SYLLABUS OF

M.Sc. (Physics)

Programme Code: MPHY

Session: 2025-26, 2026-27

GURU NANAK COLLEGE

BUDHLADA

(An Autonomous College)

Under Punjabi University Patiala

Head
Department of Physics
Guru Nanak College Budhlada

Guru Nanak College, Budhlada

(Autonomous College, Punjabi University Patiala)

STUDY SCHEME

M.Sc. (PHYSICS) PART– I (I & II SEMESTER)
2025-2026 & 2026-27 SESSION

Code	Title of Paper	Hours (Per Week)	Max Marks				Examination Time (Hours)
SEMESTER – I			**Total**	**Ext.**	**Int.**	**Credits**	
Core Theory Papers							
MPHY1101T	Mathematical Methods of Physics– I	4	80	60	20	4	03
MPHY1102T	Classical Mechanics	4	80	60	20	4	03
MPHY1103T	Classical Electrodynamics	4	80	60	20	4	03
MPHY1104T	Nuclear and Particle Physics	4	80	60	20	4	03
Elective Theory Papers* (one of the followings)							
MPHY1105T	(i) Electronics-I	4	80	60	20	4	03
MPHY1106T	(ii) Remote Sensing						
MPHY1107T	(iii) Microwave and its propagation						
Core Paper (Laboratory Practice)							
MPHY1108P	Laboratory Practice: Electronics Lab	9	100	75	25	4.5	03
SEMESTER—II							
Core Theory Papers							
MPHY1201T	Mathematical Methods of Physics II	4	80	60	20	4	03
MPHY1202T	Advanced Classical Mechanics & Electrodynamics	4	80	60	20	4	03
MPHY1203T	Quantum Mechanics	4	80	60	20	4	03
MPHY1204T	Statistical Mechanics	4	80	60	20	4	03
MPHY1205T	Vikasheel Brehmand	4	100	70	30		03
Elective Papers* (One of the followings)							
MPHY1206T	i) Electronics –II	4	80	60	20	4	03
MPHY1207T	ii) Physics of Electronic Devices & Fabrication of Integrated Circuit and Systems						
MPHY1208T	iii) Science and Technology of Solar Hydrogen and Other Renewable Energies						
Core Paper (Laboratory Practice)							
MPHY1209P	Laboratory Practice: Laser – Optics Lab	9	100	75	25	4.5	03

Guru Nanak College, Budhlada

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Semester– I

MATHEMATICAL METHODS OF PHYSICS– I
(COURSE CODE: MPHY1101T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand and apply the Legendre differential equation and its solutions including Legendre polynomials, Rodrigue's formula, generating functions, recurrence relations, and orthogonality properties for solving problems in mathematical physics.*
2. *Gain proficiency in Bessel functions of the first and second kind, including their generating functions, recurrence relations, and orthogonality, and apply them to problems involving cylindrical symmetry.*
3. *Analyze complex functions using complex variable techniques: understand analyticity, solve problems using Cauchy-Riemann equations, perform complex integrations, and apply Cauchy's theorems, Taylor/Laurent series, and residue theorem to evaluate definite integrals.*
4. *Develop understanding of Cartesian tensors and their transformation properties, including tensor algebra, symmetric/antisymmetric tensors, contraction, differentiation, and covariant/contravariant forms, for applications in theoretical physics.*
5. *Apply concepts of probability and statistics including random variables, binomial, Poisson, and normal distributions, and use Gamma and Beta functions to solve integrals and problems involving distributions and statistical mechanics.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Legendre differential equation: Solution of Legendre differential equation, Legendre polynomials, Rodrigue's formula, Generating function for Legendre polynomials and recurrence relations, Orthogonality of Legendre polynomials, Associated Legendre polynomials and their properties.

Bessel functions: Definition of Bessel functions of 1^{st} and 2^{nd} kind, Generating function of $J_n(x)$ and their recurrence relations and orthogonality.

Complex variables: Elements Complex analysis, Limit and continuity, Cauchy's Riemann equations, Complex integrations, Cauchy's theorem for simply and multiply connected regions, Cauchy's integral formula, Taylor and Laurents series, Poles and singularities, Cauchy's residue theorem and its application to evaluation of definite integrals.

***Gamma and beta functions**: Definition of beta and gamma functions, Evaluation of -(1/2), Relation between beta and gamma functions, Evaluation of integrals using beta & gamma function*

SECTION B

Tensor: Cartesian tensors, Vector components and their transformation properties under three dimensional rotation in rectangular coordinates, Direct product of two and more tensors, Tensors of second and higher ranks, Symmetric and anti-symmetric tensors, Contraction and differentiation, Kronecker and alternating tensors and their isotropy property, Contra-variant and covariant tensors,

Evaluation of Polynomials: Horner's method; Root finding; Fixed point iteration, Bisection method, Regula falsi method, Newton method, Error analysis, System of linear equations. Gauss Seidal methods, Interpolation and

Extrapolation: Lagrange's interpolation, least square fitting; Differentiation and Integration: Difference operators, simpson and trapezoidal rules; Ordinary differential equation: Euler method, Taylor method.

Text Books:

1. Applied Mathematics, L.A. Pipes and Harwill, McGraw Hill Pub.
2. Mathematical Physics, G.R.Arfken, H.I. Weber, Academic Press, USA (Ind. Ed.)
3. Cartesian Tensors, H. Jeffreys, Cambridge University, Press.
4. Numerical Methods: J.H.Mathew, Prentice Hall of India, New Delhi.

CLASSICAL MECHANICS
(COURSE CODE: MPHY1102T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35 %

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Apply the Lagrangian formulation to derive equations of motion for various mechanical systems, incorporating constraints, generalized coordinates, and dissipation functions, and analyze conservation laws for linear momentum, angular momentum, and energy.*
2. *Utilize the variational principle, especially Hamilton's principle and calculus of variations, to derive equations of motion and solve physical problems such as geodesics, brachistochrone, and harmonic oscillator using symmetry and conservation theorems.*
3. *Understand the foundational concepts of the special theory of relativity, including Lorentz transformations, space-time invariance, and covariant mechanics, and apply them to analyze relativistic particle dynamics.*
4. *Formulate and solve dynamical problems using the Hamiltonian approach, employing Hamilton's equations, principle of least action, and Legendre transformation in both simple and complex mechanical systems, including charged particle dynamics.*
5. *Implement canonical transformations using generating functions and Poisson brackets, analyze their invariance properties, and solve equations of motion in Poisson bracket formalism for systems like harmonic oscillators and particles in central or electromagnetic fields.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.
Use of scientific calculator is allowed.

SECTION A

Lagrangian formulation: Conservation laws of linear, angular momentum and energy for a single particle and system of particles, Constraints and generalized coordinates, Principle of virtual work, D'Alembert principle, Lagrange's equations of motion, Velocity dependent potential and dissipation function.
Problems: Lagrangian and equations of motion for systems like motion of single particle in space, on the surface of a sphere, cone & cylinder, Atwood's machine, Bead sliding on rotating wire, Simple, spherical and compound pendulums, Projectile motion and harmonic oscillator.

Variational principle: Hamilton's principle, Calculus of variations, Lagrange's equations from Hamilton principle. Generalized momentum, Cyclic coordinates, Symmetry properties and Conservation theorems.
Problems: Applications of calculus of variations for geodesics of a plane and sphere, Minimum surface of revolution, Brachistochrone and harmonic oscillator-problems.

SECTION B

Rigid body dynamics: Angular momentum and kinetic energy of rotation of rigid body about a point, Inertia tensor and its eigen values, Principal moments, Principal axes transformation. Euler equations of motion, Heavy symmetrical top with one point fixed (analytical treatment only).

Hamiltonian formulation: Legendre transformation, Hamilton's equations of motion, Hamilton's equation from variational principle, Principle of least action.
Problems: Hamiltonian and equations of motion for system like simple and compound pendulum, Harmonic oscillator, Motion of particle in central force field, on the surface of a cone & cylinder, and near earth's surface, One-dimensional motion on a plane tangent to the earth's surface, Charged particle's motion in electromagnetic field.

Canonical transformation: Generating function, Poisson brackets and their canonical invariance, Equations of motion in Poisson bracket formulation, Poisson bracket relations between components of linear and angular momenta. *Problems*: Harmonic oscillator problem, Check for transformation to be canonical and determination of generating function

Text Book:
1. Classical Mechanics, H. Goldstein, Narosa Publishing House, New Delhi.

Reference Book:
1. Classical Mechanics, N.C. Rana and P.S. Joag, Tata McGraw-Hill, N. Delhi,

CLASSICAL ELECTRODYNAMICS
(COURSE CODE: MPHY1103T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

***Course Outcomes:** On completion of this course, student will be able to: –*

1. *Understand and apply the fundamental laws of electrostatics such as Coulomb's law, Gauss's law, and Poisson/Laplace equations to analyze electric fields, potentials, and energy distributions for various charge configurations.*
2. *Analyze the behavior of dielectric materials in electrostatic fields, including concepts such as molecular polarizability, local field, Clausius-Mosotti relation, and solve boundary value problems in dielectric media.*
3. *Solve boundary value problems in electrostatics using analytical techniques such as method of images and apply coordinate systems (Cartesian, cylindrical, spherical) to evaluate electric potentials and fields.*
4. *Understand the principles of magnetostatics, including Biot–Savart law, Ampere's law, vector potential, magnetic moment, and analyze boundary conditions for electric and magnetic fields.*
5. *Comprehend the behavior of time-varying electromagnetic fields through Faraday's law, Maxwell's equations, displacement current, and electromagnetic potentials, and evaluate energy flow using the Poynting theorem and Maxwell stress tensor.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Electrostatics: Coulomb's law, Electric field, Evaluation of electric field due to uniformly charged sphere using Coulomb's law, Differential form of Gauss law, Dirac delta function and its properties, Representation of charge density by Dirac delta function, Equations of electrostatics, Scalar potential and potential due to arbitrary charge distribution, Discontinuities in electric field, Electric potential, Poisson and Laplace equations, Dirichlet and

Neumann boundary conditions, Uniqueness theorem, Electrostatic potential energy for continuous charge distributions, Energy density.

Boundary value problems in electrostatics: Boundary value problems in one and two dimensions in Cartesian, spherical and cylindrical coordinates. Methods of images, Point charge placed near a grounded sheet and near a grounded conducting sphere.

Dielectrics: Microscopic and macroscopic fields, Equations of electrostatic field in a dielectric, Bound charge densities.

SECTION B

Magnetostatics: Continuity equation, Biot savart law, Differential equations of magnetostatics and Ampere's law, Vector potential and its calculation, Magnetic moment Boundary conditions on B and E, Magnetic scalar potential.

Time varying fields: Faraday's law of electromagnetic induction, Energy in the Magnetic field, Maxwell equations, Displacement current, Electromagnetic potential, Lorentz and Coulomb gauge. Maxwell equations in terms of electromagnetic potentials, Poynting theorem and Maxwell stress tensor

Text Book:

1. Classical Electrodynamics, J.D. Jackson, Wiley Eastern Ltd.

Nuclear and Particle Physics
(COURSE CODE: MPHY1104T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: On completion of this course, student will be able to: –

1. Understand the basic properties of atomic nuclei including constituents, intrinsic properties (mass, radius, density), binding energy, and analyze patterns such as the binding energy curve and the N/A (neutron-to-proton) ratio.
2. Explain the mechanism of alpha decay, including decay systematics, the theory of alpha emission, and evaluate the role of angular momentum and parity in alpha transitions.
3. Understand the process of beta decay, derive energy relations, and apply the Fermi theory. Analyze selection rules, forbidden transitions, and the role of the neutrino and parity non-conservation in weak interactions.
4. Interpret the energetics of gamma decay, apply selection rules for angular momentum and parity, and understand the phenomenon of internal conversion.
5. Develop problem-solving skills by quantitatively analyzing decay processes (alpha, beta, gamma), their systematics, and applying theoretical frameworks such as Fermi theory and angular momentum conservation laws.

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Radiation Detectors: Interaction of radiations with matter (Charged particles and electromagnetic radiations), Gas-filled counters, Scintillation and Semiconductor detectors, Energies and intensity measurements.

Alpha Decay: Why alpha decay occurs? Basic alpha decay processes, Alpha decay systematics. Theory of alpha emission. Angular momentum and Parity in Alpha Decay.

Beta Decay: Energy Released in Beta Decay. Fermi Theory of Beta Decay. Angular Momentum and Parity Selection Rules. Comparative Half Lives and Forbidden Decays. Neutrino Physics. Non-conservation of Parity.

Gamma Decay: Energetics of gamma decay, Angular momentum and Parity selection rules, Internal conversion.

SECTION B

Particles and Forces: Classification and Properties of Hadron and Leptons and Fundamental Forces.

Conservation Laws: Parity and Isospin strangeness, charm bottom non conservation, Operations and transformations, Baryons and Leptons Conservation, Tau lepton, C,P and CP Violation in Weak Interactions, K-decays, CPT invariance (Statement and consequences).

Meson Physics: Yukawa's Hypothesis, Discovery and properties of pions and muons and Tau Lepton , Spin, parity and isospin of π mesons, Pion-proton scattering

Strange Particles: Mass and lifetime for K-meson, Production and decay of $½^+$ hyperons charm and Bottom hadrons (spectres only).

Relativistic kinematics, Gellmann-Nishijima Scheme, Baryons and Meson Multiplets, **Quark Model**: Development, Meson Baryon construction, Colour Quantum Number. Magnetic Moments, Nucleon Structure from Scattering and Evidence of Quark Structure, Observation of New Flavors. **Theories of Fundamental Interactions:** (qualitative ideas) and Grand Unified Theory. Planak scale and Recent Developments (Qualitative ideas)

Text Books:

1. Introductory Nuclear Physics: K.S. Krane, John Wiley & Sons, New York
2. Elementary Particle Physics: I.S. Hughes, Cambridge Univ.Press
3. Introductory Nuclear Physics: S.S.M. Wong, Prentice Hall of India, New Delhi.
4. Introduction to Elementary Particles: D.J. Griffiths, John Wiley & Sons.

Elective Paper: Option (i) **ELECTRONICS–I**
(COURSE CODE: MPHY1105T)

Maximum Marks: External	60	Time Allowed: 3 Hours
Internal	20	Total Teaching hours: 50
Total	80	Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Analyze the principles and advantages of negative feedback in amplifiers, including gain stabilization, distortion reduction, and its effect on input/output resistance in voltage and current feedback configurations.*
2. *Understand and design various transistor biasing techniques such as fixed bias, voltage divider, emitter feedback, and FET biasing, ensuring thermal stability and proper amplifier operation*
3. *Examine and evaluate the performance of multistage amplifiers, including direct-coupled, RC-coupled, Darlington, and cascade configurations, with emphasis on frequency response and bandwidth.*
4. *Understand the conditions for oscillation and operation of different types of oscillators including Hartley, Colpitts, RC, and crystal oscillators, and analyze their feedback mechanisms and frequency stability.*
5. *Demonstrate knowledge of digital electronics fundamentals including number systems, binary arithmetic, Boolean algebra, logic gates, K-maps, and the design of combinational circuits and flip-flops (RS, JK, D, T) for digital logic design.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Feedback in amplifiers: Stabilization of gain and reduction of non-linear distortion by negative feedback. Effect of feedback on input and output resistance. Voltage and current feedback.

Bias for transistor amplifier : Fixed bias circuit, Voltage feedback bias. Emitter feedback bias, Voltage divider bias method, Bias for FET.

Multistage amplifier : Direct coupled CE two stage amplifier. RC coupling and its analysis in mid- high-and low-frequency range. Effect of cascading on bandwidth. Darlington and cascade circuits.

Oscillators : Feedback and circuit requirements for oscillator, Basic oscillator analysis, Hartley, Colpitts, RC-oscillators and crystal oscillator.

SECTION B

Number Systems: Binary, octal and hexadecimal number systems. Arithmetic operations: Binary fractions, Negative binary numbers, Floating point representation, Binary codes: weighted and non-weighted binary codes, BCD codes, Excess-3 code, Gay codes, binary to Gray code and Gray to binary code conversion, error detecting and error correcting codes.

Logic Gates: AND, OR, NOT, OE operations: Boolean identities, Demorgan's theorem: Simplification of Boolean functions. NAND, NOR gates.

Combinational logic: Minterms, Maxterms, K-map (upto 4 variables), POS, SOP forms. Decoders. Code converters, Full adder, Multiple divider circuits.

Flip flops: RS, JK-, D- and T-flip flops set up and hold times, preset and clear operations.

Binary counters: Series and parallel counters. Shift registers. Data in data out modes. Ring counter.

Text Books:

1. Electronic Fundamentals and Applications: J.D. Ryder, Prentice Hall of India (5^{th} Ed.), New Delhi.
2. Electronic Devices and Circuits: G.K. Mithal, Khanna Publishers
3. Digital Principles and Applications: A.P. Malvino & D.P. Leach, Tata McGraw-Hill, New Delhi
4. An Introduction to Digital Electronics: M. Singh, Kalyani Publishers, New Delhi

Elective Paper: Option (ii) REMOTE SENSING
(COURSE CODE: MPHY1106T)

Maximum Marks: External	60	Time Allowed: 3 Hours
Internal	20	Total Teaching hours: 50
Total	80	Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examination, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand the history, scope, and fundamental principles of remote sensing, including the remote sensing process, key concepts, and career prospects in the field.*
2. *Explain the nature and interaction of electromagnetic radiation with the atmosphere and surface features, and differentiate between passive and active sensing systems along with image characteristics.*
3. *Gain knowledge of various remote sensing sensors and platforms (ground, airborne, and satellite), including sensor characteristics such as spatial, spectral, radiometric, and temporal resolution, and understand data acquisition techniques.*
4. *Understand the basics of microwave remote sensing and radar systems, including viewing geometry, image distortions, target interactions, and applications of polarimetry using airborne and spaceborne systems.*
5. *Apply techniques of image analysis (visual and digital), including preprocessing, enhancement, classification, and data integration, and demonstrate their applications in diverse fields like agriculture, forestry, geology, hydrology, oceanography, and urban planning.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carry 10 marks. Section C will carry 20 marks.

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Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks. Use of scientific calculators is allowed.

SECTION A

History and scope of remote sensing: Milestones in the history of remote sensing, overview of the remote sensing process, A specific example, Key concepts of remote sensing, career preparation and professional development.

Introduction: Definition of remote sensing, Electromagnetic radiation, Electromagnetic Spectrum, interaction with atmosphere, Radiation-Target, Passive vs. Active Sensing, Characteristic of Images.

Sensors: On the Ground, In the Air& in Space, Satellite characteristics, Pixel Size and Scale, Spectral Resolution, Radiometric Resolution, Temporal Resolution, Cameras and Aerial photography, Multispectral Scanning, thermal Imaging, Geometric Distortion, Weather Satellites, Land Observation Satellites, Marine Observation Satellites, Other Sensors, Data Reception.

SECTION B

Microwaves: Introduction, Radar Basics, Viewing Geometry & Spatial Resolution, Image Distortion, Target Interaction, Image Properties, Advanced Applications, Polarimetry, Airborne vs. Spaceborne, Airborne & Spaceborne Systems.

Image Analysis: Visual Interpretation, Digital processing, Preprocessing, Enhancement, Transformations, Classification, Integration.

Applications: Agriculture—Crop Type Mapping and Crop Monitoring; Forestry---Clear cut Mapping, Species identification and Burn Mapping; Geology---Structural Mapping & Geological Units; Hydrology-----Food Delineation & Soil Moisture; Sea Ice----Type & Concentration, Ice Motion; Land Cover----Rural/Urban Change, Biomass Mapping; Mapping-----Planimetry, DEMs, Topo Mapping; Oceans & Coastal-----Ocean features, Ocean Colour, Oil Spill Detection.

Text Books:

1. Introduction to Remote Sensing : James B. Cambell
2. Fundamentals of Remote Sensing: Natural Resources, Canada Centre of Remote Sensing.

Elective Paper: Option (iii) **MICROWAVE AND ITS PROPAGATION**
(COURSE CODE: MPHY1107T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand the structure, working principles, and characteristics of microwave linear beam tubes such as klystrons, reflex klystrons, and travelling wave tubes, and evaluate their performance in terms of velocity modulation, power output, and beam loading.*
2. *Analyze the design and operation of crossed-field microwave tubes including various types of magnetrons, forward/backward wave amplifiers, and oscillators, focusing on their operational mechanisms and characteristics.*
3. *Demonstrate knowledge of microwave semiconductor devices, including bipolar transistors, heterojunction transistors, tunnel diodes, and various types of field effect transistors (JFETs, MESFETs, MOSFETs, HEMTs), along with their structural design and electronic applications.*
4. *Understand the operation and applications of transferred electron devices like Gunn diodes, and avalanche transit time devices such as IMPATT, TRAPATT, Read, and BARITT diodes, including their theoretical principles and performance characteristics.*
5. *Apply principles of microwave measurement and transmission, including impedance, attenuation, SWR, power, and frequency measurements, and analyze microwave transmission lines, hybrid circuits, directional couplers, circulators, and isolators using tools like the Smith chart for impedance matching.*

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Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculators is allowed.

SECTION A

Microwave linear beam tubes: Conventional vacuum tubes, Klystrons, resonant cavities, velocity modulation process, branching process, output power and beam loading; multi cavity klystron amplifiers, reflex klystrons, helix travelling wave tubes, slow wave structures.

Microwave crossed field tubes: Magnetron oscillators: cylindrical, linear and coaxial, forward wave crossed field amplifier, backward wave crossed field amplifier, backward wave crossed field oscillator, their principle of operation and characteristics.

Microwave transistor and tunnel diodes: Microwave bipolar transistors, physical structures, configurations, principles of operation, amplification phenomena, power-frequency limitations, heterojunction bipolar transistors, physical structures, operational mechanism and electronic applications, microwave tunnel diodes, principles of operation, microwave characteristics.

Microwave field effect transistors: Junction field effect transistors, metal semiconductor field effect transistors, high electron mobility transistors, metal oxide semiconductor field effect transistors, physical structures, principle of operation and their characteristics. MOS transistor and memory devices: NMOS, CMOS and memories. **Charged coupled devices:** Operational mechanism, surface channel CCD's dynamic characteristics.

SECTION B

Transferred electron devices: Gunn effect diodes, Ridley-Walkins-Hilsum theory, modes of operation, LSA diodes, InP diodes, CdTe diodes, microwave generation and amplification.

Avalanche transit time devices: Read diode, IMPATT diodes, TRAPATT diodes, BARITT diodes, their physical structure, principle of operation and characteristics.

Microwave measurements: Measurement of impedance, attenuation, insertion loss, coupling and directivity, frequency, power and wavelength at microwave frequencies.

Microwave transmission lines: Transmission line equations and solutions, reflection coefficient and transmission coefficient, standing wave and standing wave ratio, line impedance and admittance, Smith chart, impedance matching. Microwave cavities, microwave hybrid circuits, directional couplers, circulators and isolators.

Text Books:

1. Microwave Devices and Circuits: Sameul Y. Liao, Pearson Education
2. Microwaves: K.C. Gupta, Wiley Eastern Limited.

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LABORATORY PRACTICE: Electronic Lab
(COURSE CODE: MPHY1108P)

Maximum Marks: External	75		Time Allowed: 3 Hours
Internal	25		Total Teaching hours: 125
Total	100		Pass Marks: 45%

Instructions for Examiners
Out of 100 Marks, internal assessment (based on seminar, viva-voce of experimental reports, number of experiments performed and attendance) carries 25 marks, and the final examination at the end of the semester carries 75 marks.

Course Outcomes: *On completion of this course, student will be able to: –*
1. *Demonstrate the ability to analyze and design amplifier circuits, including BJT configurations (CE, CB, CC), RC-coupled amplifiers, push-pull amplifiers, and biasing techniques, by studying their gain, frequency response, and operating regions.*
2. *Understand and perform experiments related to oscillator circuits (Hartley, Colpitts, RC-phase shift), and verify principles of modulation and demodulation (AM and FM), including measurement of modulation index and frequency components.*
3. *Apply knowledge of semiconductor devices by experimentally studying the characteristics of FETs, tunnel diodes, thyristors (SCR, MOSFET, UJT, TRIAC), and thermistors, including parameters like energy gap and temperature coefficient.*
4. *Verify fundamental digital logic principles, such as De-Morgan's laws, Boolean algebra, logic gate combinations, and perform operations using flip-flops, binary adders/subtractors, and understand basic sequential logic circuits.*
5. *Analyze and implement signal processing circuits including clipping and clamping circuits, rectifiers with different filters, and series voltage regulators, and perform Fourier analysis of various waveform signals to study harmonic content.*

<u>ELECTRONICS EXPERIMENTS</u>: (10 out of the followings)

1. Study the gain frequency response of a given RC coupled BJT, CE amplifier.
2. Study of Clipping & Clamping circuits.
3. Study of shunt capacitor filter, inductor filter, LC filter and π filter using Bridge Rectifier.
4. Find the energy gap of a given semi conductor by reverse bias junction method.
5. To calculate the temperature coefficient of Thermistor.
6. Verify De-Morgan's law and various combinations of gates using Logic gates circuit.
7. Study of various types of Flip-Flops.
8. To study various Oscillators (Hartley, Colpit, RC Phase shift etc.).
9. To study Amplitude Modulation and De-Modulation and calculate modulation index.
10. To study characteristics of FET and determine its various parameters.
11. Study the characteristics of Tunnel Diode.
12. To study 2 bit, 3 bit and 4 bit Adder & Subtractor.
13. Study the characteristics of basic Thyristors (SCR, MOSFET, UJT, TRIAC etc.).
14. Use of Transistor as a push pull amplifier (Class 'A', 'B' and 'AB').
15. Application of transistor as a series voltage regulator.

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16. Study of biasing techniques of BJT.
17. To study Frequency Modulation and Demodulation.
18. Study of transistor as CE, CB and CC amplifier.
19. Fourier series analysis of square, triangular and rectified wave signals.

Semester – II

MATHEMATICAL METHODS OF PHYSICS– II
(COURSE CODE: MPHY1201T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. Understand the theory and application of Laplace transforms, including their existence conditions, elementary and special functions, inverse transforms, convolution theorem, and use them to solve ordinary differential equations and simultaneous differential equations.
2. Analyze and derive properties of Hermite and Laguerre polynomials, including their differential equations, generating functions, Rodrigue's formula, recurrence relations, and orthogonality for applications in mathematical physics.
3. Develop proficiency in Fourier series and Fourier transforms, including Dirichlet conditions, sine/cosine series, complex form, finite transforms, Parseval's identity, and their use in signal analysis and solving PDEs.
4. Apply analytical methods to solve partial differential equations, including the wave equation, heat equation, and problems related to vibrating strings, membranes, and temperature distributions in rectangular and circular geometries.
5. Understand the fundamentals and applications of group theory in physics, including group postulates, subgroups, isomorphism, Lie groups and algebras, irreducible representations, and special unitary groups SU(2) and SU(3), with relevance to quantum mechanics and particle physics.

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Laplace transforms: Definition, Conditions of existence, Functions of exponential orders, Laplace transform of elementary functions, Basic theorems of Laplace transforms, Laplace transform of special functions, Inverse Laplace transforms, its properties and related theorems, Convolution theorem, Use of Laplace transforms in the solution of differential equations with constant and variable coefficients and simultaneous differential equations.

Hermite Polynomials: Solution of Hermite differential equation. Hermite polynomials. Generating function and recurrence relations for Hermite polynomials. Rodrigue's formula and orthogonality.

Fourier series and transform: Dirichlet conditions, Expansion of periodic functions in Fourier series, Complex form of Fourier series, Sine and cosine series, The finite Fourier sine and cosine transforms, Fourier integral theorem and Fourier transform, Parseveall's identity for Fourier series and transforms. Convolutions theorem for Fourier transforms.

Laguerre Polynomials: Laguerre differential equation and its solution, Porperties of Laguree and associated laguerre functions.

Anup

SECTION B

Partial differential equations, One dimensional wave equation, The vibrating string fixed at both ends, D'Alembert and Fourier series solutions, Vibrations of a freely hanging chain, vibrations of rectangular membrane, Vibrations of a circular membrane, Temperature distribution in a rectangular and circular plate.

Group theory: Group postulates, Multiplication table, conjugate elements and classes sub-group, Isomorphism and homomorphism, Discrete groups, Permutation groups, Lie group and Lie algebra, Reducible and irreducible representation, Young diagrams and direct product; SU(2) and SU(3) groups.

Text Books:

1. Applied Mathematics, L.A. Pipes and Harwill, McGraw Hill Pub.
2. Mathematical Physics, G.R.Arfken, H.I. Weber, Academic Press, USA (Ind. Ed.)
3. Laplace Transforms, M.R.Spiegel, Schaum Series, Mc Graw Hill Publication.

Reference Book:

1. Mathematical Physics: B.S. Rajput, Pragati Parkashan, Meerut.

ADVANCED CLASSICAL MECHANICS & ELECTRODYNAMICS
(COURSE CODE: MPHY1202T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35 %

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand and apply* ***Hamilton-Jacobi theory*** *to formulate equations for Hamilton's principal and characteristic functions and solve problems such as the* ***harmonic oscillator*** *using both* ***Hamilton-Jacobi*** *and* ***action-angle variables*** *methods.*
2. *Develop a deep understanding of the* ***Special Theory of Relativity****, including* ***Lorentz transformations, Einstein velocity addition****, and* ***Minkowski space formulation****, and apply these concepts to relativistic mechanics involving* ***force, energy, and momentum****.*
3. *Formulate and solve problems involving* ***small oscillations****, determine* ***normal modes*** *and* ***eigenfrequencies*** *for systems like* ***diatomic and linear triatomic molecules****, and analyze oscillatory systems using* ***eigenvalue techniques****.*
4. *Comprehend and apply* ***Maxwell's inhomogeneous equations****,* ***Poynting theorem****, and* ***Maxwell stress tensor****, and analyze* ***fields and radiation from localized oscillating sources****, such as* ***electric and magnetic dipoles*** *and* ***antennas****.*
5. *Analyze the behavior of* ***electromagnetic waves*** *in various media, including* ***non-conducting*** *and* ***conducting media****, and study phenomena such as* ***polarization****,* ***Stokes parameters****,* ***reflection/refraction****,* ***total internal reflection****, and* ***skin depth***

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Hamilton-Jacoby theory: Hamilton-Jacobi equations for Hamilton principal and characteristic functions. *Problems*: Harmonic oscillator using Hamilton-Jacobi formulation and through action-angle variables.

Special theory of relativity: Lorentz transformation in vector form and orthogonality of Lorentz transformation, Lorentz orthogonal transformation matrix, Equivalent rotation angle and Einstein addition law for parallel velocities, Intervals in four-space and Invariance of Space-time interval, covariant formulation of four space and representation of various vectors in four-space, covariant formulation of Force, momentum and energy equation in Minkowski space, Lagrangian formulation of relativistic mechanics.
Problems: Applications of relativistic formulation in the study of motion under constant force and relativistic one dimensional harmonic oscillator.

Small oscillations: Formulation of problem, Eigen value equation, Frequencies of free vibration and normal modes.
Problem: Normal mode frequencies and eigen vectors of diatomic and linear tri-atomic molecule.

SECTION B

Maxwell inhomogeneous equations and conservation laws: Poynting theorem and Maxwell stress tensor, Poynting theorem for harmonic fields. Fields and radiation of a localised oscillating source, Electric dipole fields and radiation, Magnetic dipole field, Centre fed linear antenna.

Electromagnetic waves and wave propagation: Plane waves in a non-conducting medium, Polarization and Stokes parameter, Energy flux in a plane wave, Reflection and refraction across a dielectric interface, Total internal reflection, Polarization by reflection, Waves in a conducting medium and skin depth.

Text Books:
1. Classical Mechanics: H. Goldstein, Narosa Publishing House, New Delhi
2. Classical Electrodynamics, J.D. Jackson, Wiley Eastern Ltd.

QUANTUM MECHANICS
(COURSE CODE: MPHY1203T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. Solve the Schrödinger equation for systems with central potentials including the hydrogen atom, and interpret results in terms of radial solutions, spherical harmonics, energy spectra, and angular momentum eigenstates.
2. Understand the structure of linear vector spaces and Hilbert spaces, including bras and kets, Hermitian and unitary operators, and apply representation theory in coordinate and momentum bases to formulate the postulates of quantum mechanics.
3. Analyze the generalized uncertainty principle, density matrix formalism, and distinguish between Schrödinger, Heisenberg, and interaction pictures in quantum theory.
4. Apply symmetry principles in quantum systems, demonstrating how conservation laws (energy, momentum, angular momentum) arise from space-time symmetries, and understand the effects of parity and time-reversal invariance.
5. Solve the quantum harmonic oscillator using both wave mechanics and matrix mechanics, understand creation and annihilation operators, coherent states, and zero-point energy, and evaluate angular momentum algebra, including spin, Pauli matrices, Clebsch-Gordon coefficients, and Wigner-Eckart theorem.

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

Amy

SECTION A

Motion in a Central Potential: Solution of the Schrodinger equation for the hydrogen atom, Eigen values and eigen vectors of orbital angular momentum, Spherical harmonics, Radial solutions, Hydrogen atom energy spectra. Rigid rotator.

Linear vector spaces: State vectors, Orthonormality, Hilbert spaces, Linear manifolds and subspaces, Hermitian, unitary and projection operators and commutators; Dirac Bra and Ket Notation: Matrix representations of bras and kets and operators; Continuous basis, Change of basis-Representation theory. Coordinate and momentum representations. Fundamental postulates of quantum mechanics.

Generalized uncertainty principle; time energy uncertainty principle. Schrodinger, Heisenberg and interaction pictures.

SECTION B

Linear Harmonic Oscillator: Solution of Simple harmonic oscillator; Vibrational spectra of diatomic molecule; Anisotropic three dimensional oscillator in cartesian coordinates, Isotropic three dimensional oscillator in spherical coordinates.

Matrix mechanical treatment of linear harmonic oscillator: Energy eigen values and eigen vectors of SHO, Matrix representation of creation and annihilation operators, Zero-point energy.

Angular momentum : Eigen values, Matrix representations of J^2,J_z, J_+,J_-. Spin: Pauli matrices and their properties, Addition of two angular momenta: Clebsch-Gordon coefficients and their properties, Spin wave functions for two spin-1/2 system, Addition of spin and orbital momentum, derivation of C.G. coefficients for ½+1/2 and ½+1, addition, Spherical tensors and Wigner-Eckart theorem (Statement only).

Text Books:

1. Quantum Mechanics (2nd Ed.) : V.K. Thankappan, New Age International Publications, New Delhi, 1996
2. Quantum Mechanics: P.M. Mathews and K. Venkatesan, Tata-McGraw Pub., New Delhi, 1997.

Reference Books:

1. Quantum Mechanics: L. I. Schiff (Int. Student Ed.), Mc Graw Hill Co. Ltd.
2. Quantum Mechanics: W. Greiner, Springer Verlag Pub., Germany, 1994, 3rd Edition
3. Modern Quantum Mechanics: J. J. Sakurai, Addison Wesley Pub.,USA,1999, Ist ISE Rep.

STATISTICAL MECHANICS
(COURSE CODE: MPHY1204T)

Maximum Marks: External	60	Time Allowed: 3 Hours
Internal	20	Total Teaching hours: 50
Total	80	Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand the postulates of classical statistical mechanics, distinguish between macroscopic and microscopic states, and explain the connection between thermodynamic quantities and statistical ensembles using Liouville's theorem and phase space representation.*
2. *Analyze the microcanonical ensemble, derive Gibbs distribution, calculate the entropy of an ideal gas, and resolve conceptual challenges like Gibbs paradox using the Sackur-Tetrode equation.*
3. *Apply the principles of the canonical ensemble to calculate thermodynamic properties using the partition function, and solve model systems such as the classical ideal gas and harmonic oscillator system.*
4. *Explain the grand canonical ensemble, interpret energy and density fluctuations, and demonstrate the equivalence between the canonical and grand canonical ensembles using examples like the classical ideal gas.*
5. *Understand and apply quantum statistical mechanics to systems of ideal Bose, Fermi, and Boltzmann gases, derive distribution functions, and analyze quantum phenomena such as Fermi energy, Bose-Einstein condensation, and black body radiation.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Guru Nanak College, Budhlada

(Autonomous College, Punjabi University Patiala)

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Classical Statistical Mechanics Postulates, the macroscopic and microscopic states, contact between statistics and thermodynamics, connection between statistical and thermodynamic quantities, Ensemble, Phase space, Liouville's theorem, Representation of Ensembles in Phase space

Micro canonical ensemble, Gibb's micro canonical distribution, Ideal gas in micro canonical ensemble, Entropy of an ideal gas, Gibb's paradox, Sackur-Tetrode equation.

Canonical ensemble and its thermodynamics, Partition function, Partition function in phase space, *Problems in canonical ensembles:* Classical ideal gas, System of independent harmonic oscillators.

Grand canonical ensemble and its thermodynamics, Energy and Density fluctuations. Equivalence of canonical and the grand canonical ensembles. Classical Ideal gas in grand canonical ensemble.

SECTION B

Postulates of Quantum Statistical Mechanics, Density matrix, Different ensembles in quantum statistical mechanics for different Ideal gases (Ideal Fermi Gas, Ideal Bose Gas and Boltzman Gas): Distribution function for different ideal gases, density of states for an ideal gas.

Equation of state of an Ideal Fermi Gas, Degeneracy, Fermi energy at T=0 and at low temperatures. Thermodynamics of an ideal Fermi gas, Free electron gas in metal

Bose Gas: Equation of state of an Ideal Bose gas, Bose-Einstein condensation, Thermodynamics of an Ideal Bose gas, Black body radiation (The photon gas)

Text Book:
1. Statistical Mechanics: Kerson Huang, (John Wiley & Sons, 2nd Ed.)

Reference Book:
1. Statistical Mechanics: R.K. Patharia (2nd Ed.), Butterworth Oxford

ਵਿਕਾਸਸ਼ੀਲ ਬ੍ਰਹਿਮੰਡ
(COURSE CODE: MPHY1205T)

Maximum Marks: External	100	Time Allowed: 3 Hours
Internal	30	Total Teaching hours: 50
Total	70	Pass Marks: 40%

ਪੇਪਰ ਸੈਟਰ ਲਈ ਹਦਾਇਤਾਂ: ਬਾਹਰੀ ਪ੍ਰੀਖਿਆ ਦਾ ਪੇਪਰ 70 ਅੰਕ ਅਤੇ ਤਿੰਨ ਘੰਟੇ ਦਾ ਹੋਵੇਗਾ। ਪ੍ਰਸ਼ਨ ਪੱਤਰ ਦੇ ਤਿੰਨ ਭਾਗ (ੳ, ਅ, ੲ) ਹੋਣਗੇ। ਪ੍ਰਸ਼ਨ ਪੱਤਰਾਂ ਦੇ ਭਾਗ ੳ ਤੇ ਅ ਵਿੱਚ ਪਾਠਕ੍ਰਮ ਦੇ ਭਾਗ ੳ ਅਤੇ ਅ ਵਿੱਚ 4-4 ਪ੍ਰਸ਼ਨ ਹੋਣਗੇ। ਜਿਸ ਵਿੱਚੋਂ 2-2 ਪ੍ਰਸ਼ਨ ਹੱਲ ਕਰਨੇ ਜਰੂਰੀ ਹੋਣਗੇ। ਭਾਗ ੲ ਲਾਜ਼ਮੀ ਹੋਵੇਗਾ, ਇਸ ਭਾਗ ਵਿੱਚ ਦੋ ਦੋ ਅੰਕਾਂ ਵਾਲੇ 11 ਪ੍ਰਸ਼ਨ ਪੂਰੇ ਪਾਠਕਰਮ ਵਿੱਚੋਂ ਪੁੱਛੇ ਜਾਣਗੇ।
ਪ੍ਰੀਖਿਆਰਥੀ ਲਈ ਹਦਾਇਤਾਂ: ਪ੍ਰੀਖਿਆਰਥੀ ਨੇ ਭਾਗ ੳ ਤੇ ਅ ਵਿੱਚੋਂ ਦੋ ਦੋ ਪ੍ਰਸ਼ਨਾਂ ਦੀ ਚੋਣ ਕਰਕੇ ਕੋਈ ਚਾਰ ਪ੍ਰਸ਼ਨ ਹੱਲ ਕਰਨੇ ਹੋਣਗੇ। ਭਾਗ ੲ ਲਾਜ਼ਮੀ ਹੋਵੇਗਾ।
ਕੋਰਸ ਵਰਣਨ: ਵਿਕਾਸਸ਼ੀਲ ਬ੍ਰਹਿਮੰਡ ਵਿਸ਼ੇ ਦਾ ਕੋਰਸ ਬ੍ਰਹਮੰਡ ਦੀ ਉਤਪੱਤੀ ਅਤੇ ਵਿਕਾਸ ਚੰਨ ਤਾਰਿਆਂ ਗ੍ਰਹਾਂ ਅਤੇ ਹੋਰ ਪੁਲਾੜੀ ਪਿੰਡਾਂ ਬਾਰੇ ਵਰਣਨਯੋਗ ਜਾਣਕਾਰੀ ਪ੍ਰਦਾਨ ਕਰਦਾ ਹੈ
ਸਿੱਖਣ ਦੇ ਨਤੀਜੇ: ਕੋਰਸ ਕਰਨ ਉਪਰੰਤ ਵਿਦਿਆਰਥੀ ਸੌਰ ਮੰਡਲ ਵਾਯੂ ਮੰਡਲ ਤਾਰਿਆਂ ਦੀ ਉਪੱਤੇ ਗਲੈਕਸੀ ਖਗੋਲ ਵਿਗਿਆਨ ਅਤੇ ਬ੍ਰਹਮੰਡ ਨੂੰ ਸਮਝਣ ਦੇ ਸਮਰੱਥ ਹੋ ਜਾਣਗੇ।

ਭਾਗ ੳ

ਸੌਰ ਮੰਡਲ: ਜਾਣ ਪਛਾਣ, ਚਟਾਨੀ ਗ੍ਰਹਿ ਜੋਵੀਅਨ ਗ੍ਰਹਿ, ਕੁਦਰਤੀ ਉਪਗ੍ਰਹਿ, ਸੋਰਮੰਡਲ ਦੇ ਛੋਟੇ ਛੋਟੇ ਪਿੰਡ, ਐਸਟਰੋਇਡਜ਼, ਧੂਮਕੇਤੂ, ਖੋਟੇ ਗ੍ਰਹਿ, ਟਰਾਂਸ ਨੈਪਚੂਨੀਅਨ ਪਿੰਡ।
ਸੋਰ ਮੰਡਲ ਦਾ ਮੁੱਢ: ਮੁਢਲੇ ਸਿਧਾਂਤ
ਸੂਰਜ: ਬਣਤਰ ਅਤੇ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ
ਪ੍ਰਿਥਵੀ: ਬਣਤਰ, ਭੂਵਿਗਿਆਨਕ ਕਿਰਿਆ, ਚੁੰਬਕਤਾ
ਪ੍ਰਿਥਵੀ ਦਾ ਚੰਦਰਮਾ: ਮੁਢਲੀ ਜਾਣ ਪਛਾਣ, ਉਤਪੱਤੀ,ਬਣਤਰ, ਵੱਖ ਵੱਖ ਅਵਸਥਾਵਾਂ , ਚੰਦਰਮਾ ਅਤੇ ਪ੍ਰਿਥਵੀ ਦਾ ਇੱਕ ਦੂਸਰੇ ਉੱਪਰ ਪ੍ਰਭਾਵ
ਵਾਯੂਮੰਡਲ: ਮੁਢਲੀ ਜਾਣ ਪਛਾਣ, ਚਟਾਨੀ ਗ੍ਰਹਿਆਂ ਦਾ ਵਾਯੂਮੰਡਲ, ਜੋਵੀਅਨ ਗ੍ਰਹਾਂ ਦਾ ਵਾਯੂ ਮੰਡਲ, ਟਾਈਟਨ ਉਪਗ੍ਰਹਿ ਦਾ ਵਾਯੂਮੰਡਲ

ਸੂਰਜੀ ਪੌਣ ਚੁੰਬਕ ਯੁਕਤ ਗ੍ਰਹਿ ਅਤੇ ਮੈਗਨੇਸਫੀਅਰ ਅਰੋਰਾ ਪੁਲਾੜੀ ਵਾਤਾਵਰਨ

ਭਾਗ ਅ

ਤਾਰੇ: ਤਾਰਿਆਂ ਦੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ (ਦੂਰੀ, ਆਕਾਰ ਪੰਜ) ਸਾਰਿਆਂ ਵਿਚਕਾਰਲਾ ਮਾਧਿਅਮ ਆਮ ਵੇਰਵਾ ਤਾਰਿਆਂ ਦੀ ਉਤਪੱਤੀ ਤਾਰਿਆਂ ਦੇ ਜੀਵਨ ਚੱਕਰ ਦੇ ਵੱਖ ਵੱਖ ਪੜਾਵਾਂ ਬਾਰੇ ਵਿਸਥਾਰਤ ਜਾਣਕਾਰੀ ਵਾਈਟ ਡਵਾਰ ਨਿਊਟਰੋਨ ਤਾਰੇ ਸੁਪਰਨੋਵਾ ਬਲੈਕ ਹੋਲ ਬਾਰੇ ਵਿਸਥਾਰਤ ਜਾਣਕਾਰੀ

ਗਲੈਕਟਿਕ ਖਗੋਲ ਵਿਗਿਆਨ: ਗਲੈਕਸੀਆਂ ਗਲੈਕਸੀ ਦਾ ਵਰਗੀਕਰਨ ਗਲੈਟਿਕ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ ਆਕਾਸ਼ ਗੰਗਾ ਬਣਤਰ ਅਤੇ ਭਾਗ ਕਵਾਸਰ (ਸੰਖੇਪ ਵੇਰਵਾ)

ਬ੍ਰਹਿਮੰਡ: ਜਾਣ ਪਛਾਣ ਸੰਕਲਪ ਬ੍ਰਹਮੰਡ ਦੀ ਵਡ ਆਕਾਰੀ ਬਣਤਰ ਗਲੈਕਸੀ ਸਮੂਹ ਕਲਸਟਰ ਅਤੇ ਸੁਪਰ ਕਲਸਟਰ ਬ੍ਰਹਮਣ ਦੀ ਉਤਪੱਤੀ ਅਤੇ ਵਿਕਾਸ ਸਥਿਰ ਅਵਸਥਾ ਸਿਧਾਂਤ ਬਿੱਗ ਬੈਗ ਸਿਧਾਂਤ ਡੋਲਕ ਸਿਧਾਂਤ ਡਾਰਕ ਮੈਟਰ ਅਤੇ ਡਾਰਕ ਊਰਜਾ

ਪੁਲਾੜ ਖੋਜ ਦਾ ਤਕਨੀਕੀ ਵਿਕਾਸ: ਦੂਰਬੀਨਾ ਅਤੇ ਪੁਲਾੜੀ ਜਹਾਜਾਂ ਦਾ ਵਰਗੀਕਰਨ ਅਤੇ ਵਿਸਥਾਰਤ ਜਾਣਕਾਰੀ

ਸਹਾਇਕ ਪੁਸਤਕਾਂ:-

1. Astronomy Dinah L Moche, John Wiley and sons, Inc
2. The Cosmos astronomy in the new millennium: Jam M Pasachoff & Alex Filippenko, Cambridge University Press
3. The life and death of stars : Kenneth R Lang, Cambridge University press
4. The Cambridge guide to the solar system: Kenneth R lang, Cambridge University press.

Elective Paper: Option (i) **ELECTRONICS– II**
(COURSE CODE: MPHY1206T)

Maximum Marks: External	60	Time Allowed: 3 Hours	
Internal	20	Total Teaching hours: 50	
Total	80	Pass Marks: 35%	

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand the design and frequency response of band-pass amplifiers using parallel resonant circuits, and analyze tuned primary and tuned secondary amplifiers in RF and audio applications.*
2. *Analyze and compare the operation of different power amplifiers, including Class A, Class B, and push-pull configurations, with emphasis on power relations, operating conditions, and non-linear distortion.*
3. *Explain the principles of modulation and demodulation, including amplitude modulation (AM), frequency modulation (FM), SSB systems, and analyze both transmission and receiving systems for analog communication.*
4. *Apply the characteristics of operational amplifiers (Op-Amps) in designing circuits such as inverting, non-inverting, differential amplifiers, and understand DC/AC parameters, CMMR, slew rate, and internal architecture of Op-Amps.*
5. *Design and implement various Op-Amp applications including analog computation circuits, converters (V-I, I-V), log/antilog amplifiers, signal generators, comparators, and timing circuits using 555 timers and voltage regulators (Op-Amp based, ICs, and 723 regulator).*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Band-pass amplifiers: Parallel resonant circuit and its bandwidth. Tuned primary and tuned secondary amplifiers.

Power amplifiers: Operating conditions, Power relations, Nonlinear distortion, Class A power amplifier, Push-pull principle, Class B Push pull amplifier.

Fundamentals of modulation: Frequency spectrum in amplitude modulation, Methods of amplitude modulation, Frequency modulation, Linear demodulation of AM signals, SSB system, AM and FM transmission, Receiving systems.

Operational amplifiers: Ideal operational amplifier. Inverting and non-inverting amplifiers. Differential amplifiers. CMMR. Internal circuit of operational amplifier. Examples of practical operational amplifier. Operational amplifier characteristics. DC and AC characteristics, slew rate.

SECTION B

Operational amplifier applications: Instrumentation amplifier. AC amplifier. V to I and I to V converters. Precision diode circuits. Sample and hold circuits. Log and antilog amplifiers. Differentiator and integrator. Analog computation.

Comparator and applications: Regenerative comparator. Square wave generator, monostable and bistable multivibrator. Triangular wave generator. Sine wave generator.

Voltage regulators: series Op. Amp. regulator, IC regulators and 723 general purpose regulator.

555 Timer : Functional Diagram, monostable, astable operations and their applications

Text Books:

1. Electronic Fundamentals and Applications: J.D. Ryder, Prentice Hall of India (5th Ed.), N. Delhi.
2. Linear Integrated Circuit: D. Roy Choudury and Shail Jain, Wiley Eastern, New Delhi

Elective Paper: Option (ii) **PHYSICS OF ELECTRONIC DEVICES & FABRICATION OF INTEGRATED CIRCUITS AND SYSTEMS**
(COURSE CODE: MPHY1207T)

Maximum Marks: External	60		Time Allowed: 3 Hours
Internal	20		Total Teaching hours: 50
Total	80		Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand the energy band structure and carrier concentration in elemental and compound semiconductors, including the effect of doping, diffusion techniques, and alloy formation in materials such as Si, GaAs, and quaternary compounds.*
2. *Analyze carrier transport mechanisms in semiconductors such as drift, diffusion, injection, and generation-recombination processes, and evaluate semiconductor parameters like conductivity, Hall coefficient, and minority carrier lifetime using standard techniques (four-probe, Van der Pauw, Haynes-Shockley experiment).*
3. *Explain the working principles and energy band diagrams of junction devices, including p-n junctions, Schottky diodes, and MOS diodes, and interpret their current-voltage characteristics, C-V behavior, and practical applications.*
4. *Describe the principles and applications of microwave and photonic devices, such as Gunn diodes, IMPATT, LEDs, photodetectors, solar cells, and laser diodes, with emphasis on carrier recombination, optical gain, threshold current, and cavity design.*
5. *Understand the structure and operation of memory devices (SRAM, DRAM, ferroelectric, CCD) and explore optoelectronic and smart materials (electro-optic, magneto-optic, piezoelectric, pyroelectric) used in modern sensor, actuator, and SAW-based applications.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Semiconductor Materials: Energy Bands, Intrinsic carrier concentration, Donors and Acceptors, Direct and Indirect band semiconductors. Degenerate and compensated semiconductors. Elemental (Si) and compound semiconductors (GaAs). Replacement of group III element and Group V elements to get tertiary alloys such as $Al_xGa_{(1-x)}$ As or $GaP_yAs_{(1-y)}$ and quaternary $In_xGa_{(1-x)}P_yAs_{(1-y)}$ alloys and their important properties such as band gap and refractive index changes with x and y. Doping of Si (Group III (n) and Group V (p) compounds and GaAs (group II (p), IV (n.p) and VI (n compounds). Diffusion of Impurities. Thermal Diffusion, Constant Surface Concentration, Constant Total Dopant Diffusion, Ion Implantation

Carrier Transport in Semiconductors: Carrier Drift under low and high fields in (Si and GaAs), saturation of drift velocity. High field effects in two valley semiconductors. Carrier Diffusion, Carrier Injection, Generation Recombination Processes-Direct, Indirect bandgap semiconductors. Minority Carrier Life Time, Drift and Diffusion of Minority Carriers (Haynes-Shockley Experiment) Determination of: Conductivity (a) four probe and (b) Van der Paw techniques. Hall Coefficient, Minority Carrier Life Time. Junction Devices: (i) p-n junction-Energy Band diagrams for homo and hetro junctions. Current flow mechanism in p-n junction, effect of indirect and surface recombination currents on the forward and reverse bias diffusion current, p-n junction diodes-rectifiers (high frequency limit) (ii) Metal-semiconductor (Schottky Junction): Energy band diagram, current flow mechanisms in forward and reverse bias, effect of interface states. Applications of Schottky diodes, iii) Metal-Oxide-Semiconductor (MOS) diodes. Energy band diagram, depletion and inversion layer. High and low frequency Capacitance Voltage (C-V) characteristics. Smearing of C-V curve, flat band shift. Applications of MOS Diode.

Microwave Devices: Tunnel diode, transfer electron devices (Gunn diode) Avalanche Transit time devices (Read, impatt diodes, and parametric devices)

Photonic Devices: Radiative and non-radiative transitions. Optional Absorption, Bulk and Thin film Photo-conductive devices (LDR), diode photodetectors, solar cell-(open circuit voltage and short circuit current, fill factor) LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), diode lasers (conditions for population inversion, in active region, light confinement factor. Optional gain and threshold current for lasing, Fabry-Perrot Cavity Length for lasing and the separation between modes)

SECTION B

Memory and other Electronic Devices: Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile-NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD).

Others Electronic Devices: Electro-Optic, Magneto-Optic and Acousto-Optic Effects. Material Properties related to get these effects. Important Ferroelectric, Liquid Crystal and Polymeric materials for these devices. Piezoelectric, Electrostrictive and magneto strictive Effects, Important materials exhibiting these properties, and their applications in sensors and actuator devices. Acoustic Delay lines, piezoelectric resonators and filters. High frequency piezoelectric devices-Surface Acoustic Wave Devices. Pyroelectric effect. Inorganic oxide and Polymer pyroelectric materials and their applications

Fabrication of integrated Devices: Thin film Deposition Techniques: Vacuum Pumps and gauges-pumping speed, throughout. Effective conductance control. Chemical Vapor Deposition (CVD), MOCVD, PEMOCVD (Plasma enhanced chemical vapor deposition). Physical Vapor deposition, Thermal Evaporation, Molecular Beam Epitaxy (MBE), Sputtering and Laser Ablation. Lithography, Etching and Micro-machining of Silicon, Fabrication of Integrated Circuits and Integrated Micro-Electro-Mechanical-Systems (MEMS)

Text and Reference Books

1. The Physics of Semiconductor Devices by D.A. Eraser, Oxford Physics Series (1986)
2. Semiconductor Devices-Physics and Technology, by SM Sze Wiley (1985)
3. Introduction to semiconductor devices, M.S.Tyagi, John Wiley & Sons
4. Measurement, Instrumentation and Experimental Design in Physics and Engineering by M.Sayer and A. Mansingh, Prentice Hall, India (2000)
5. Thin film phenomena by K.L.Chopra
6. The material science of thin films, Milton S. Ohring
7. Optical electronics by Ajoy ghatak and K.Thyagarajan, Cambridge Univ. Press
8. Material Science for Engineers, by James F. Shackelford, Prentice Hall
9. Deposition techniques for films and coatings, R.F Bunshah (Noyes publications)
10. Solid state electronics, Ben G.Streetman.

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Guru Nanak College, Budhlada

(Autonomous College, Punjabi University Patiala)

Elective Paper: Option (iv) **SCIENCE AND TECHNOLOGY OF SOLAR HYDROGEN AND OTHER RENEWABLE ENERGIES**

(COURSE CODE: MPHY1208T)

Maximum Marks: External 60
Internal 20
Total 80

Time Allowed: 3 Hours
Total Teaching hours: 50
Pass Marks: 35%

Out of 80 Marks, internal assessment (based on two mid-semester tests/ internal examinations, written assignment/project work etc. and attendance) carries 20 marks, and the final examination at the end of the semester carries 60 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. *Understand the fundamentals of photovoltaic energy conversion, including optical properties of solids, semiconductor physics, and the role of direct and indirect band gaps in determining solar cell performance.*
2. *Analyze the working principles and characteristics of various solar cell types, including p-n junction solar cells, solid-liquid junction cells, photoelectrochemical cells, and advanced tandem solar cells, along with key parameters like current density, open-circuit voltage, and short-circuit current.*
3. *Explain the importance of hydrogen energy as a sustainable alternative to fossil fuels, and describe the physical principles and material requirements for solar hydrogen production through photoelectrolysis and photocatalytic processes.*
4. *Evaluate different hydrogen storage technologies, focusing on solid-state storage materials, their structural and electronic properties, and explore new storage modes for future energy systems.*
5. *Discuss the safety considerations, utilization strategies, and applications of hydrogen in fuel cells, electricity generation, transportation, and other hydrogen-based devices such as hydride batteries and air conditioners, as well as gain basic insights into solar thermal energy conversion.*

Instruction for the Paper Setter: The question paper will consist of three sections A, B and C. Each of sections A and B will have four questions from respective section of the syllabus. Section C will have 10 short answer type questions, which will cover the entire syllabus uniformly. Each question of sections A and B carries 10 marks. Section C will carry 20 marks.

Instruction for the candidates: The candidates are required to attempt two questions each from sections A and B, and the entire section C. Each question of sections A and B carries 10 marks and section C carries 20 marks.

Use of scientific calculator is allowed.

SECTION A

Solar Energy

Fundamentals of Photovoltaic Energy Conversion Physics and Material Properties Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Type of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. Tandem Solar Cells. Solid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte Junction, Principles of Photo-electrochemical solar cells.

Hydrogen Energy

Relevance in relation to depletion of fossil fuels and environmental considerations

Hydrogen Production

Solar Hydrogen through Photoelectrolysis and Photocatalytic process. Physics of material characteristic for production of Solar Hydrogen

Section B

Storage of Hydrogen

Brief discussion of various storage processes, special features of solid state hydrogen storage materials, structural and electronic characteristics of storage materials. New Storage Modes.

Safety and Utilization of Hydrogen

Various factors relevant to safety, use to Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydride Batteries.

Other Renewable Clean Energies: Elements of Solar Thermal Energy Conversion.

Text and Reference Books

1. Fonash: Soalr Cell Devices Physics
2. Fahrenbruch & Bube: Fundamentals of Solar Cells Photovoltaic Solar Energy
3. Chandra: Photoeloectrochemical Solar Cells
4. Winter & Nitch (Eds): Hydrogen as an Energy Carrier Technologies Systems Economy

LABORATORY PRACTICE: Laser-Optics Lab
(COURSE CODE: MPHY1209P)

Maximum Marks: External	75	Time Allowed: 3 Hours
Internal	25	Total Teaching hours: 125
Total	100	Pass Marks: 45%

Instructions for Examiner:
Out of 100 Marks, internal assessment (based on seminar, viva-voce of experimental reports, number of experiments performed and attendance) carries 25 marks, and the final examination at the end of the semester carries 75 marks.

Course Outcomes: *On completion of this course, student will be able to: –*

1. Understand the working principles of optical instruments like microscopes and telescopes, and determine key parameters such as numerical aperture, magnifying power, and angular field of view using optical bench setups.
2. Investigate the photoelectric effect and photovoltaic behavior by conducting experiments on solar cells and photovoltaic cells, and determine fundamental constants like Planck's constant.
3. Analyze wave optics phenomena including interference, diffraction, and polarization, using setups such as Michelson interferometer, channel spectrum interferometer, and laser diffraction methods.
4. Explore the properties and behavior of optical and optoelectronic materials and devices, such as LEDs, photodiodes, phototransistors, LDRs, and $LiNbO_3$ crystals under electro-optic effects.
5. Apply laser-based techniques to determine physical parameters such as refractive index, particle size, and Brewster's angle, and explore optical fiber communication principles through dedicated kits.

LASERS AND OPTICS EXPERIMENTS: **(10 out of the followings)**

1. To study the optical bench model of microscope and to determine the numerical aperture of the microscope.
2. To study the optical bench model of telescope and to determine the angular field of view and magnifying power by entrance and exit pupil method.
3. To study the characteristics of solar cell.
4. To study the magnetostriction in an iron rod using Michelson interferometer.
5. To study the optical thickness of mica sheet using channel spectrum interferometry.
6. To determine the Planck's constant using photovoltaic cell.
7. To obtain the coherence matrix and stokes parameters for (i) unpolarized light (ii) polarized light and hence to determine their degree of polarization.
8. To study the aberrations of a convex lens.
9. To study the electro-optic effect in $LiNbO_3$ crystal using He-Ne laser.
10. To study B-H curve.
11. To study the characteristics of optoelectronic devices (LED, Photodiode, Photodiode, Phototransistor, LDR).
12. To study the diffraction pattern by pin hole, single slit, double slit and grating and to calculate the wavelength of He-Ne laser.
13. To study microwave optics system for reflection, refraction, polarization phenomena.

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14. To calibrate the prism spectrometer using mercury lamp and to determine the refractive index of material of the prism for a given wavelength of light.

15. Measurement of Brewster angle and refractive index of materials like glass and fused silica (with He-Ne laser) with a specially designed spectrometer.

16. Particle size determination by diode laser

17. Study of optical fiber communication kit.