

Engineering Physics

Semester I & II
First Year Engineering Common to All Branches
As per the new revised syllabus of SSPU. w.e.f. academic year 2012-2013

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First Edition : 2017

Published By –

Gigatech Publishing House

631/32, Budhawar Peth,

Office No. 105, First Floor, Shan Bramha Complex, Pune – 411 002 .

Phone No. 952 952 0952

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ISBN NO. : 978-81-9341-401-9

Price : ₹ 250/-

Available at All Leading Book Stalls

Distributor :

PRADEEP BOOK DISTRIBUTORS

102/3, 1ST Floor, Shan Bramha Complex,

Pune. Telephone No. 020 – 24458333,

942 208 7031 / 844 699 5959

E-mail : pbd0909@gmail.com

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Preface

We are delighted to present this book to the students of First Year (all branches) from all the engineering colleges affiliated to the Savitribai Phule Pune University.

Physics is a mandatory subject for first year engineering students, where almost all the important engineering elements of the subject are covered. This book is written according to the **revised (2012) curriculum** of 'Engineering Physics'. The aim of writing this book has been to present the material in a concise and simple way so that even weak students can grasp the fundamentals. Each Unit of the book starts with simple introduction and then related topics are covered with required description along with the help of figures. A large number MCQ's and solved problems, properly graded have been added in all units to enable the students to attempt different types of questions in the university examination without any difficulty.

This book has been written after understanding the exact requirement of F.E. (all branches) students thoroughly. We are sure that it will satisfy all the needs of F.E. students from the Savitribai Phule Pune University.

We express our sincere thank to Hon. Prof. M. N. Navale, Founder-President STES, Hon. Dr. (Mrs.) Sunanda M. Navale, Founder- Secretary STES, Hon. Mr Rohit Navale, Vice president (HR), STES and Hon. Mrs. Rachana Navale – Ashtekar, Vice President (Admin), STES as they are constant source of inspiration to us right from the first day of our teaching carrier. we would also like to thank Principal SCOE, SKNCOE, NBNSOE, SAE, SITS, RMDSOE, SIT, SKNSITS for their co-operation and support. We would also thank our department colleagues for their suggestions and timely help.

Any suggestions for the improvement of this book will be sincerely acknowledged and incorporated in the next edition.

We are thankful to Mr. Harshal J Potadar and Rohit K Dongare from **Gigatech Publishing House (GPH)** for their continuous support and patience in preparing this book.

13 July 2017

Author

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SYLLABUS

Unit 1 : Interference – Diffraction and its Engineering application (08 Hours)

Interference : Introduction, Concept of thin film, Interference due to thin films of uniform thickness (with derivation), Interference due to wedge shaped thin films (qualitative), fringe width (with derivation), Formation of colors in thin films, Newton's rings, its applications(i) for the determination of wavelength of incident light or radius of curvature of a given plano-convex lens, (ii) for the determination of refractive index of a given liquid, Applications of Interference (i) Testing of optical flatness of surfaces, (ii) Thickness of thin film, (iii) anti-reflection coating.

Diffraction : Diffraction of waves, classes of diffraction, Fraunhofer diffraction of single slit (geometrical method) Conditions for maxima & minima, Intensity pattern due to single slit, diffraction at circular aperture, plane diffraction grating (qualitative only), Conditions for maxima & minima, Intensity pattern, Scattering of light as an application of diffraction (qualitative only),

Unit 2 : Sound Engineering (08 Hours)

Definitions :Velocity, frequency, wavelength, intensity, loudness (expression), timbre of sound, reflection of sound, echo, Reverberation, reverberation time, Sabine's formula (qualitative only), remedies over reverberation Absorption of sound, absorbent materials, Conditions for good acoustics of the building, Noise, its effects and remedies. Ultrasonics Production of ultrasonics by Piezo-electric and magnetostriction oscillator, Detection of ultrasonics, Engineering applications of ultrasonics (Non-destructive testing, cavitations, measurement of gauge).

Unit 3 : Polarization and Laser (08 Hours)

Polarization : Introduction, Polarization of waves, Polarization of light, Representation of PPL, UPL & partially polarized light, Production of PPL by (i) Reflection, (ii) Refraction (pile of plates), (iii) Selective absorption (dichroism) (iv) Double refraction, Law of Malus, Huygen's theory of double refraction cases of double refraction of crystal cut with the optic axis lying in the plane of incidence & (i) Parallel to surface (ii) Perpendicular surface (iii) Inclined to surface, retardation plates, QWP, HWP, optical activity, specific rotation (qualitative only), optically active materials, LCD (as an example of polarization).

LASER : Absorption, spontaneous emission, requirement for lasing action (stimulated emission, population inversion, metastable state, active medium, resonant cavity, pumping) characteristics of laser monochromaticity, coherence, directionality, brightness, various levels of laser systems with examples (i) two levels laser system-semiconductor laser, (ii) three level laser system ruby laser, (iii) four level laser system He-Ne laser.

Applications in Industry (drilling, welding, micromachining etc), Medicine (as a surgical tool), Communication (Principle and advantages only), Information Technology (Holography-Recording and reconstruction)

Unit 4 : Solid State Physics**(08 Hours)**

Band theory in solids, free electron theory (qualitative) electrical conductivity in conductor and semiconductor, influence of external factors on conductivity (temperature, light and impurity), Fermi energy, density state (qualitative) concept of effective mass, electrons and holes, Fermi- Dirac probability distribution function (effect of temperature on Fermi level with graph), Position of Fermi level in intrinsic semiconductor (with derivation) and extrinsic semiconductors, Dependence of Fermi level on temperature and doping concentration (qualitative), diffusion and drift current (qualitative), band structure of PN junction diode under i) zero bias, ii) forward bias, iii) reverse bias, Working of transistor (NPN only) on the basis of Band diagram, Hall effect (with derivation), photovoltaic effect working of solar cell on the basis of diagram and its applications.

Unit 5 : Wave Mechanics**(08 Hours)**

Wave particle duality of radiation & matter, De Broglie's concept of matter waves, expressing de Broglie wavelength in terms of kinetic energy and potential, concept and derivation of group and phase velocity, group and phase velocity of matter waves, Heisenberg's uncertainty principle, Illustration of it by electron diffraction at single slit, why an electron cannot exist in the nucleus, concept of wave function ψ and probability interpretation of $|\psi|^2$, Schrodinger's time independent and dependent wave equations, applications of Schrodinger's time independent wave equation (i) Particle in 1-D rigid box (infinite potential well), Comparison of quantum mechanical and classical mechanical predictions (ii) Particle in 1-D non rigid box (finite potential well-qualitative, result only), tunnelling effect, example of tunnelling effect in tunnel diode and scanning tunnelling microscope.

Unit 6 : Superconductivity and Physics of nano-particles**(08 Hours)**

Superconductivity Introduction to Superconductivity, Properties of Superconductors (zero resistance, Meissner effect, critical fields, persistent currents), isotope effect, BCS theory, Type-I & Type-II Super conductors, Applications (super conducting magnets, transmission lines etc.) DC & AC Josephson Effect.

Physics of nano-particles Introduction, Nanoparticles, Properties of nanoparticles Optical, electrical (quantum dots, quantum wires), magnetic, structural, mechanical, brief introduction to different methods of synthesis of nanoparticles such as physical, chemical, biological, mechanical. Synthesis of colloids, Growth of nano-particles, Synthesis of metal nano-particles by colloidal route, Application of nanotechnology- electronics, energy, automobiles, space & defense, medical, environmental, textile, cosmetics.

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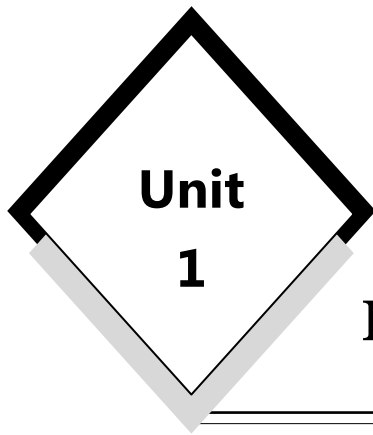
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MCQ'S 1 – 94**SOLVED QUESTION PAPER MAY-2017 Q.1 – Q.23****QUESTION BANK 1 – 8**



Interference and Diffraction

: Syllabus :

Interference : Introduction, Concept of thin film, Interference due to thin films of uniform thickness (with derivation), Interference due to wedge shaped thin films (qualitative), fringe width (with derivation), Formation of colors in thin films, Newton's rings, its applications (i) for the determination of wavelength of incident light or radius of curvature of a given plano-convex lens, (ii) for the determination of refractive index of a given liquid, Applications of Interference (i) Testing of optical flatness of surfaces, (ii) Thickness of thin film, (iii) anti-reflection coating.

Diffraction : Diffraction of waves, classes of diffraction, Fraunhofer diffraction of single slit (geometrical method) Conditions for maxima & minima, Intensity pattern due to single slit, diffraction at circular aperture, plane diffraction grating (qualitative only), Conditions for maxima & minima, Intensity pattern, Scattering of light as an application of diffraction (qualitative only).

1.1 Interference:

In rainy season, while passing by the roads, it is our common experience that we see beautiful colours on the ponds of water. In our childhood almost everybody has played with the soap bubbles and amazed about the colours observed on it. These both are the examples of interference due to thin films which mainly we are going to deal with in this unit.

When a single source of light emits energy then it spreads out uniformly in all the directions. But whenever there are two sources of light emitting light of same wavelength and same amplitude then due to 'superposition of waves' from the two sources, the distribution of light is not uniform.

1.2 Prerequisites:

1.2.1 Superposition principle:

When two or more waves travelling in a medium superimpose on each other, they lose their individual identity and a new wave is formed, whose resultant amplitude can be determined using superposition principle. According to superposition principle, when the two or more waves arrives at a point simultaneously i.e. they superimpose on each other then their resultant amplitude at that point at any instant of time is the algebraic sum of the amplitudes of the individual waves.

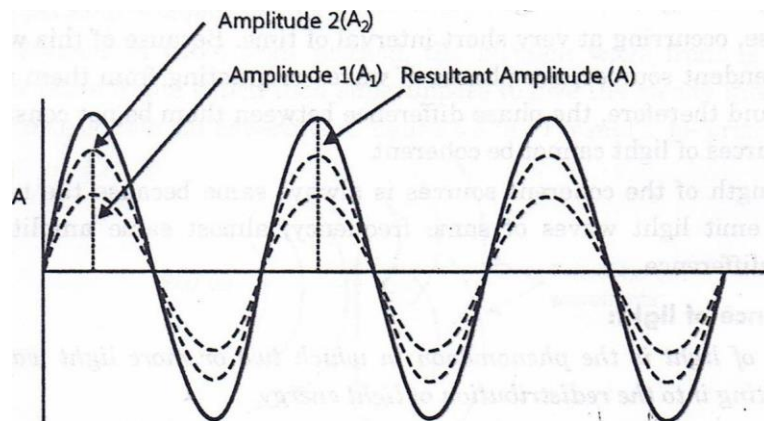


Fig. 1.1: Superposition of waves having same phase and frequency

If A is a resultant amplitude of a wave and $A_1, A_2, A_3,$ are the amplitudes of the individual waves, then

$$A = A_1 \pm A_2 \pm A_3 + \dots \quad \dots(1.1)$$

The positive sign is taken when amplitudes of the waves are in the same direction and negative sign when they are in opposite direction. The superposition principle is illustrated in figure 1.1.

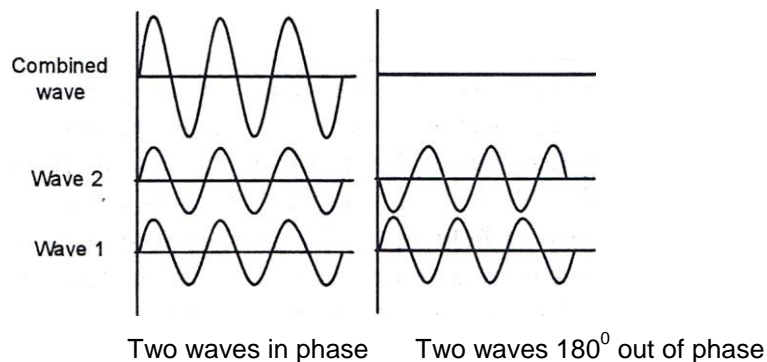


Fig. 1.2 Superposition of waves having same amplitude.

Figure 1.2 shows the result of superposition of waves having same amplitude.

1.2.2 Coherent Sources:

The two light sources are said to be coherent when there is no phase/path difference or constant phase/path difference between them.

The two independent light sources cannot be coherent. When electron makes transition from a higher energy state to a lower energy state, it gives out the energy in the form of radiation. When the wavelength and frequency of these radiations lies within the visible spectrum, we get a light. This light consists of discontinuous waves and having abrupt changes in phase, occurring at very short interval of time. Because of this when light comes from two independent sources, the phases of waves originating from them will be changing independently and therefore, the phase difference between them be not constant. Hence, two independent sources of light cannot be coherent.

The wavelength of the coherent sources is always same because the two sources to be coherent must emit light waves of same frequency, almost same amplitude but with a constant phase difference.

1.2.3 Interference of light:

University Questions

1. Obtain the equation of path difference between the reflected rays when the monochromatic light is incident on the uniform thickness film. **(May 2011) (7 Marks)**
2. Derive the expression for brightness and darkness for a monochromatic light beam reflected from a thin parallel film of transparent material. **(Dec. 2009) (7 Marks)**
3. Draw a neat labelled diagram showing interference of light in a transparent thin film of uniform thickness **(May 2012) (7 marks)**

Interference of light is the phenomenon in which two or more light waves superimpose each other resulting into the redistribution of light energy.

Constructive and Destructive interference:

Consider two light waves of equal frequency and amplitude travelling with a same speed in the positive X-direction, but with a phase difference ϕ between them. Let these waves superimpose on each other. Interference will occur in the region of superposition.

'Constructive interference' is said to be take place when the two waves superimpose (meet at a point) and phase difference between them is zero or even multiple of π i.e $2n\pi$ (they are in phase) or the path difference between the two interfering waves is integral multiple of wavelength λ .

$$\text{i.e.} \quad \text{p.d.} = n\lambda \quad (\text{Where, } n = 0, 1, 2, 3, \dots) \quad \dots(1.2)$$

and we get bright band or spot there and intensity is maximum.

Destructive interference is said to be take place when the two waves superimpose (meet at a point) and phase difference between them is odd multiple of π i.e.

$(2n+1)\pi$ (they are in opposite phase) or path difference between the two interfering waves is odd multiple of half the wavelength λ .

i.e.
$$\text{p.d.} = (2n+1) \frac{\lambda}{2} \quad \dots(1.3)$$

Where, $n = 0, 1, 2, 3, \dots$ and we get dark band or spot there and intensity is minimum.

Thus the interference pattern consists of alternate bright and dark bands.

1.2.4 Conditions to obtain steady interference pattern in laboratory:

University Questions

1. Derive an expression for condition of maxima for reflected light in case of thin transparent film of uniform thickness. **(May 2010, May 2011, May 2012) (3 Marks)**
2. Derive an expression for condition of minima for reflected light in case of thin transparent film of uniform thickness. **(May 2010, May 2011, May 2012) (3 Marks)**

To obtain the steady resultant interference pattern on the screen, the following conditions must be satisfied.

- (i) The two light waves should be coherent. The phase difference between them should not vary with time. The two interfering light waves must be obtained from a single source as the light waves from two independent sources cannot be coherent.

If ϕ is a phase difference at a point between two interfering waves, then intensity at that point is $I = \cos^2 \phi/2$. Hence, when ϕ changes with time then the resultant intensity will change with time and steady interference pattern cannot be obtained on the screen. Therefore it is necessary that the two interfering waves are coherent.

There are two methods of getting such coherent beams and hence accordingly the phenomenon of interference is studied under two categories.

1. Division of wave front method.
2. Division of amplitude method.

In the division of wave front method, the incident wave front is divided into two separate wave fronts which then superimpose to give the steady interference pattern. e.g. Young's double slit experiment, figure 1.3 (a), Fresnel's bi- prism.

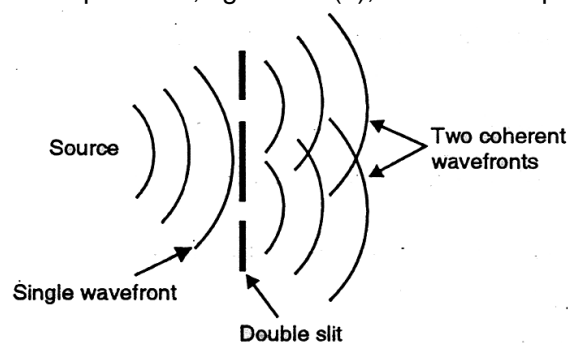


Figure 1.3 (a)

In the division of amplitude method, the incident wave is divided into two beams by using a phenomenon of partial reflection and refraction. figure 1.3 (b) (i.e. amplitude or the intensity of incident wave is divided into two parts.)

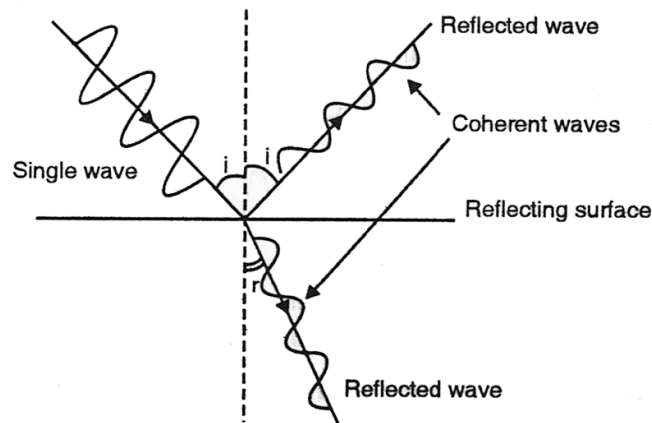


Figure 1.3 (b)

- (ii) The two interfering waves should be monochromatic. i.e. they should have same wavelength.
- (iii) To have good contrast between bright and dark bands (fringes), amplitudes of interfering waves should be equal or nearly equal.
- (iv) The good visibility of the fringes on the screen is possible if the fringe width and the separation between the fringes is large.

To get large separation between the fringes, the separation between the interfering wave sources should be very small and to get large fringe width the separation between the wave sources and the screen on which the interference pattern is obtained should be large.

- (v) The two sources of interfering waves should be narrow or they must be extremely small. A broad source is equivalent to a large number of fine sources. Each pair of fine sources will give its own pattern. The fringes of different interference pattern will overlap.
- (vi) The angle between the interfering waves should be very small. Large angle will introduce large path difference between the interfering waves resulting poor contrast and visibility in the resultant interference pattern.

1.2.5 Some important results :

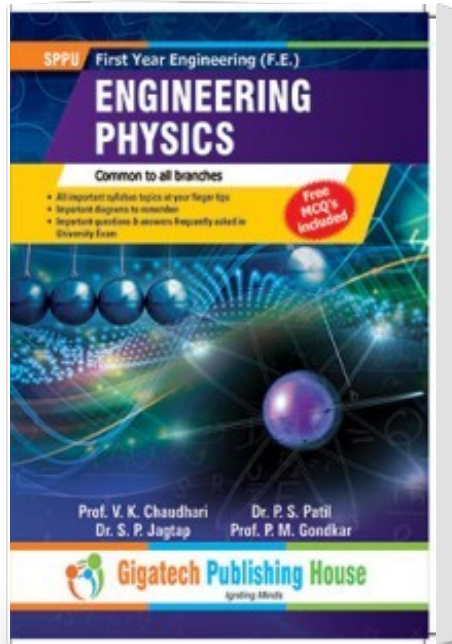
Before studying the interference in thin films some useful results in the optics, that will be needed are,

(a) When p.d. between two waves is $= \lambda$. Phase difference $\Delta\phi = 2\pi$

When, p.d. = x then,

$$\text{phase difference } \Delta\phi = \frac{2\pi}{\lambda} \times x \quad \dots(1.4)$$

Engineering Physics Semester I And II (Common for all branches)



Publisher : Gigatech Publishing
House

ISBN : 9788193414019

Author : V K Chaudhari, S P
Jagtap, P S Patil And P M
Gondkar

Type the URL : <http://www.kopykitab.com/product/11940>



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