APPLIED PHYSICS-II

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Preface

Physics is the liberal arts of high technology

This books is based on the common core syllabus of State Board of Technical Education, Haryana. It explains, in simple and systematic manner, the basic principles and applications of Applied Physics-II for diploma students. The book would serve as an excellent text for first year diploma students.

Physics is a fundamental science, and those who study it will gain an understanding of the basic laws that govern everything from the very small subatomic to the very large cosmic scale. The study of physics provides us with an unparalleled power of analysis that is useful in the daily life. This first edition of Applied Physics-II, contains material for the new syllabus. It includes a chapter I about Applications of Sound waves, along with many discussion question Sound waves and their propagation and applications etc., Chapter II covers Principles of optics in an easy and interesting way, Chapter III covers Electrostatics effectively with examples, similarly whole syllabus is covered very clearly and in an easy way. The questions at the end of each chapter will increase the knowledge of students. The book contains many example questions and answers that are meant to make the student more confortable with solving problems. Some are more involved than others. There are also questions at the end of each chapter, which the student should attempt to answer to test his or her understanding. (Starting a physics course at this level knows the basics of trigonometry and is confortable with simple algebraic manipulations). In the end of each chapter Hindi Version of most of the topics of the chapter is given for the better knowledge of our students.

Applied Physics is not watered-down physics. It is advanced physics. It covers the most interesting and most important topics. Students recognize the value of what they are learning, and are naturally motivated to do well. In every chapter they find material they want to share with their friends, roommates, and parents.

The response to this new approach is going to be fantastics. Many of the students previously hated physics, and swore (after their high school class) never to take it again. But they will drawn, like moths to a flame, to a subject they find fascinating and important. My job is to make sure their craving is fulfilled, and that they won't be burnde again. These students come to college to learn, and they will feel happiest when they sense their knowledge and abilities growing.

Students don't take the course because it is easy; it isn't. It covers an enormous amount of material. But every chapter is full of information that is evidently important. That's why students will signup. They don't want to be entertained. They want a good course, well taught, that fills them with important information and the ability to use it well. They are proud to take this course, but more imporantly, they will feel very proud that they are going to enjoy it.

Physics is the liberal arts of high technology. Understand physics, and never again be intimidated by technological advances. This book is designed to attract student, and each teach them the physics they need to know to be an effective engineer.

All valuable suggestions for its improvement will be highly appreciated and gratefully received by the authors.

—Author

Syllabus

APPLIED PHYSICS - II

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3 - 2

RATIONALE

Applied Physics includes the study of a large number of diverse topics related to things that go in the world around us. It aims to give an understanding of this world both by observation and prediction of the way in which objects behave. Concrete use of physical principles and analysis in various fields of engineering and technology are given prominence in the course content.

Note: Teachers should give examples of engineering/technology applications of various concepts and principles in each topic so that students are able to appreciate learning of these concepts and principles.

DETAILED CONTENTS

1. Waves and Vibrations **(10 hrs)**

1.1. Definition of wave with examples

1.2. Types of wave motion, transverse and longitudinal wave motion with examples

1.3. Relation between velocity of wave, frequency and wave length of a wave (v = n ?)

1.4. Simple harmonic motion: definition, expression for displacement, velocity, acceleration, time period, frequency in S.H.M.

1.5. Vibration of spring mass system, cantilever and determination of their time period.

1.6. Free, forced and resonant vibrations with examples

2. Applications of Sound Waves (10 hrs)

2.1 Acoustics of buildings-reverberation, reverberation time, echo, noise, coefficient of absorption of sound, methods to control reverberation time

2.2 Ultrasonics-Methods of production (magnetostriction oscillator only) and their engineering applications to cold welding, drilling, cleaning and SONAR

3. Principles of Optics (10 hrs)

3.1 Lenses, reflection and refraction of light, refractive index, lens formula (no derivation), real and virtual image, magnification.

3.2 Power of lens, microscope, telescope (definition only)

3.3 Total internal reflection, critical angle and conditions for total internal reflection.

4. Electrostatics (12 hrs)

4.1 Coulomb's Law, unit charge

4.2 Gauss's Law

4.3 Electric field intensity and electric potential (definition and units only)

4.4 Application of Gauss's Law to straight charged conductor, plane charged sheet

4.5 Capacitance, capacitance of parallel plate capacitor, series and parallel combination of capacitors

4.6 Dielectric and its effect on capacitors, dielectric constant and dielectric breakdown

5. CURRENT ELECTRICITY (10 HRS)

5.1 Definition of electric current, resistance, potential and their units.

5.2 Ohm's law

5.3 Specific resistance, series and parallel combination of resistances, effect of temperature on resistance.

5.4 Kirchhoff's laws, Wheatstone bridge

5.5 Heating effect of current and concept of electric power

6. SEMI CONDUCTOR PHYSICS (10 HRS)

6.1 Types of materials (insulator, semi-conductor, conductor), intrinsic and extrinsic semi conductor, p-n junction diode and its characteristics

6.2 Diode as rectifier-half wave and full wave rectifier, semi conductor transistor pnp and npn (introduction only)

7. MODERN PHYSICS (10 HRS)

7.1 Lasers: concept of energy levels, ionizations and excitation potentials; spontaneous and stimulated emission; population inversion, Laser, types of lasers, ruby laser and applications of laser

7.2 Fiber optics: Introduction and applications

7.3 Super conductivity: Phenomenon of super conductivity, Type I and Type II super conductor and its applications

LIST OF PRACTICALS

1. To determine and verify the time period of cantilever.
2. To determine time period of Simple Pendulum.
3. To verify Ohm's Law.
4. To verify law of resistance in series.
5. To verify law of resistances in parallel.
6. To find resistance of galvanometer by half deflection method.
7. To convert a galvanometer into an ammeter of given range.
8. To convert a galvanometer into a voltmeter of given range.
9. To study and verify laws of reflection using mirrors.

SUGGESTED DISTRIBUTION OF MARKS

S.No	Time Allotted (Hrs.)	Marks Allotted (%)
1	10	14
2	10	14
3	10	14
4	12	20
5	10	16
6	06	12
7	06	10
Total	**64**	**100**

Contents

CHAPTER 1

Wave and Vibrations

1.1. WAVE

Waves *are produced in a material medium by the repeated periodic motion of the particles of the medium. The waves which can be propagated in a medium are called* **mechanical waves.**

For example, waves on water surface, sound waves etc.

1.2 WAVE MOTION

Wave motion *is a form of disturbance which travels through a material medium due to the repeated periodic motion of the particles of the medium about their mean positions, the motion being handed over from particle to particle. Sometimes, wave motion is called simply* **progressive waves.** eg. Throw a stone in pond of still water.

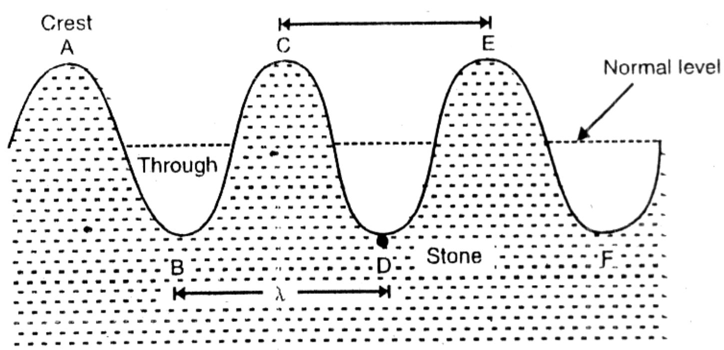


Fig. 1.1

Types of Wave Motion

(*i*) **Transverse Wave Motion:** *The wave motions in which the particles of the medium vibrate about their mean positions in a direction at right angles to the direction of propagation of the wave is called* transverse wave motion *e.g.* Wave on water surface, waves in a rope, light waves, radio waves are some example of transverse waves.

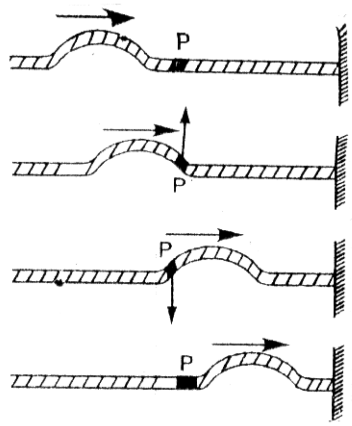


Fig. 1.2

2. Longitudinal Wave Motions

The wave motion in which the particles of the medium vibrate about their mean positions in a direction along the direction of propagation of the wave is called longitudinal wave motion.

Examples:

(*i*) waves in springs;

(*ii*) sound waves

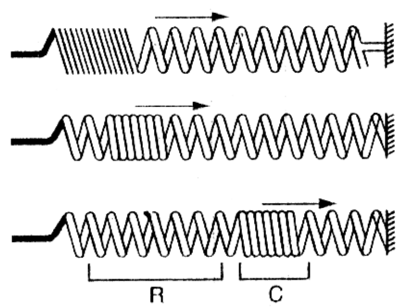


Fig. 1.3

Difference Between Transverse and Longitudinal Waves

The difference between transverse and longitudinal waves are as follows:

Transverse wave	Longitudinal wave
1. In this wave the particles of the medium vibrate at right angle to the direction of propagation.	1. In this wave the particles of the medium vibrate in back and forth to the direction of propagation.
2. In this wave, crests and troughs are formed.	2. In this wave, compressions and rarefactions are formed.
3. These are possible in solids and liquid surface only.	3. These are possible in solid, liquids and gases medium.
4. Transverse waves can be polarised.	4. Longitudinal waves cannot be polarised.
5. There is no change in the density of the medium.	5. There is change in the density of the medium.
6. Ripples formed in water is example of transervse wave.	6. Sound waves are example of longitudinal waves.

1.3 RELATION BETWEEN WAVE VELOCITY, WAVE LENGTH AND FREQUENCY ($v = n\lambda$)

Let, v = Wave velocity

n = Frequency

and λ = Wave length

By definition, wave length is the distance travelled by the wave in T seconds, the time period of a particle. Then, velocity of wave is given by the relation,

$$\text{Velocity} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

or $$v = \frac{\lambda}{T} \qquad (\because \lambda \text{ is the distance travelled in T seconds})$$

$$= \frac{1}{T} \times \lambda = n\lambda \qquad \left(\because n = \frac{1}{T}\right)$$

or $$v = n\lambda$$

i.e., Wave velocity = Frequency × Wave length.

Periodic. Motion: A motion in which the body repeats its path after fixed time intervals is called a periodic motion. For example, motion of blades of fan, motion of pendulum.

Oscillatory Motion

Oscillatory motion is a specific type of periodic motion in which the body moves back and forth about a fixed point, called mean position.

For example, motion of a pendulum, swing of a child.

1.4. SIMPLE HARMONIC MOTION (S.H.M.)

A body is said to execute Simple Harmonic Motion, if its acceleration is proportional to its displacement from a fixed point (mean position) and is always directed towards that point.

Examples of S.H.M.

(*i*) To and fro motion of the piston of an engine.

(*ii*) Oscillations of mercury column in a U-tube.

(*iii*) Vibrations of the prongs of a tuning fork.

Expression for Displacement in S.H.M

or

Equations of Simple Harmonic Motion ($y = a \sin \omega t$).

Let there be a particle P, moving in the anticlockwise direction along the circumference of a circle (see fig. 1.4).

Let, v = Uniform speed of the particle

ω = Angular velocity of the particle

a = Radius of the circle

= Amplitude of the particle executing S.H.M

The projection N of the moving particle on the diameter YOY' executes S.H.M. Let θ be angular displacement at any instant t.

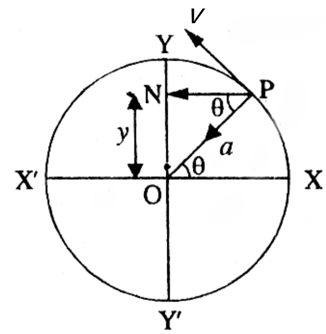


Fig. 1.4

$\therefore$ In Δ ONP, $\frac{ON}{OP} = \sin\theta$

$= \sin \omega t \quad \left(\because \omega = \frac{\theta}{t}\right)$

or $ON = OP \sin \omega t$

or $y = a \sin \omega t$

Thus Displacement = Amplitude $\times$ sin ωt.

The above equation gives the value of displacement of a particle executing S.H.M. in terms of its amplitude a and angular velocity ω at any instant t. Therefore, this equation is called the equation of motion of a particle executing S.H.M.

Amplitude (a): *The* **amplitude** *of a particle executing S.H.M. is its maximum displacement from the mean position to one extreme position.*

The maximum displacement of the vibrating particle is given by OY = OY′ = a.

EXPRESSION FOR VELOCITY OF A PARTICLE EXECUTING S.H.M.

To find an expression for the velocity of a particle moving with S.H.M., consider a particle P moving in the anticlockwise direction in a circle with an angular velocity ω radian / second. (see fig.)

Let after time, t this particle be at P and N be the projection of P on YOY′. The projection N executes S.H.M. along diameter YOY′ and it is desired to find its velocity V.

Let the linear velocity of particle is v and acts along the tangent to the circle at P. This linear velocity of the particle can be resolved into two components: v

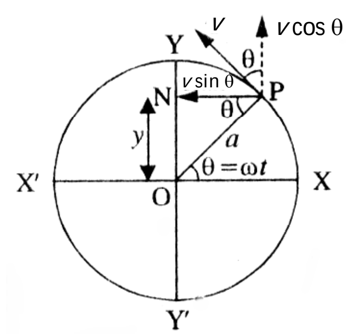


Fig. 1.5

(i) Component $v \cos\theta$ along YOY′ directed towards OY.

(ii) Component $v \sin\theta$ perpendicular to YOY′ along PN.

The component $v \sin\theta$ is perpendicular to YOY′, therefore, it produces no effect on the motion of N.

But the component $v \cos\theta$ acts along YOY′ and gives the velocity of N.

$\therefore$ Velocity 'V' of N is given by;

$$V = \theta \cos\theta = V\cos\omega t \qquad [\because \theta = \omega t]$$

$$= a\omega\cos\omega t \qquad [\because v = a \times \omega]$$

$$= a\omega\frac{NP}{OP} \qquad \left[\because \text{In rt. } \angle d\Delta ONP, \frac{NP}{OP} = \cos\theta = \cos\omega t\right]$$

$$= a\omega\frac{\sqrt{a^2 - y^2}}{a} = \omega\sqrt{a^2 - y^2}$$

$$\therefore \qquad V = \omega\sqrt{a^2 - y^2}$$

i.e., Velocity of Projection N = angular velocity $\sqrt{(amplitude)^2 - (displacement)^2}$

Special cases: From the above expression, it is clear that the velocity of N will be different at different points along its path YOY′

(*i*) **Mean position:** At the mean position, $y = 0$

$$\therefore \qquad V = \omega\sqrt{a^2 - 0} = a\omega$$

Therefore, velocity at mean position is maximum and is given by;

$$V_{max} = a\omega = v, \text{ the same as that of } P$$

(*ii*) **Extreme position:** At extreme position, $y = a$

$$V = \omega\sqrt{a^2 - a^2} = 0$$

Therefore, velocity is zero at the extreme position.

1.5 EXPRESSION FOR ACCELERATION OF A PARTICLE EXECUTING S.H.M.

Consider a particle P moving in the anticlockwise direction with an angular velocity ω rad/second along the circle. Let at any instant this particle be at P. Then N is the projection of P on YOY′ and the motion of N is S.H.M. We are to find the acceleration of N.

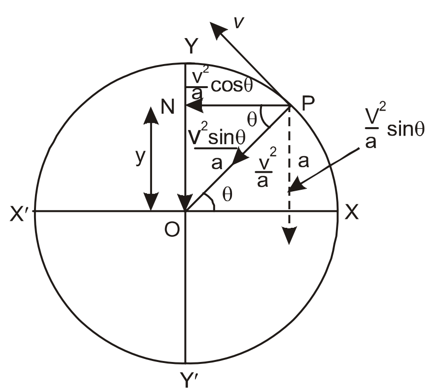


Fig. 1.6

The particle at point P is acted upon by a centripetal acceleration $\frac{v^2}{a}$ along the radius PO. This acceleration can be resolved into two components:

(*i*) $\frac{v^2}{a}\cos\theta$ along PN perpendicular to YOY′

(*ii*) $\frac{v^2}{a}\sin\theta$ along YOY′ directed toward NO.

The component $\frac{v^2}{a}\cos\theta$ being perpendicular to YOY′ produces no effect on the motion of N. But the component $\frac{v^2}{a}\sin\theta$ acts along YOY′ and hence gives the acceleration of N.

$\therefore$ Acceleration of $N = \frac{v^2}{a}\sin\theta$ along NO

$$= \frac{(a\omega)^2}{a}\times\sin\theta \qquad [\because v = a\omega]$$

$$= \omega^2 \; a\sin\omega t = \omega^2 y \qquad [\because \theta = \omega t)\ [y = a\sin\omega t]$$

$\therefore$ Acceleration $= \omega^2 y$

i.e., **Acceleration = (angular velocity)^2 × displacement**

Since ω is constant therefore. **Acceleration $\propto$ displacement** (y).

Special cases: From the expression, it is clear that the acceleration on N will be different at different points along its path YOY′.

(*i*) Mean Position: At mean position, $y = 0$

$\therefore$ Acceleration $= \omega^2 \times 0 = 0$

Thus, acceleration at mean position (point O) is zero.

(*ii*) Extreme Position: At extreme position, $y = a$

$\therefore$ Acceleration $= \omega^2 \; a = a\,\omega^2$

i.e., Acceleration is maximum.

Thus, acceleration is maximum at the extreme position.

Expression for Time Period of a particle Executing S.H.M.

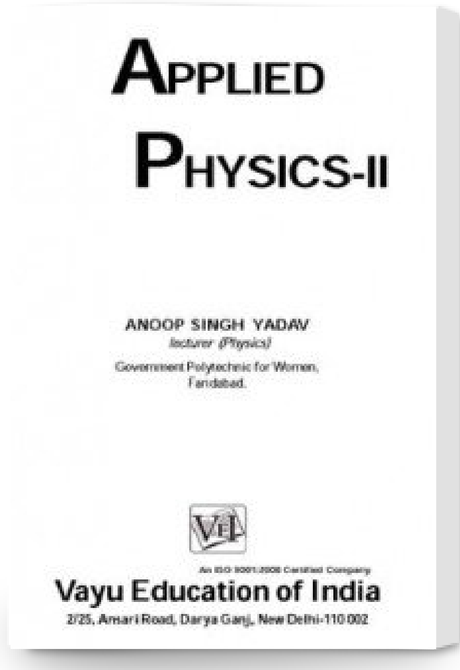
Let a particle be executing S.H.M.

Where, T = Time period in seconds.

When the particle completes one revolution, it describes an angle of 2π radians at the centre. During this time, the projection completes one vibration and, therefore, takes time T seconds.

$$\text{Now, Angular velocity} = \frac{\text{Angle described}}{\text{Time taken}}$$

Applied Physics-II By Anoop Singh Yadav



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