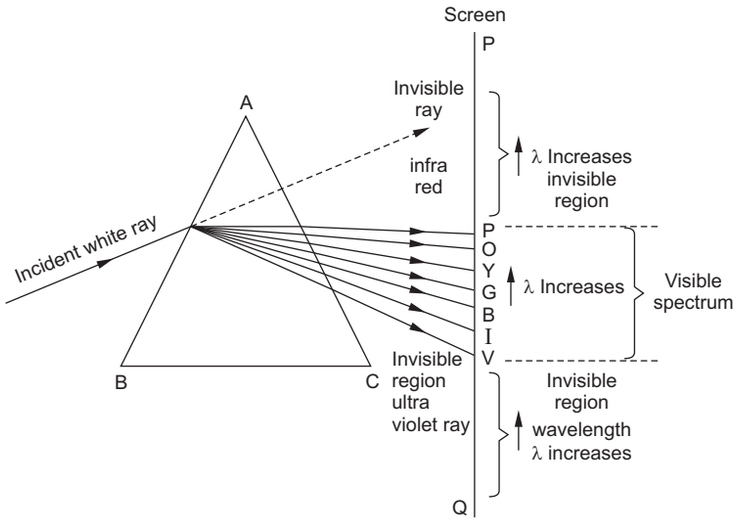


Fig. 1.4 Dispersion of light

Infrared Rays and Ultraviolet Rays

The visible spectrum extends from red (7,500 Å) to violet (4,000 Å). Extending on both sides of the visible region, below the violet and beyond red, there invisible radiations.

Infrared Rays

The radiations beyond red consists of longer waves, whose wavelengths extend up to 4000000 Å. The radiation discovered by Herschel are called **"Infrared rays"**.

Ultraviolet Rays

The radiations below violet consist of shorter waves, whose wavelengths extend up to 100 Å. These radiations discovered by Ritter are called **"Ultraviolet rays"**.

Cauchy's Formula

Cauchy in 1836, successfully gave the accurate equation to explain the curve of normal dispersion of figure.

His equation is

$$n = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} \qquad ...(3)$$

where, A, B and C are constants, which are the characteristic of any one substance.

This equation (3) represents the curves in the visible region. To find the value of three constants it is essential to know the value of n for three different λ's.

Dispersion concerns the velocity of light in material substances and its variation with wavelength.

Measurements for the same glass, the variation of refractive index with wavelength λ is plotted and shown in the Fig. 1.5.

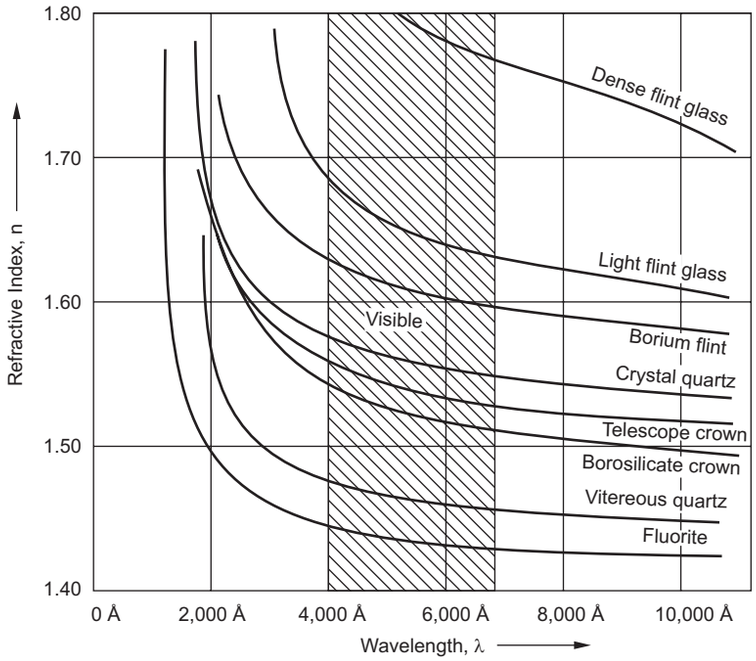


Fig. 1.5 Dispersion curves for several different materials commonly used for lenses and prisms.

The curves found different for prism of different materials. These curves are the representative of **"normal dispersion"**. We find

1. The refractive index increases as the wavelength decreases.
2. The rate of increase becomes greater at shorter wavelengths.
3. For different substances the curve at a given wavelength is usually steeper, the larger, the refractive index.

On the above 1st fact, in refraction by a transparent substance the violet is more deviated then the red. The second fact can also expressed by saying that the dispersion increases with decreasing wavelength.

Angular Dispersion

"When a beam of white light passes through a prism, the angular separation between two extreme colours *i.e.*, violet and red is called **"Angular Dispersion"**.

Deviation Produced by a Thin Prism

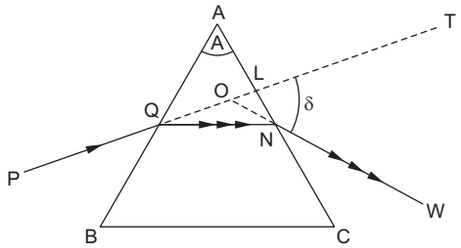


Fig. 1.6 Deviation by a thin prism

Let angle of prism = A

Refractive index of the material of the prism = n

Deviation suffered by incident ray PQ on emerging from the prism

$$= \angle TOW = \delta \text{ (say)}$$

For a prism, we know that,

Refractive index of the material of the prism is

$$n = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin A/2} \quad \ldots(4)$$

where, δ_m is the "Angle of minimum deviation".

For thin prism,

Deviation δ is always minimum

i.e., $\delta_m = \delta$

For thin prism, $\frac{A + \delta}{2}$ is very small,

so, $$\sin\left(\frac{A + \delta}{2}\right) \simeq \frac{A + \delta}{2} \quad \ldots(5)$$

Also, $\frac{A}{2}$ is very small,

so, $$\sin\frac{A}{2} \simeq \frac{A}{2} \quad \ldots(6)$$

For thin prism, relation (4), (5) and (6) becomes,

$$n = \frac{A + \delta/2}{A/2} = \frac{A\left(1 + \frac{\delta}{A}\right)}{A} = 1 + \frac{\delta}{A}$$

$\therefore$ $$\frac{\delta}{A} = (n - 1)$$

$\therefore$ $$\delta = (n - 1)A \quad \ldots(7)$$

This is the deviation produced by a thin prism.

Dispersive Power

"The ratio of angular dispersion to the deviation of the mean *i.e.*, yellow colour is known as the dispersive power of the prism".

i.e., Dispersive power, $\omega = \frac{\delta_v - \delta_r}{\delta_y}$ ...(8)

If A = angle of the prism

n_r = refractive index of the prism for red colour

n_y = refractive index of the prism for mean colour (*i.e.*, yellow colour) and

n_v = refractive index of the prism for violet colour

Then, $\delta_v - \delta_r = A(n_v - n_r)$ and $n_y = A(n_y - 1)$

$\therefore$ Dispersive power of the prism,

$$\omega = \frac{A(n_v - n_r)}{A(n_y - 1)}$$

$$\therefore \quad \omega = \frac{(n_v - n_r)}{(n_y - 1)} \qquad ...(9)$$

SOLVED NUMERICAL PROBLEMS

Problem 1. ***A ray of light is incident from a rarer medium of refractive index 1.5 into a denser medium. If the angle of incidence and refraction are 60° and 45°, respectively then calculate the refractive index of the denser medium.***

Solution: Let, refractive index of rarer medium = $n_1 = 1.5$

Refractive index of denser medium = $n_2 = ?$

Given, angle of incidence, $i = 60°$

Angle of refraction, $r = 45°$

Now, we have,

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

$$\therefore \quad n_2 = n_1 \frac{\sin i}{\sin r} = 1.5 \times \frac{\sin 60°}{\sin 45°} = 1.5 \times \frac{\sqrt{3}}{2} \times \sqrt{2}$$

$$= 1.5 \times \frac{\sqrt{3} \times \sqrt{2}}{\sqrt{2} \times \sqrt{2}} = 1.5 \times \sqrt{\frac{3}{2}} = 1.5 \times 1.2$$

$$\therefore \quad n_2 = 1.83. \quad \textbf{Ans.}$$

Problem 2. ***If the refractive index of water and glass with respect to air are 4/3 and 3/2 respectively. Find the refractive index of (a) glass with respect to water and (b) water with respect to glass.***

Solution: Given, refractive index water with respect to air = ${}^{a}n_w = \frac{4}{3}$

and refractive index of glass with respect to air = ${}^{a}n_g = \frac{3}{2}$.

Now, we have,

$$(a)\ {}^{w}n_g = \frac{{}^{a}n_g}{{}^{a}n_w} = \frac{3}{2} \times \frac{3}{4} = \frac{9}{8} = 1.12. \quad \textbf{Ans.}$$

$$(b)\ {}^{g}n_w = \frac{{}^{a}n_w}{{}^{a}n_g} = \frac{4/3}{3/2} = \frac{8}{9} = 0.88. \quad \textbf{Ans.}$$

Problem 3. ***A ray of light is incident on the surface of the liquid from air at 60°. If after refraction it bends towards the normal through 45°, then calculate the refractive index of liquid.***

Solution: Given,

Angle of incidence = 60°

Angle of refraction = 45°

Refractive index of liquid = ?

As we have, $$n = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 45°} = \frac{\sqrt{3}}{2} \div \frac{1}{\sqrt{2}} = \frac{\sqrt{3}}{2} \times \sqrt{2}$$

$$= \frac{\sqrt{2} \times \sqrt{2}}{\sqrt{2} \times \sqrt{2}} = \sqrt{\frac{3}{2}} = \sqrt{1.5}$$

$\therefore$ $n = 1.22$. **Ans.**

Problem 4. ***The speed of light in vacuum is 3.0 × 10^8 ms^{-1}. Calculate the speed of the light in glass of refractive index 1.5.***

Solution: Given, $c_v = 3.0 \times 10^8 \text{ ms}^{-1}$

$n = 1.5$

c_g = velocity of light in glass = ?

As we have,

$$c_g = \frac{c_v}{n} = \frac{3.0 \times 10^8}{1.5}$$

$c_g = 2 \times 10^8 \text{ ms}^{-1}$. **Ans.**

Problem 5. ***Light in air is incident at an angle of 45° on the surface of a glass plate for which the refractive index is 1.526. Through what angle is light deviated upon refraction at the top surface?***

Solution: Given, $i = 45°$

$n_1 = 1.0$ (air)

$n_2 = 1.526$ (glass)

r = ?

and deviation of light = $i - r$ = ?

As we know,

$$\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

$\therefore$ $$\sin r = \frac{n_1}{n_2} \times \sin i = \frac{n_1}{n_1} \times \sin 45° = \frac{1.0}{1.526} \times \frac{1}{\sqrt{2}}$$

$$= \frac{1.0}{1.526} \times \frac{1}{1.41} = \frac{1}{1.526} \times 1.41 = \frac{1}{2.15} = 0.4634$$

$\therefore$ $r = \sin^{-1} 0.4634 = 27.61°$

Now, deviation of light = $i - r = 45° - 27.61° = 17.39°$. **Ans.**

MULTIPLE CHOICE QUESTIONS

1. The total internal reflection take place when light passes from
(*a*) rarer to denser (*b*) denser to rarer (*c*) in same medium (*d*) none of these
[JUT-2019]

2. Dispersion is maximum for
(*a*) violet colour (*b*) yellow colour (*c*) red colour (*d*) none of these
[SBTEJ-2018, New syllabus]

3. Refractive index of glass is least for
(*a*) red light (*b*) yellow light (*c*) violet colour (*d*) green colour
[SBTEB, Even-2017]

4. The refractive index of a given piece of transparent quartz is the greatest for
(*a*) red light (*b*) violet light (*c*) green light (*d*) yellow light
[SBTEB-2007]

5. The dispersion of light in a medium implies that
(*a*) light of different wavelength has different speed
(*b*) light of different frequencies has different speeds
(*c*) the refractive indices are different for different wavelengths
(*d*) all of the above **[SBTEB-2007]**

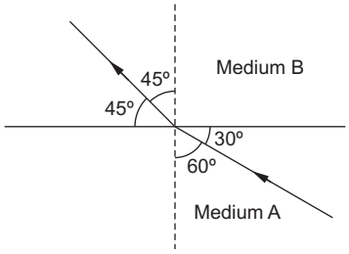
6. Which phenomenon causes the dispersion of white light into a spectrum by a prism.
(*a*) refraction (*b*) reflection (*c*) diffraction (*d*) absorption
[SBTEB-2012]

7. Diffraction of light is
(*a*) bending of waves around the edges of obstacks
(*b*) rectilinear propagation of light (*c*) superposition of waves
(*d*) none of the above **[SBTEB-2017]**

8. Snell's law is defined as
(*a*) $\frac{\sin i}{\sin r} = {}^1n_2$ (*b*) $\frac{\sin r}{\sin i} = {}^1n_2$ (*c*) $\frac{\sin i}{\sin r} = {}^2n_1$ (*d*) none of these
[SBTEJ-2016]

9. The critical angle of a transparent denser medium than air,
(*a*) increases with its refractive index (*b*) decreases with its refractive index
(*c*) independent of its refractive index (*d*) none of these

10. Figure shows a ray of light as it travels from medium *A* to medium *B*. Refractive index of the medium *B* relative to medium *A* is



(*a*) $\frac{\sqrt{3}}{\sqrt{2}}$ (*b*) $\frac{\sqrt{2}}{\sqrt{3}}$ (*c*) $\frac{1}{\sqrt{2}}$ (*d*) $\sqrt{2}$

11. Critical angle of light passing from glass to air is minimum for
(*a*) red (*b*) green (*c*) yellow (*d*) violet

12. The splitting up of a beam of white light into its different colours is known as
(*a*) refraction (*b*) reflection (*c*) interference (*d*) dispersion

SHORT TYPE QUESTIONS

1. State and explain Snell's law of refraction of light. Define refractive index.
[SBTEJ-2018 (New syllabus)]

2. State two laws of refraction of light. **[SBTEJ-2016]**

3. What is light? What do you mean by refractive index of light?

LONG TYPE QUESTIONS

1. Define reflection and refraction of light. Write physical significance of refraction of light.

2. State dispersion of light with ray diagram.

3. Explain what happens when
(*a*) A ray of light travels from a rarer medium to a denser medium?
(*b*) A ray of light travels from a denser medium to a rarer medium?

4. State and explain laws of reflection. **[JUT-2019]**

UNSOLVED NUMERICAL PROBLEMS

1. The refractive index of water is 4/3. Calculate the speed of light in water. The speed of light in vacuum is 3×10^8 ms^{-1}. [**Ans.** 2.25×10^8 ms^{-1}]

2. The velocity of light in air is 3.0×10^8 ms^{-1}. Calculate the velocity of light in diamond of refractive index 2.5. [**Ans.** 1.2×10^8 ms^{-1}]

3. A ray of light travelling in air strikes the glass surface at an angle of incidence 60°. Find the angle of refraction in glass if refractive index of glass is 3/2 and given that $\sin 35° = \frac{1}{\sqrt{3}}$. [**Ans.** 35°]

4. The refractive index of water with respect to air is 4/3. What is the refractive index of air with respect to water? [**Ans.** 0.75]

5. How long will the light take in travelling a distance of 500 m in water? Refractive index of water is 4/3 and velocity of light in vacuum is 3×10^8 ms^{-1}. [**Ans.** 222.22×10^{-8} sec]

Answers of Multiple Choice Questions

1. (*b*)	**2.** (*a*)	**3.** (*a*)	**4.** (*b*)	**5.** (*d*)	**6.** (*a*)
7. (*a*)	**8.** (*a*)	**9.** (*b*)	**10.** (*a*)	**11.** (*d*)	**12.** (*d*)

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