APPLIED PHYSICS – II (TH-2)
FULL COURSE FILE (UNIT 1–7)

APPLIED PHYSICS – II (TH-2)
UNIT–1: WAVE MOTION AND ITS APPLICATIONS

1. Wave Motion

Wave motion is a type of motion in which a disturbance travels through a medium, transferring energy from one point to another without the actual transfer of matter. The particles of the medium only vibrate about their mean positions.

2. Types of Waves

Transverse Waves: In transverse waves, particles vibrate perpendicular to the direction of propagation. Examples include waves on a stretched string and light waves.

Longitudinal Waves: In longitudinal waves, particles vibrate parallel to the direction of propagation. Examples include sound waves in air.

3. Wave Parameters

Wavelength (λ): Distance between two successive points in the same phase.
Frequency (f): Number of oscillations per second.
Time Period (T): Time taken for one oscillation.
Wave Velocity (v): Distance travelled by wave per second.

Relation: $v = f\lambda$

4. Sound Waves and Light Waves

Sound waves are mechanical and longitudinal waves which require a medium for propagation. Light waves are electromagnetic and transverse in nature and do not require a medium.

5. Wave Equation

A progressive wave is represented as:
$y = a \sin(\omega t - kx)$

Where a is amplitude, ω is angular frequency and k is wave number.

6. Superposition of Waves and Beats

According to the principle of superposition, when two or more waves overlap, the resultant displacement is the algebraic sum of individual displacements.

Beats are periodic variations in sound intensity produced by two waves of slightly different frequencies. Beat frequency = $|f1 - f2|$.

7. Simple Harmonic Motion (SHM)

Simple Harmonic Motion is a periodic motion in which the restoring force is directly proportional to displacement and acts towards the mean position.

Displacement: $x = a \sin \omega t$
Velocity: $v = \omega\sqrt{(a^2 - x^2)}$
Acceleration: $a = -\omega^2 x$
Time Period: $T = 2\pi/\omega$

8. Progressive Wave and Energy Transfer

In a simple harmonic progressive wave, each particle executes SHM while energy is transferred through the medium without transport of matter.

9. Vibration of Cantilever

A cantilever is a beam fixed at one end and free at the other. When disturbed, it vibrates in SHM. The time period depends on length, mass and elasticity of the material.

10. Types of Vibrations

Free Vibrations: Vibrations without external force.
Forced Vibrations: Vibrations under external periodic force.
Resonant Vibrations: Occur when forced frequency equals natural frequency.

11. Acoustics of Buildings

Acoustics deals with the production, transmission and control of sound in halls.
Reverberation is persistence of sound after the source stops.

Reverberation Time (RT) is the time taken for sound intensity to reduce to one millionth of its original value.
$RT = 0.161 V / A$

12. Control of Reverberation

Reverberation can be controlled using acoustic tiles, false ceilings, curtains, carpets and perforated boards to improve clarity of sound.

13. Ultrasonic Waves

Ultrasonic waves are sound waves having frequency greater than 20 kHz. They are highly directional and possess high penetrating power.

Engineering Applications: Non-destructive testing, ultrasonic cleaning, SONAR.
Medical Applications: Ultrasonography, kidney stone detection, fetal imaging.

APPLIED PHYSICS – II (TH-2)
UNIT–2: OPTICS

1. Introduction to Optics

Optics is the branch of physics that deals with the nature, propagation and behavior of light and its interaction with matter.

2. Reflection of Light

Reflection is the phenomenon by which light returns to the same medium after striking a reflecting surface.

Laws of Reflection:
1. Angle of incidence equals angle of reflection.
2. Incident ray, reflected ray and normal lie in the same plane.

3. Refraction of Light

Refraction is the bending of light when it passes from one medium to another due to change in speed.

Snell's laws:
1. Incident ray, refracted ray and normal lie in the same plane.
2. $\sin i / \sin r = \text{constant}$.

4. Refractive Index

Refractive index is the ratio of velocity of light in vacuum to velocity of light in a medium.
$\mu = c / v$

5. Image Formation by Mirrors

Mirrors form images due to reflection. Types of mirrors are plane, concave and convex mirrors.

Mirror formula: $1/f = 1/v + 1/u$
Magnification $m = v/u$

6. Image Formation by Lenses

Lenses form images due to refraction. Types are convex and concave lenses.

Lens formula: $1/f = 1/v + 1/u$
Magnification $m = v/u$

7. Thin Lens

A thin lens is one whose thickness is negligible compared to its focal length.

8. Power of Lens

Power of a lens is the reciprocal of focal length in meters.
$P = 1/f$
Unit: Diopter

9. Total Internal Reflection

Total internal reflection occurs when light travels from denser to rarer medium at an angle greater than critical angle.

Conditions:
1. Light must travel from denser to rarer medium.
2. Angle of incidence > critical angle.

10. Optical Fiber

Optical fiber works on the principle of total internal reflection. It consists of core and cladding.

Applications include telecommunication and medical endoscopy.

11. Simple Microscope

A simple microscope uses a convex lens to magnify small objects.

Magnifying power $M = 1 + D/f$

12. Compound Microscope

A compound microscope uses two lenses: objective and eyepiece.

Magnifying power $M = (L/fo) \times (D/fe)$

13. Astronomical Telescope

An astronomical telescope is used to observe distant objects. In normal adjustment, final image is at infinity.

Magnifying power $M = fo/fe$

14. Optical Projection Systems

Optical projection systems project enlarged images on a screen using lenses and light sources.

APPLIED PHYSICS – II (TH-2)
UNIT–3: ELECTROSTATICS

1. Introduction to Electrostatics

Electrostatics is the branch of physics that deals with electric charges at rest and the forces, fields, and potentials associated with them.

2. Electric Charge

Electric charge is a fundamental property of matter responsible for electric forces. There are two types of charges: positive and negative. Like charges repel each other while unlike charges attract each other.

3. Coulomb's Law

Coulomb's law states that the force between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.

$$F = (1 / 4\pi\epsilon_0) \times (q_1q_2 / r^2)$$

Where q_1 and q_2 are charges, r is the distance between them, and ϵ_0 is the permittivity of free space.

4. Electric Field

Electric field is defined as the force experienced by a unit positive charge placed at a point in an electric field.

$$E = F / q$$

Unit: N/C or V/m

5. Electric Lines of Force

Electric lines of force are imaginary lines used to represent the direction and strength of electric fields. They originate from positive charges and terminate at negative charges.

6. Electric Flux

Electric flux is a measure of the number of electric field lines passing through a given surface.

$$\Phi = E \cdot A$$

Unit: $N \cdot m^2/C$

7. Electric Potential and Potential Difference

Electric potential at a point is the work done in bringing a unit positive charge from infinity to that point in an electric field.

$V = W / q$

Potential difference is the work done in moving a unit charge between two points.

8. Gauss's Law

Gauss's law states that the total electric flux through a closed surface is equal to the total charge enclosed divided by the permittivity of free space.

$\oint E \cdot dA = Q / \epsilon_0$

9. Applications of Gauss's Law

Gauss's law is used to find the electric field intensity of:
1. Infinite straight charged conductor
2. Infinite plane charged sheet
3. Charged spherical shell

10. Capacitor

A capacitor is an electrical device used to store electric charge and energy. It consists of two conductors separated by an insulating material called dielectric.

11. Capacitance

Capacitance is the ability of a capacitor to store electric charge.

$C = Q / V$

Unit: Farad (F)

12. Parallel Plate Capacitor

A parallel plate capacitor consists of two parallel conducting plates separated by a small distance.

$C = \epsilon_0 A / d$

Where A is the area of plates and d is the separation between them.

13. Combination of Capacitors

Capacitors can be connected in series and parallel.

Series combination: $1/C = 1/C_1 + 1/C_2 + ...$
Parallel combination: $C = C_1 + C_2 + ...$

14. Dielectric and Its Effect

A dielectric is an insulating material placed between the plates of a capacitor. It increases the capacitance of the capacitor by reducing the electric field.

15. Dielectric Breakdown

Dielectric breakdown occurs when the electric field across the dielectric becomes strong enough to cause it to conduct electricity.

APPLIED PHYSICS – II (TH-2)
UNIT–4: CURRENT ELECTRICITY

1. Introduction to Current Electricity

Current electricity deals with the study of electric charges in motion. It explains how electric current flows through conductors and the factors affecting it.

2. Electric Current

Electric current is defined as the rate of flow of electric charge through a conductor.

$I = Q / t$

Unit: Ampere (A)

3. Types of Current

Direct Current (DC): Current flowing in one direction only. Example: battery.

Alternating Current (AC): Current which changes its direction periodically. Example: household supply.

4. Resistance

Resistance is the opposition offered by a conductor to the flow of electric current.

$R = V / I$

Unit: Ohm (Ω)

5. Specific Resistance (Resistivity)

Specific resistance or resistivity is the resistance of a conductor having unit length and unit cross-sectional area.

$\rho = R A / l$

Unit: Ohm-meter ($\Omega \cdot m$)

6. Conductance and Specific Conductance

Conductance is the reciprocal of resistance.

$G = 1 / R$

Specific conductance is the reciprocal of resistivity.

7. Factors Affecting Resistance

Resistance of a conductor depends on:
1. Length of conductor
2. Area of cross-section
3. Nature of material
4. Temperature

8. Combination of Resistances

Series combination:
$R = R_1 + R_2 + R_3 + ...$

Parallel combination:
$1/R = 1/R_1 + 1/R_2 + 1/R_3 + ...$

9. Carbon Resistance and Colour Coding

Carbon resistors are widely used in electronic circuits. Their resistance value is indicated by colour bands.

10. Ohm’s Law

Ohm’s law states that at constant temperature, the current through a conductor is directly proportional to the potential difference across it.

$V = IR$

11. Kirchhoff’s Laws

Kirchhoff’s Current Law (KCL): Algebraic sum of currents at a junction is zero.

Kirchhoff’s Voltage Law (KVL): Algebraic sum of voltages in a closed loop is zero.

12. Wheatstone Bridge

Wheatstone bridge is an arrangement of four resistances used to measure unknown resistance accurately. Slide wire bridge is a practical form of Wheatstone bridge.

13. EMF and Terminal Potential Difference

Electromotive force (EMF) is the potential difference between terminals of a cell when no current flows.

Terminal potential difference is the potential difference across terminals when current is drawn.

14. Heating Effect of Electric Current

When electric current flows through a conductor, heat is produced. This is known as heating effect of current.

$H = I^2 R t$

15. Electric Power and Energy

Electric power is the rate at which electrical energy is consumed.

$P = V I$

Electric energy is given by:
$E = P t$

Unit of energy: kilowatt-hour (kWh)

16. Advantages of Electric Energy

Electric energy is clean, easily controllable, economical, and can be converted into other forms of energy efficiently.

APPLIED PHYSICS – II (TH-2)
UNIT–5: ELECTROMAGNETISM

1. Introduction to Magnetism

Electromagnetism is the branch of physics that deals with magnetic fields, magnetic materials, and the interaction between electricity and magnetism.

2. Magnetic Field

Magnetic field is the region around a magnet or current-carrying conductor in which magnetic force can be experienced.

Unit: Tesla (T)

3. Magnetic Lines of Force

Magnetic lines of force are imaginary lines used to represent magnetic fields. They emerge from the north pole and enter the south pole outside the magnet.

4. Magnetic Flux

Magnetic flux is the total number of magnetic field lines passing through a surface.

$\Phi = B \cdot A$

Unit: Weber (Wb)

5. Magnetic Intensity and Magnetization

Magnetic intensity represents the strength of the magnetic field. Magnetization is the magnetic moment per unit volume of material.

6. Types of Magnetic Materials

Diamagnetic Materials: Weakly repelled by magnetic field (e.g., bismuth).

Paramagnetic Materials: Weakly attracted by magnetic field (e.g., aluminum).

Ferromagnetic Materials: Strongly attracted by magnetic field (e.g., iron, cobalt).

7. Electromagnetic Induction

Electromagnetic induction is the phenomenon of production of emf due to change in magnetic flux linked with a conductor.

8. Faraday’s Laws of Electromagnetic Induction

First Law: Whenever magnetic flux linked with a conductor changes, an emf is induced.

Second Law: The magnitude of induced emf is proportional to the rate of change of magnetic flux.

$e = - d\Phi/dt$

9. Lorentz Force

Lorentz force is the force experienced by a charged particle moving in electric and magnetic fields.

$F = qvB \sin\theta$

10. Force on a Current Carrying Conductor

A current-carrying conductor placed in a magnetic field experiences a force.

$F = B I l \sin\theta$

11. Force on a Rectangular Coil

When a rectangular coil carrying current is placed in a magnetic field, it experiences a torque which causes it to rotate.

12. Moving Coil Galvanometer

A moving coil galvanometer is a sensitive instrument used to detect small electric currents.

13. Principle of Moving Coil Galvanometer

It works on the principle that a current-carrying conductor placed in a magnetic field experiences a force.

14. Construction and Working

It consists of a rectangular coil, soft iron core, permanent magnet, suspension fiber, and pointer. When current flows, the coil rotates producing deflection.

15. Conversion of Galvanometer

Galvanometer can be converted into:
Ammeter by connecting low resistance in parallel.
Voltmeter by connecting high resistance in series.

APPLIED PHYSICS – II (TH-2)
UNIT–6: SEMICONDUCTOR PHYSICS

1. Introduction to Semiconductor Physics

Semiconductor physics deals with the study of materials whose electrical conductivity lies between that of conductors and insulators. Semiconductors play a vital role in modern electronic devices.

2. Energy Bands in Solids

In solids, energy levels form continuous bands known as energy bands. The important bands are:

1. Valence Band – highest occupied energy band
2. Conduction Band – band responsible for electrical conduction
3. Forbidden Energy Gap – energy gap between valence and conduction bands

3. Classification of Materials Based on Energy Band

Conductors: Valence and conduction bands overlap.

Insulators: Large forbidden energy gap.

Semiconductors: Small forbidden energy gap.

4. Semiconductors

Semiconductors are materials with moderate conductivity. Examples include silicon and germanium.

5. Types of Semiconductors

Intrinsic Semiconductor: Pure semiconductor with equal number of electrons and holes.

Extrinsic Semiconductor: Semiconductor doped with impurities to increase conductivity.

6. Doping and Types of Extrinsic Semiconductors

Doping is the process of adding impurities to a semiconductor.

n-type Semiconductor: Doped with pentavalent impurity.

p-type Semiconductor: Doped with trivalent impurity.

7. p–n Junction

A p–n junction is formed by joining p-type and n-type semiconductors. It forms the basic structure of semiconductor devices.

8. Junction Diode

A junction diode is a two-terminal device formed using a p–n junction. It allows current to flow in one direction only.

9. Forward and Reverse Biasing

Forward Biasing: p-side connected to positive terminal and n-side to negative terminal.

Reverse Biasing: p-side connected to negative terminal and n-side to positive terminal.

10. V–I Characteristics of Diode

In forward bias, current increases rapidly after threshold voltage.

In reverse bias, a small leakage current flows.

11. Types of Junction Diodes

Zener Diode
Light Emitting Diode (LED)
Photodiode

12. Diode as Rectifier

A rectifier converts alternating current into direct current.

Half-wave Rectifier: Uses one diode.

Full-wave Rectifier (Centre-tapped): Uses two diodes.

13. Transistor

A transistor is a three-terminal semiconductor device used for amplification and switching.

14. Types of Transistors

pnp Transistor
npn Transistor

15. Applications of Transistor

Amplifiers
Switching circuits
Oscillators
Signal processing

16. Photocells

Photocells are light-sensitive devices that convert light energy into electrical energy.

17. Solar Cells

Solar cells convert solar energy directly into electrical energy using photovoltaic effect.

Applications include power generation, satellites, and calculators.

APPLIED PHYSICS – II (TH-2)
UNIT–7: MODERN PHYSICS

1. Introduction to Modern Physics

Modern physics deals with the study of phenomena that cannot be explained by classical physics. It includes the study of lasers, fiber optics and nanotechnology which have wide engineering and medical applications.

2. LASER

LASER stands for Light Amplification by Stimulated Emission of Radiation. A laser produces a highly intense, monochromatic and coherent beam of light.

3. Energy Levels, Excitation and Ionization

Energy levels are fixed energies possessed by electrons in an atom.

Excitation occurs when an electron jumps to a higher energy level by absorbing energy.

Ionization is the process of completely removing an electron from an atom.

4. Spontaneous and Stimulated Emission

Spontaneous emission occurs when an excited atom returns to lower energy level on its own.

Stimulated emission occurs when an excited atom is forced to emit radiation by an external photon.

5. Population Inversion

Population inversion is a condition in which the number of atoms in higher energy state is greater than those in lower energy state. It is essential for laser action.

6. Pumping Methods

Pumping is the process of supplying energy to achieve population inversion.

Methods include optical pumping, electrical pumping and chemical pumping.

7. Optical Feedback

Optical feedback is achieved using mirrors placed on either side of the active medium to amplify light by multiple reflections.

8. Types of Lasers

Ruby Laser – solid state laser.

He-Ne Laser – gas laser.

Semiconductor Laser – widely used in communication.

9. Characteristics of Laser

Laser light is monochromatic, coherent, highly directional and very intense.

10. Applications of Lasers

Engineering applications: cutting, welding, drilling, alignment.

Medical applications: eye surgery, cancer treatment, dermatology.

Communication and research.

11. Fiber Optics

Fiber optics deals with transmission of light through thin flexible fibers using the principle of total internal reflection.

12. Light Propagation in Optical Fiber

Light propagates through the fiber core by repeated total internal reflections at the core-cladding interface.

13. Acceptance Angle and Numerical Aperture

Acceptance angle is the maximum angle at which light can enter the fiber.

Numerical Aperture (NA) indicates the light gathering capacity of the fiber.

14. Types of Optical Fibers

Single-mode fiber
Multi-mode fiber
Step index fiber
Graded index fiber

15. Applications of Fiber Optics

Telecommunication
Medical endoscopy
Sensors
Data transmission

16. Nanoscience and Nanotechnology

Nanoscience deals with materials at nanoscale (1–100 nm).

Nanotechnology involves designing and application of nanomaterials.

17. Nanoparticles and Nanomaterials

Nanoparticles are particles of size less than 100 nm.

Nanomaterials exhibit unique electrical, optical and mechanical properties.

18. Properties at Nanoscale

High surface area to volume ratio
Enhanced strength
Unique optical properties

19. Applications of Nanotechnology

Electronics and semiconductors
Medical diagnostics and drug delivery
Sensors
Energy storage and conversion