SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

(Deemed to be University)

Syllabus for
B.Sc. (Hons.) in Physics

(Parallel implementation for all 3 years w.e.f 2018-19)

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Program Objective and Outcome

The 3-year B.Sc. (Hons.) in Physics program offered by the department of Physics has been designed to provide a strong foundation in fundamental physics concepts that form the very basis of advanced scientific inventions. The curriculum presents a blend of science and technology, with the physics courses complimented by adequately equipped laboratory experiments and supplemented by lessons in advanced electronics and microprocessors. Additionally, students are trained in computational techniques, simulations and computer programming providing a holistic education at the bachelor's level. While the first 4 semester courses are common to all the B.Sc. students, with one theory and corresponding laboratory in each semester, the 5th and 6th semesters contain 5 theory and 3 laboratories each, enabling students to learn various topics in physics. The program aims at inspiring students to pursue science further at postgraduate level and beyond. Student completing this Honours program become eligible to continue M.Sc. in Physics at SSSIHL or become competent enough to join premier institutions like IISc for an integrated M.Sc-Ph.D program. The rigorous training obtained during the three years brings out students who are capable of pursuing higher education in abroad Universities also.

Above all healthy teacher-student interactions ensure that students develop into individually competent, collectively compatible and socially responsible citizens.

DEPARTMENT OF PHYSICS

Undergraduate Honours Programme Structure consists of Three Parts.

PART-I: LANGUAGES#

(a) General English (four papers offered, one each in the first four semesters)
(b) Another Language (four papers offered, one each in the first four semesters – Any one out of: HINDI / SANSKRIT / TELUGU / ADDITIONAL ENGLISH)

PART-II: CORE SUBJECTS
(Offered in all the six semesters) – Titles of the papers are given below in the Scheme of Instruction & Evaluation and the syllabus contents are enclosed.

Part-II consists of three-subject-combination during the first four semesters, which, each student has to study. Three Subject combinations that are offered in the Honours Programme are Mathematics/Physics/Chemistry). During the fifth and sixth semesters the students will choose one of the three subjects in the three-subject-combination as subject of exclusive study for Honours. (i.e., either MATHEMATICS or PHYSICS or CHEMISTRY).

PART-III: AWARENESS COURSE and ENVIRONMENTAL COURSE##

a) Awareness Courses – (UAWR) (six papers offered, one each in all the six semesters)
b) Environmental Courses – (UENT) (two papers offered, one each in the first two semesters)

NOTE: The title of the papers and the syllabus contents of Part-I and Part-III are provided separately.

SCHEME OF INSTRUCTION AND EVALUATION

B.Sc. (HONOURS) in PHYSICS

(Effective 2018/19 batch onwards)

PART-I: LANGUAGES

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester I						
UGEN-101	General English-I #	5	5	IE1	T	100
	Another Language-I #	4	4	IE1	T	100
Semester II						
UGEN-201	General English-II #	5	5	IE1	T	100
	Another Language-II #	4	4	IE1	T	100
Semester III						
UGEN-301	General English-III #	5	5	IE1	T	100
	Another Language-III #	4	4	IE1	T	100

Contd…

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester IV						
UGEN-401	General English-IV #	5	5	IE1	T	100
	Another Language-IV #	4	4	IE1	T	100
	PART-I TOTAL	**36** credits	**36** hours			**800** marks

PART-II: CORE SUBJECTS (Hons. in Physics)

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester I						
UPHY-101	Electronics-I: Analog and Digital	3	3	IE1	T	100
UPHY-102	Electronics Laboratory –I	1	3	I	P	50
		4 credits	**6** hours			**150** marks
Semester II						
UPHY-201	Optics	3	3	IE1	T	100
UPHY-202	Optics Laboratory	1	3	I	P	50
		4 credits	**6** hours			**150** marks
Semester III						
UPHY-301	Classical Mechanics	4	4	IE1	T	100
UPHY-302	Mechanics Laboratory	1	3	I	P	50
		5 credits	**7** hours			**150** marks
Semester IV						
UPHY-401	Electromagnetism	4	4	IE1	T	100
UPHY-402	Electromagnetism Laboratory	1	3	I	P	50
		5 credits	**7** hours			**150** marks
Semester V						
UPHY-501	Mathematical Physics-I	3	3	IE1	T	100
UPHY-502	Mathematical Physics-II	3	3	IE1	T	100
UPHY-503	Quantum Mechanics	4	4	IE1	T	100
UPHY-504	Electronics-II: Operational Amplifiers	3	3	IE1	T	100
UPHY-505	Computational Techniques in Physics	3	3	IE1	T	100
UPHY-506	General Physics Laboratory-I	2	6	I	P	50
UPHY-507	Electronics Laboratory-II	2	6	I	P	50
UPHY-508	Software Laboratory-I	2	4	I	P	50
		22 credits	**32** hours			**650** marks

Contd…

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester VI						
UPHY-601	Solid State Physics	4	4	IE1	T	100
UPHY-602	Nuclear Physics	3	3	IE1	T	100
UPHY-603	Thermal and Statistical Physics	3	3	IE1	T	100
UPHY-604	Elements of Atomic and Molecular Spectroscopy and Lasers	3	3	IE1	T	100
UPHY-605	Microprocessors	3	3	IE1	T	100
UPHY-606	General Physics Laboratory-II	2	6	I	P	50
UPHY-607	Microprocessors Laboratory	2	4	I	P	50
UPHY-608	Software Laboratory-II	2	6	I	P	50
		22 credits	**32** hours			**650** marks
	PART II TOTAL (Honours in Physics)	**62** credits	**90** hours			**1900** marks

PART-II: CORE SUBJECT (Mathematics)

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester I						
UMAT-101	Multivariable Calculus	4	4	IE1	T	100
UMAT-102	Foundations of Mathematics	2	2	IE1	T	50
		6 credits	**6** hours			**200** marks
Semester II						
UMAT-201A	Probability* (MPC only)	3	3	IE1	T	100
UMAT-202	Methods of Ordinary Differential Equations	3	3	IE1	T	100
		6 credits	**6** hours			**200** marks
Semester III						
UMAT-301	Introduction to Real Analysis	3	3	IE1	T	100
UMAT-302	Introduction to Linear Algebra	3	3	IE1	T	100
		6 credits	**6** hours			**200** marks
Semester IV						
UMAT-401	Real Analysis II	3	3	IE1	T	100
UMAT-402	Algebraic Structures - I	3	3	IE1	T	100
		6 credits	**6** hours			**200** marks
	PART-II TOTAL (Mathematics)	**24** credits	**24** hours			**800** marks

Notes: The Choice of Electives and Streams of Specialization offered shall be decided by the Head of the Department.

***UMAT- 201 A is only applicable for MPC students

PART-II: CORE SUBJECT (Chemistry)

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester I						
UCHM-101	Theoretical Chemistry and Analytical Chemistry	3	3	IE1	T	100
UCHM-102	Laboratory course in Qualitative Inorganic Analysis	1	3	I	P	50
		4 credits	**6** hours			**150** marks
Semester II						
UCHM-201	Inorganic, Organic and Physical Chemistry-I	3	3	IE1	T	100
UCHM-202	Laboratory Course in Inorganic, Organic and Physical Chemistry-I	1	3	I	P	50
		4 credits	**6** hours			**150** marks
Semester III						
UCHM-301	Inorganic, Organic and Physical Chemistry-II	4	4	IE1	T	100
UCHM-302	Laboratory course in Inorganic, Organic and Physical Chemistry-II	1	3	I	P	50
		5 credits	**7** hours			**150** marks
Semester IV						
UCHM-401	Inorganic, Organic and Physical Chemistry–III	4	4	IE1	T	100
UCHM-402	Laboratory course in Inorganic, Organic and Physical Chemistry-III	1	3	I	P	50
		5 credits	**7** hours			**150** marks
	PART-II TOTAL (Chemistry)	**18** credits	**26** hours			**600** marks

PART-III: AWARENESS and ENVIRONMENTAL COURSES

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester I						
UAWR-100	Awareness Course-1: Sai Education for Transformation (Based on Life and Teachings of Bhagawan Baba)	2	2	I	T	50
UENT-101	Environment-I ##	2	2	I	T	75
Semester II						
UAWR-200	Awareness Course-2: Unity of Religions	2	2	I	T	50
UENT-201	Environment-II ##	2	2	I	T	75
Semester III						
UAWR-300	Awareness Course-3: Study of Classics-I: Ramakatha Rasavahini	2	2	I	T	50

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practical	Maximum Marks
Semester IV						
UAWR-400	Awareness Course-4: Study of Classics-II: Bhagawatha Vahini	2	2	I	T	50
Semester V						
UAWR-500	Awareness Course-5: Eternal Values for the changing world	2	2	I	T	50
Semester VI						
UAWR-600	Awareness Course-6: Life and its Quest	2	2	I	T	50
	PART-III TOTAL	**16** credits	**16** hours			**450** marks

Modes of Evaluation

Indicator	Legend
IE1	CIE and ESE ; ESE single evaluation
IE2	CIE and ESE ; ESE double evaluation
I	Continuous Internal Evaluation **(CIE)** only Note: 'I' does not connote 'Internal Examiner'
E	End Semester Examination **(ESE)** only Note: 'E' does not connote 'External Examiner'
E1	ESE single evaluation
E2	ESE double evaluation

Types of Papers

Indicator	Legend
T	Theory
P	Practical
V	Viva voce
PW	Project Work
D	Dissertation

Continuous Internal Evaluation (CIE) & End Semester Examination (ESE)

PS: Please refer to guidelines for 'Modes of Evaluation for various types of papers', and Viva voce nomenclature & scope and constitution of the Viva-voce Boards.

SUMMARY

	Credits	Hours	Maximum Marks
PART-I: LANGUAGES			
PART-I TOTAL	**36** credits	**36** hours	**800** marks
PART-II: CORE SUBJECTS			
PART-II TOTAL (Honours in Physics)	**62** credits	**90** Hours	**1900** marks
PART-II TOTAL (Mathematics)	**24** credits	**24** Hours	**800** marks
PART-II TOTAL (Chemistry)	**18** credits	**26** Hours	**600** marks
PART-III: AWARENESS and ENVIRONMENTAL COURSES			
PART-III TOTAL	**16** credits	**16** hours	**450** marks
GRAND TOTAL (B.Sc. (Hons.) in Physics)	**156** Credits	**192** hours	**4550** marks

UPHY-101 ELECTRONICS-I: ANALOG AND DIGITAL 3 Credits

Course objectives:

The objectives of this lab-based course are to:

- understand the working of diodes, transistors, basic gates, flip flops, registers and counters
- understand the application of different electronic devices and be able to analyze the working as well as troubleshoot simple circuits
- provide the necessary background for UPHY-504 (Electronics-II) and UPHY-605 (Microprocessors) courses in the final year of the Physics program

Learning outcomes:

At the end of the course, the student should be able to:

- Define a voltage and current source; state and apply Thevenin's and Norton's theorems
- Understand the role of diodes in rectifier, wave shaping, voltage multiplier and voltage regulation circuits
- Explain how the transistor works and describe how it can be used as an amplifier and switch
- Develop a complete understanding of number systems, gates, Boolean algebra, arithmetic and logic circuits, flip-flops, registers and counters.

Course content:

1. **Introduction**:
   Voltage and current sources; superposition theorem *1 unit*
   Thevenin's and Nortons's theorems; power transfer theorem *2 units*

2. **Diode theory**:
   Intrinsic and extrinsic semiconductors; pn junction diode; approximations of a diode; biasing and its effects; V-I characteristics, specifications of a diode *2 units*
   Rectifiers: Half wave rectifier, full wave rectifier, bridge rectifier, power supply LC and RC filters and regulators *2 units*
   Types of diodes and their applications: power, signal, Zener, Schotkky, LED, 7-segment displays and photodiodes *1 unit*
   Clippers; negative and positive clampers; voltage multipliers *2 units*
   Zener diode as a constant voltage source & as a regulator *1 unit*
   Use of LED as a display, high frequency application of Schotkky, photodiode as a photo detector *2 units*

3. **Bipolar Junction Transistors (BJTs)**:
   Basic construction of a junction transistor; working of an npn transistor, I_E, I_C, & I_B and their relationship in terms of current gains αandβ; transistor specifications *2 units*

Biasing and different types of biasing; base, emitter and collector feedback bias (in brief); voltage divider bias (in detail) *2 units*
Transistor circuit as an amplifier and its characteristics, namely, voltage gain, current gain, input and output impedance, frequency response, input and output phase relationship and dynamic range *2 units*
Ac transistor amplifier types based on configuration: CE, CC & CB; Characteristics of CE and CC (in detail) *2 units*
Cascaded stages (in block diagrams) for different applications namely, high voltage gain (CE & CE), high frequency range (CE & CB), impedance matching (CE & CC), high input impedance and high current gain (CC & CC) *2 units*
Transistor as switch and as current source. *2 units*

4. Digital Concepts:
Digital vs. analog signal; characteristics of digital signal; advantage of digital over analog; number systems: decimal, binary, hexadecimal and BCD; conversion from one to the other *1 unit*

5. Logic Gates:
Basic gates: NOT, OR, AND gates; combination logic, NOR, NAND, XNOR and XOR; symbol, truth tables and Boolean expressions timing diagrams *2 units*
Universal property of NAND and NOR *1 unit*
Application of gates: binary controlled switch; word comparator; encoders; decoders; controlled inverters *2 units*

6. Boolean algebra and Karnaugh Maps:
Boolean relations; De Morgan's theorems; sum of products method; Karnaugh maps up to four inputs including don't care conditions *3 units*

7. Arithmetic logic units:
Binary addition and subtraction; Half adder, full adder and binary adders; Signed binary numbers; 2's complement representation; 2's complement adder-subtractor; *2 units*

8. Latches and Flip Flops:
SR latch; D latch; clocked latches; basic types of flip flops based on triggering – JK flip flop, D flip flop and Master Slave flip flop. *3 units*
Registers and Counters: Buffer registers; shift registers; control shift registers; ripple counters; mod-10 counter; synchronous and ring counters. *3 units*

9.* Basic Electronic Instruments:
Definition and application of instruments; measuring, generating and display instruments *1 unit*
Multimeters (Analog and Digital), signal generator, Power supplies, Oscilloscopes; specifications for each – capabilities, power requirements and dimensions *2 units*
(* not for testing, to be covered in the practical class)

UPHY-101 Contd….

KEYED TEXTS:

1. Malvino, A.P.: **Electronic principles**, Tata-McGraw Hill, Ed VI, 2002
2. Malvino, A.P.: **Digital computer electronics**, Tata-McGraw Hill, Ed V, 2002

REFERENCES:

1. Floyd T L, **Electronic Devices**, Pearson Education, Ed VI, 2003
2. Floyd T L, **Digital Fundamentals**, Pearson Education, Ed VIII, 2003
3. Prasad, K B R.: **Experiments in Electronic Principles: A text-Laboratory Manual**, Department of Physics, SSSIHL
4. Khalsi, **Electronic Instrumentation,** Tata McGraw Hill, 2002

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UPHY-102 ELECTRONICS LABORATORY-I 1 Credit

1. **Familiarization Experiment**: Components and equipment familiarization - Power supply, multimeter, function generator, oscilloscope and Digital trainer. Relevant instruments' usage may be introduced as and when required.

2. **Study of a potential divider circuit**: Potential divider, current divider, Kirchhoff Voltage rule, Kirchhoff Current rule, and loading effect of a voltmeter

3. Verification of circuit theorems:
   a. Thevenin's theorem
   b. Norton's theorem.
   c. Maximum power transfer theorem.

4. Diode characteristics: Voltage vs. current plot

5. Zener diode: a) V-I characteristics b) as a voltage regulator (Load regulation)

6. Study of half wave, full wave and bridge rectifier without filters.

7. Study of half wave, full wave and bridge rectifier with capacitor input filter

8. Transistor a) testing using a multimeter b) Characteristics (collector curves)

9. Truth tables of logic gates: a) Verification b) Universality of NAND/NOR gates.

10. Half-adder and Full adder: Fabrication using logic gates

11. Study of Flip-Flops: NAND /NOR latch, Clocked RS NAND latch, D-flipflop using NAND /NOR gates on a digital trainer

Extra: Soldering skills

Note: Students should do a minimum of 8 experiments

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UPHY-201 **OPTICS** 3 Credits

Course objectives:

The objectives of this lab-based course are to:

- give students an in-depth look at geometrical and physical optics phenomena
- expose them to the various historical theories of light and its propagation - rectilinear propagation, reflection, refraction, culminating in Fresnel's equations derived from the electromagnetic wave approach
- provide a deeper knowledge of basic concepts and applications of phenomena like interference, diffraction and polarization and their related optical techniques
- give a hands-on experience to study different optical phenomena by performing experiments related to the concepts studied

Learning outcomes:

Upon completion of this course, student must be able to:

- describe basic optical phenomena and comment on basic concepts and principles of geometrical and physical optics.
- discuss the nature of light, its propagation and interaction with matter.
- understand ray-based optical system analysis and design, and operation of simple optical instruments.
- model a complex optical system using paraxial ray tracing.
- use the electromagnetic wave approach to explain the phenomena caused by the wave nature of light such as polarization, interference and diffraction, and their applications.
- explain fundamental limits in imaging and resolution of optical system due to diffraction and aberrations.
- handle optical elements and perform experiments to study various optical phenomena and determine optical properties like wavelength, refractive index, etc. through the hands-on experience provided by the associated lab course.

Course content:

***I Geometrical Optics**:*

1. **Introduction:**
   Electromagnetic spectrum, visible spectrum; Distinction between Geometrical and Physical optics *1 unit*

2. **Laws of reflection and refraction**:
   Huygen's principle; Fermat's principle; principle of reversibility *1 unit*
   Derivation of Fresnel's equations for TE and TM modes *2 units*
   External and Internal reflections; Phase changes on reflection *1 unit*

UPHY-201 Contd….

3. Matrix methods in paraxial optics:

Translation, refraction and reflection matrices *2 units*

thick and thin lens matrices; system matrix; cardinal points and examples *3 units*

4. Aberrations:

Concept of chromatic aberration; Removal using achromatic doublet and separated doublet *2 units*

Overview of monochromatic/Seidel aberrations: Spherical aberration, Coma, Astigmatism, Distortion and Curvature of field *1 unit*

5. Optical Instruments:

Principles of Optical Instruments: Spectrometer, Eyepieces: Huygens and Ramsden, Microscopes and Telescopes 3 *units*

II Physical Optics

6. Interference:

Coherence: temporal and spatial; Relation between spectral bandwidth of light source and coherence time *2 units*

Two beam interference; Young's double slit; interference in dielectric films; fringes of equal thickness *3 units*

Newton's rings; film thickness measurement *2 units*

Michelson interferometer and applications; Stokes relations *3 units*

7. Diffraction:

Fresnel versus Fraunhofer diffraction; Fraunhofer diffraction from a single slit *2 units*

beam spreading; rectangular and circular apertures *2 units*

Rayleigh's criterion of resolution; double slit *2 units*

multiple slits; Diffraction grating *2 units*

Free spectral range, Resolution and Dispersion *1 unit*

8. Polarization:

Distinction between polarized and unpolarized light; Jones vector representation of polarized light: Plane polarized, circularly polarized and elliptically polarized beams *3 units*

Jones matrix representation of polarizers, phase retarders and rotator *1 unit*

Production of polarized light: Dichroism; Birefringence: Quarter wave plate and half wave plate 2 *units*

Double refraction: Nicol prism, Glan-air prism and Wollaston prism. *2 units*

Reflection from dielectric surfaces- Brewster's law; Optical activity *1 unit*

KEYED TEXTS:

1. Pedrotti, F. L. and Pedrotti, L. S., Introduction to Optics, Prentice Hall, 1987

UPHY-201 Contd….

REFERENCES:

1. Hecht, E., Optics, Pearson Education, 2003

2. Meyer-Arendt, J.R., Introduction to Classical and Modern Optics, II Edition, Prentice-Hall, 1988

3. Ghatak, A., Optics, Tata-McGraw-Hill, 1981

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UPHY-202 OPTICS LABORATORY 1 Credit

Basic Experiments

1) Familiarization of spectrometer: Angle of prism; angle of minimum deviation
2) Refractive Index of water using hollow prism
3) Dispersive power of a prism
4) Cardinal Points and Focal length of lenses in combination using nodal slide assembly and verification using ABCD matrices
5) Determination of refractive index using i-d curve.
6) Determination of wavelength of Na-vapour lamp using Fresnel's biprism

Interference

7) Newton's rings experiment - to determine wavelength of given monochromatic source
8) Young's double slit experiment
9) Fresnel Biprism experiment
10) To determine the thickness of insulation of a thin wire using air wedge set up

Diffraction

11) Single slit experiment
12) Determination of wavelength of given source using diffraction gratings
 (i) minimum deviation method
 (ii) normal incidence method
13) Resolving power and dispersive power of a plane transmission grating

Polarization

14) Study of double refraction using spectrometer
15) Analysis of polarized light – Babinet Compensator
16) **Verification of Brewster's law**

17) Resolving Power and dispersive power of a prism

18) Construction of telescope, microscope & eyepieces

Note: Students should do a minimum of 8 experiments

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UPHY-301 **CLASSICAL MECHANICS** **4 Credits**

Course objectives:

The objectives of this lab-based course are to:

- provide an in-depth understanding of the principles of Newtonian mechanics and apply them to solve problems involving the dynamic motion of classical mechanical systems
- explain the limitations of Newtonian mechanics for motion at very high velocities, and thus introduce the special theory of relativity
- provide hands-on experience to perform experiments to study some properties of matter and oscillations

Learning outcomes:

Upon completion of the course, student must be able to:

- apply Newton's laws of motion to different force fields for a single particle and for a system of particles
- set-up and solve differential equations to study the a) motion of a particle in a central force field, b) oscillatory motion and c) vibrations in a string and interpret the solutions obtained
- apply the concept of conservation of energy and linear momentum to solve problems involving collisions with respect to both laboratory frame of reference and center of mass frame
- appreciate the study of special theory of relativity and understand its consequences- length contraction, time dilation, simultaneity of events, mass variation and equivalence of mass and energy
- use required instruments with skill, and perform experiments to study the mechanical properties of solids and liquids, vibrations in strings, oscillations in a system, analyze experimental data and interpret graphs

Course content:

1. Newton's Laws, Equations of motion and their Solutions for a Single Particle:

Newton's laws of motion and frame of reference, relative velocity; *1 unit*

Applications of Newton's laws to the motion of a single particle – Concepts of kinetic energy and potential energy, conservative force and Work-Energy theorem; *2 units*

Equations of Motion and their solutions for motion under - constant force (Atwood's machine), force depending only on time (sinusoidal force), resistive force depending on velocity, free-fall of an object under gravity with air-resistance – terminal velocity, projectile motion without air-resistance and with air-resistance – range and time-of-flight of projectile. *4 units*

2. **Mechanics of system of particles:**
   Centre of mass- definition and calculations, linear momentum of the system, angular momentum of the system, energy of the system (no derivation) ` *2 units*
   Motion of system with variable mass – rocket motion in free space, vertical ascent under gravity *2 units*

3. **Dynamics of Rigid Body:**
   Description of rigid body; concept of degree of freedom *1 unit*
   Center of mass of a rigid body and its determination for symmetric objects (hemi-spherical shell, solid hemi-sphere, solid cone, L and arc shaped objects) *2 units*
   Rotation about an axis; Parallel and perpendicular axis theorems, calculation of moment of inertia for regular bodies (thin rod, circular ring, circular disk, rectangular plate, solid sphere) *3 units*

4. **Motion in a central force field**:
   Equivalent one body problem; motion in central force field: general features of the motion, equations of motion *2 units*
   orbits in a central field, centrifugal energy and the effective potential *3 units*
   motion in an inverse square law field; equation of orbit; Kepler's laws *3 units*

5. **Oscillations**:
   Simple harmonic oscillator-simple pendulum, physical pendulum, bar pendulum and torsional pendulum, spring mass system; *4 units*
   damped harmonic oscillator; forced oscillations; coupled oscillations *6 units*

6. **Waves:**
   Vibrating Strings; equation of motion in a string, *1 unit*
   introduction to partial differential equations; solving the wave equation using method of separation of variables, *2 units*
   normal modes of vibration, introduction to Fourier series; evaluation of Fourier coefficients *2 units*

7. **Collisions of particles**:
   Elastic and inelastic scattering; elastic scattering in laboratory and center of mass systems *3 units*
   Kinematics of elastic scattering in laboratory system *3 units*

8. **Special theory of relativity**:
   Newtonian relativity; Michelson Morley experiment *2 units*
   Postulates of special theory of relativity; Lorentz transformations and consequences: time dilation, length contraction and simultaneity of events. *4 units*
   addition of velocities; variation of mass with velocity; mass-energy relation, massless particles. *4 units*

KEYED TEXTS:

1. Takwale, R.G., and Puranik, P.S.: **Introduction to classical mechanics**, Tata McGraw Hill, 1979

UPHY-301 Contd….

2. Arya, P. Atam, **Introduction to Classical mechanics**, II ed., Prentice Hall International.

REFERENCES:

1. Spiegel, M.R.: **Theoretical Mechanics**, McGraw Hill, 1983

2. Marion, J. B. and Thornton, S. T.: **Classical Dynamics of Particles and Systems**, III Edition, Harcourt Brace Jovanovich, 1988

3. Kittel C, Knight D W, and Ruderman A M, **Mechanics**, Vol. I, Berkeley Physics Course, McGraw-Hill, 1965

4. Goldstein H, Poole C, and Safko J, **Classical Mechanics**, Ed III, Pearson Education, 2002

5. A K Ghatak, I C Goyal and S J Chua, **Mathematical Physics: Differential equations and Transform theory** – Macmillan India Ltd

6. Beiser, A.: **Concepts of Modern Physics**, IV Edition, McGraw Hill, (1987)

7. MIT lectures; Scicos Simulations using Scilab

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UPHY-302 MECHANICS LABORATORY 1 Credit

1. **Errors in observation**: Study of random errors.

2. **Young's modulus**
   a. uniform bending and/or non-uniform bending
   b. Koenig's method

3. **Rigidity Modulus**
   a. Maxwell's needle
   b. Torsional Pendulum
   c. Static Torsion
   d. Forced oscillation method

4. **Moment of Inertia of**
   a. Fly Wheel
   b. An irregular body.

5. **Acceleration due to gravity**
   a. Bar pendulum
   b. Kater's pendulum
   c. Atwood's machine

6. **Study of standing waves**
   a. Melde's apparatus
   b. AC electrical vibrator
   c. Sonometer

7. **Speed of sound in air** – Kundt's tube method

8. **Scilab simulations (like)**
   a. Superposition of waves- Interference and beats
   b. Generation of a square wave
   c. Projectile motion

9. **Study of Coupled oscillations**
   a. Coupled pendulums
   b. Double pendulum (using tracker)

10. **Tracker based experiments**
    a. Mass – Spring System
    b. Simple pendulum

UPHY-302 Contd….

11. **Coefficient of viscosity**
    a. Stokes method
    b. Poiseuille’s method

12. **Surface tension**
    a. Capillary rise
    b. Jaeger’s method

13. **Conservation of energy**

14. Set of experiments using Linear air track system

15. **Miscellaneous**
    a. Collisions in 2-D
    b. Study of laws of parallel and perpendicular axes for estimation of Moment of Inertia.

Note: Students should do a minimum of 8 experiments.

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UPHY-401 **ELECTROMAGNETISM** **4 Credits**

Course objectives:

The objectives of this lab-based course are to:

- provide a deeper understanding of electrostatics and magnetostatics leading to the fundamental laws of electrodynamics – Maxwell's equations in free space and their consequences
- develop competence in using laboratory instruments to carry out experiments to study different electromagnetic phenomena, that will enhance students class room learning

Learning outcomes:

Upon completion of this course, student must be able to:

- find expressions for the electric and magnetic fields produced by static and moving charges in a variety of configurations.
- comprehend the dynamics of a charged particle in electric, magnetic and electromagnetic fields and its applications
- formulate Maxwell's equations leading to electromagnetic wave equation and understand its propagation and energy transport
- set up and perform basic experiments to investigate the behavior of electric and magnetic fields for different configurations, to determine capacitance and inductance and study the effect of these components on the behavior of the circuits

Course content:

1. **Review of Vectors:**
   Vector algebra, Differential calculus: gradient, divergence, curl, product rules, second derivatives; *2 units*
   Integral calculus: Line, surface and volume integrals, Divergence theorem, Stokes' theorem *2 units*

2. **Electrostatics-I**:
   The electric field: Coulombs law; continuous charge distribution *2 units*
   Divergence and curl of electrostatic fields: field lines, flux and Gauss law *1 unit*
   Divergence of E; Application of Gauss's law: spherical, cylindrical and plane symmetries; curl of E *2 units*
   Electric potential, Poisson's equation and Laplace's equation; the potential of a localized charge distribution *3 units*
   Potential at a distance along the axis perpendicular
   a) to the center of two point charges of opposite charge a distance d apart,
   b) passing through the center of uniform line charge
   c) to the uniform surface charge and passing through its center. *3 units*

UPHY-401 Contd….

3. Electrostatics-II:

Work and energy in Electrostatics: work done to move a charge; energy of a point charge distribution; energy of a continuous charge distribution *3 units*

Conductors: basic properties; induced charges; surface charge and force on a conductor; Capacitors *3 units*

4. Dipoles:

Field and potential due to a dipole; torque on a dipole in an external electric field; mutual potential energy of dipoles *3 units*

5. Electric Fields in Matter:

Polarization: dielectrics; induced dipoles; alignment of polar molecules *1 unit*

Field of a polarized object: bound charges; field inside a dielectric *1 unit*

The Electric displacement: Gauss's Law in presence of dielectric *1 unit*

Linear dielectrics: susceptibility, permittivity, dielectric constant; *3 units*

6. Magnetostatics-I:

The Lorentz force law: magnetic fields; magnetic forces; currents *2 units*

Biot Savart's law and applications to find **B** due to infinitely long straight wire and circular loop *2 units*

Steady currents; magnetic field of a steady current; Divergence and curl of B straight line currents *2 units*

7. Magnetostatics-II:

Ampere's law- B due to infinitely long wire, infinite uniform surface, B due to solenoid and toroid. *3 units*

Motion of charged particle in electromagnetic field: motion in a constant electric field, a uniform magnetic field B, motion in crossed fields; The Hall effect *2 units*

8. Magnetic Fields in Matter:

Magnetization: diamagnets, paramagnets, ferromagnets. *2 units*

Torque and forces on the magnetic dipoles; effect of a magnetic field on atomic orbits *2 units*

Magnetization and Hysteresis of ferromagnetic materials *2 units*

9. Electrodynamics:

Electromotive force: motional emf; Electromagnetic induction: Faraday's laws; induced electric field *2 units*

Self-inductance & mutual inductance; energy in magnetic field *2 units*

Maxwell's equations: electrodynamics before Maxwell; Maxwell- Ampere's law; Maxwell's equations; Poynting's theorem *3 units*

10. Electromagnetic Waves:

Electromagnetic Waves in vacuum: wave equation for E and B
monochromatic plane waves; energy and momentum in EM waves *3 units*

UPHY-401 Contd….

KEYED TEXTS:

1. Griffiths, D. J: **Introduction to Electrodynamics**, Ed III, Prentice Hall of India, 2000

2. Rangwala, A.A. and Mahajan, R, **Electricity and Magnetism**, Tata McGraw Hill, 1988

REFERENCES:

1. Jordan, E. C., and Balmain, K. G.: **Electromagnetic Waves and Radiating Systems**, Prentice Hall, 1968

2. Halliday, D. and Resnick, R.: **Physics (Part 2)**, Ed III, Wiley Eastern, 1978

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UPHY-402 ELECTROMAGNETISM LABORATORY 1 Credit

1. Study of RC circuits:
   a) Transient response: Study of rise and decay of current
   b) Steady state response: Integrator, Differentiator, High pass and low pass filters

2. Study of LR circuits:
   a) Investigation of Inductance
   b) Study of rise and decay of current

3. To study the response curve of a Series LCR circuit and determine its
   (a) Resonant Frequency,
   (b) Impedance at Resonance
   (c) Quality Factor Q
   (d) Band Width.

4. To study the response curve of a Parallel LCR circuit and determine its
   (a) Anti- Resonant Frequency
   (b) Quality Factor Q.

5. Measurement of dielectric constant of a liquid.

6. Study of Hall Effect and determine the Hall Coefficient of a semiconductor

7. Determination of e/m of an electron by Thomson's method.

8. Study the variation of the magnetic field along the axis of a current carrying coil. (Stewart and Gees galvanometer/ Helmholtz double coil)

9. Study the variation of the magnetic field along the axis of a solenoid and determine the permeability constant μ_0.

10. Determination of inductance, L, using Faraday's law

11. Study of B-H curves of a ferromagnetic material.

12. Determine the Curie temperature of ferromagnetic materials

13. Measurement of low resistance- Carey Foster bridge.

Note: Students should do a minimum of 8 experiments

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UPHY-501 **MATHEMATICAL PHYSICS-I** **3 Credits**

Course objectives:

The objective of this course is to highlight the application of mathematical methods in physics by:

- familiarizing students with orthogonal coordinate systems and their properties
- teaching methods of solving differential equations that occur in various branches of theoretical physics like classical mechanics, quantum mechanics and electrodynamics
- giving a good mathematical background required for quantum mechanics through the study of special functions

Learning outcomes:

On completion of this course, student must be able to:

- solve mathematical problems in physics by a variety of mathematical techniques
- solve ordinary and partial differential equations of first order and second order that are common in physics
- describe special functions and their properties
- generate orthogonal polynomials in any domain
- use Laplace transforms to solve definite integrals and differential equations
- understand the significance and properties of Fourier series and Fourier transforms and find the Fourier transform of simple functions
- define and derive the properties of the Dirac Delta function and appreciate its application to particular physical situations

Course content:

1. Curvilinear Coordinates:

Transformation of coordinates; orthogonal curvilinear coordinates *1 unit*
Unit vectors in curvilinear system; arc length and volume elements *2 units*
Gradient, divergence and curl; special orthogonal coordinate systems *4 units*

2. Partial Differential Equations:

Some partial differential equations in Physics *1 unit*
Method of separation of variables: Separation of Laplace and Helmholtz equations in Cartesian, Spherical polar and Cylindrical polar coordinates *2 units*
Choice of coordinate system and separability of a partial differential equation *1 unit*

3. Second Order Differential equations:

General form of second order differential equations *2 units*
Ordinary and singular points; Series solution around an ordinary point and a regular singular point - Frobenius Method; *3 units*
Getting a second solution *2 units*

UPHY-501 Contd….

4. Special Functions:
Differential equation, Series solution, Generating function, Recurrence relations, Rodrigues's formula and Orthonormality relation of:
(a) Legendre polynomials *2 units*
(b) Associated Legendre functions *3 units*
(c) Laguerre polynomials (d) Associated Laguerre polynomials and *3 units*
(e) Hermite polynomials *2 units*
Generation of Legendre polynomials through Gram-Schmidt orthonormalization process *2 units*

5. Fourier Series and Fourier Transforms:
Fourier series; Parseval identity and few applications *2 units*
Fourier transform; Convolution and other properties; Parseval's theorem, applications of Fourier transform; Fourier sine and cosine transform *3 units*

6. Laplace Transforms:
Laplace transform, shifting property, transforms of derivatives and integrals *2 units*
Convolution theorem; Application to solving integrals and initial value problems *2 units*

7. Dirac Delta Function:
Strongly peaked functions and the Dirac delta function
Delta sequences-representations of the delta function (examples only) *1 unit*
Delta Calculus; Properties of the Delta function *2 units*

KEYED TEXTS:

1. Spiegel, M. R., **Theory and Problems of Vector Analysis**, McGraw Hill, 1959

2. Chattopadyay, P.K.: **Mathematical Physics**, Wiley Eastern, (1990).

3. Butkov, E.: **Mathematical Physics**, Addison Wesley, (1968).

4. Boas, M.L.: **Mathematical Methods in the Physical Sciences**, II Edition. John Wiley, (1983).

5. Arfken, G.B., and Weber, H.J.: Mathematical Methods for Physicists, IV Edition. Academic Press/Prism Books (1995).

REFERENCES:

1. Ghatak A. K., Goyal I. C., Chua S. J., **Mathematical Physics: Differential Equations and Transform Theory**, Macmillan India, 1995.

2. Riley K. F, Hobson M. P., Bence S. J., **Mathematical Methods for Physics and Engineering**, Cambridge Low-price Edition, Cambridge Univ. Press (1999).

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UPHY-502 MATHEMATICAL PHYSICS-II 3 Credits

Course objectives:

The objective of this course is to:

- acquaint the student with a range of mathematical methods, such as, complex analysis, vector spaces and probability, that are important prerequisites for other theoretical physics courses

Learning outcomes:

Upon completion of this course, the student must be able to:

- have a clear understanding of basic elements of complex analysis; apply it to solve complicated integrals
- find eigenvalues and eigenvectors of matrices and apply the concept to physical systems
- appreciate various probability distributions (Binomial, Normal and Poisson), their properties and apply them to analyze experimental data

Course content:

1. Vector Spaces:

Quick review of vector spaces; Linear transformations and matrices	*2 units*
Types of matrices and their properties: (Symmetric, Skew-symmetric, orthogonal, Hermitian, skew-Hermitian and unitary)	*2 units*
Eigen-value problems: Determination of eigenvalues and eigenvectors of matrices referred to above	*2 units*
Theorems associated with Eigen values and Eigen vectors	*2 units*
Quadratic, Hermitian and skew Hermitian forms	*1 unit*
Diagonalization and applications	*2 units*

2. Complex Numbers:

Curves and regions in complex plane; limit, derivative, analytic function	*2 units*
Cauchy-Riemann equations; Laplace equation	*2 units*
Functions of complex variables	3 *units*

3. Complex Integrals:

Line integral and properties; Cauchy's integral theorem	*2 units*
Indefinite integration; Cauchy's integral formula	*2 units*
Derivatives of analytic function	*1 unit*

4. Series:

Power series; Taylor series; methods for power series	*3 units*
Laurent series; zeroes and singularities	*3 units*

UPHY-502 Contd….

5. Residues:

Residue theorem and application to the evaluation of integrals *4 units*

6. Fundamentals of Probability:

Introduction; probability theorems; conditional probability *2 units*
Bayes' formula; counting, permutations and combinations *2 units*
Random variables; mean, standard deviation, variance *1 unit*
Distribution functions; Binomial, Gaussian and Poisson distributions 3 *units*
Applications to experimental measurements 1 *unit*

KEYED TEXTS:

1. Kreyszig, E., **Advanced Engineering Mathematics**, IX Edition, Wiley Eastern.

2. Boas, M.L., **Mathematical Methods in the Physical Sciences**, II Edition, John Wiley (1983).

REFERENCES:

1. Gupta, B.D., **Mathematical Physics**, III Edition, Vikas publishing house (2004).

2. Riley K. F, Hobson M. P., Bence S. J., Mathematical Methods for Physics and Engineering, Cambridge Low-price Edition, Cambridge Univ. Press (1999).

3. Arfken, G.B., and Weber, H.J., **Mathematical Methods for Physicists**, IV Edition Academic Press/Prism Books (1995).

4. Butkov, E, **Mathematical Physics**, Addison Wesley (1968)

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UPHY-503 QUANTUM MECHANICS 4 Credits

Course objectives:

The objectives of the course are to:

- review the experiments that led development of quantum theory
- understand the underlying foundations and basic principles of quantum mechanics
- apply non- relativistic Schrödinger wave mechanics to a variety of potentials in one and three dimensions

Learning outcomes:

On completion of the course, the student should be able to:

- appreciate the need to study quantum mechanics by accepting the limitations of classical physics through experimental evidences and understand quantum theory of radiation and matter
- understand the wave-particle duality, develop the concept of the wave function and give its interpretation, discuss Heisenberg's uncertainty principle and its applications
- discuss the concept of probability conservation and probability current density, formulate the set of postulates to study quantum mechanics and apply the principles of quantum mechanics to calculate observables of a quantum system
- solve time-dependent and time-independent Schrödinger wave equation for simple potentials in one and three dimensions

Course content:

1. Evolution of Quantum Theory:

Limitations of classical physics *1 unit*
Blackbody radiation; Rayleigh Jeans' formula; Ultraviolet catastrophe; Wien's law *1 unit*
Planck's quantum hypothesis and Planck's Radiation formula *1 unit*
Photoelectric effect; Einstein's theory of photoelectric effect *2 units*
Compton scattering; Expression for Compton shift and Compton wavelength; *1 unit*
Hydrogen spectrum; Bohr model of Hydrogen atom; *2 units*
Franck Hertz experiment; Wave particle duality; Davisson and Germer experiment; Stern-Gerlach experiment *3 units*

2. Wave mechanical concepts:

Matter waves; Superposition principle and construction of wave packet;
Motion of wave packet; Group velocity and phase velocity, *3 units*
Heisenberg's uncertainty principle;
Position-momentum uncertainty; Uncertainty relation for other variables *2 units*
Applications of uncertainty relations *1 unit*
Exact statement and proof of uncertainty principle *1 unit*

UPHY-503 Contd….

3. Time dependent Schrödinger equation:

One dimensional equation for a free particle; Particle in 1-D box *3 units*
Probabilistic interpretation of the wave function and its normalization;
Time independent Schrödinger equation *1 unit*
Stationary state solutions of the Schrödinger equation,
Operators for momentum and energy; *1 unit*
Expectation values of dynamical quantities; Momentum operator *1 unit*
Wave function in momentum space; Probability current density *2 units*

4. Operators in quantum mechanics:

Linear operator; Algebra of linear operators *1 unit*
Eigen functions and Eigen values of operators; Boundary and continuity conditions; Orthonormal set of Eigen functions *1 unit*
Hermitian operator; Properties of Hermitian operators *2 units*
Postulates of Quantum mechanics; Expansion postulate and its physical interpretation *2 units*
Simultaneous measurability and commutators *1 unit*
Uncertainty relation for commutators; Dirac's notation *1unit*
The fundamental commutation relation; Equation of motion for operators
Ehrenfest theorem; Correspondence principle *1 unit*
Parity operator; Momentum representation *1 unit*

5. One dimensional potentials:

Square well potential with rigid walls *1 unit*
Potential step *1 unit*
Potential barrier: Tunneling *2 units*
Linear Harmonic oscillator: Energy eigen values, energy eigen functions *3 units*

6. Angular Momentum:

The angular momentum operators in spherical polar co-ordinates *1 unit*
Angular momentum commutation relations *1 unit*
Eigen values and eigen functions of L^2 and L_z *2 units*

7. Three dimensional Eigen value problems:

Particle in a three dimensional box; Degeneracy *1 unit*
Particle moving in a spherically symmetric potential
Separation of variables; Solution of the φ -equation
Solution of the θ-equation; Spherical harmonics; 2 *units*
Radial equation
Rigid rotator
Hydrogen atom; Radial equation; Energy Eigen values 3 *units*
Wave functions of hydrogen like atoms; Radial probability density;
Hydrogenic orbitals 3 *units*

UPHY-503 Contd….

KEYED TEXTS:

1. Goswami, A, **Quantum Mechanics**, II Edition, Wm. C. Brown Publ. 1997
2. Ghatak, A, **Introduction to Quantum Mechanics**, Macmillan India Ltd, 2000
3. Powell, J. and Crasemann, B., **Quantum Mechanics**, Narosa, 1988

REFERENCES:

1. Schiff, L. I., **Quantum Mechanics**, III Edition, McGraw Hill, 1968
2. Gasiorowicz, S., **Quantum Physics**, John Wiley, 1974

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UPHY-504 ELECTRONICS-II: OPERATIONAL AMPLIFIERS

3 Credits

Course objectives:

The objectives of this **lab-based** course are to:

- study the performance of power amplifiers, operational amplifiers and IC timers and oscillators
- establish the general methods for analyzing, modeling and predicting the performance of op-amps and related linear integrated circuits.
- develop the students faculty in designing realistic circuits to perform specified operations using op-amps

Learning outcomes:

On completion of the course, the student should be able to:

- describe the characteristic features of power amplifiers in class A, class B and class C operation and determine the efficiency of these amplifiers
- analyze and design various op-amp circuits using the ideal model assumptions
- understand the practical limitations of realistic op-amps and the associated dc and ac effects on operating performance
- analyze frequency dependent circuits like integrators and differentiators
- employ the op-amp in comparator circuits , both open-loop and feedback circuits
- understand the working of a 555 timer and use it in astable and monostable modes of operation
- design and analyze waveform generation circuits using op-amps by employing the Barkhausen criterion
- rig up circuits using op-amps and electrical components with appropriate sources and measuring instruments to perform experiments for specified operations, thereby complimenting the learning outcomes of the theory course

Course content:

1. **FETs:** The JFET basics, JFET characteristics, biasing; drain curves; transconductance curves, The MOSFET; MOSFET; characteristics and parameters; MOSFET biasing 2 *units*
2. **Power amplifiers:**
   Review of CE, Swamped, and CC amplifiers 3 *units*
   Class A power amplifier; Ac load line, formulae for class A; power gain, efficiency of each stage; 3 *units*
   Class B and class AB push-pull amplifier; Class C operation; tuned amplifier; 3 *units*

UPHY-504 Contd….

3. **Operational Amplifiers:**
   Introduction; op-amp fundamentals; Block diagram of a typical op-amp and equivalent circuit; *1 unit*
   Ideal and practical op-amp characteristics; the 741C general purpose op-amp data sheet and its interpretation; op-amp powering; *1 unit*

4. **Linear Op-amp circuits:**
   Introduction; 4 types of negative feedback in op-amp circuits; VCVS, VCIS, ICVS, ICIS
   Ideal assumptions and their implications. *1 unit*
   VCVS: basic op-amp configurations– inverting, non-inverting and voltage follower. Design and role of compensation resistance *2 units*
   VCIS: Floating load inverting and non-inverting, Grounded load VCIS. *1 units*
   Current controlled sources; **ICVS and ICIS** *1 units*
   Linear combination circuits: inverting and non-inverting summing circuit,
   Closed -loop differential amplifier 2*units*
   Common- mode Rejection; Instrumentation amplifier *2 units*
   Integrators and differentiator circuits using op-amps *1unit*

5. **Op Amp- dc effects and limitations:**
   Low-frequency model of op-amp; finite open –loop gain, finite input impedance and non-zero output impedance of op-amp
   Non-inverting amplifier and Inverting Amplifier; Gain, Input impedance and Output impedance due to realistic model of op-amp, Noise Gain 3 *units*
   Dc Offset voltage and currents, experimental procedure to measure offset voltage and bias currents, Drift specifications, nulling. *2 units*

6. **Op Amp- ac effects and limitations:**
   Frequency response; Open-loop gain as a function of frequency, Gain-bandwidth relationship, Closed-loop bandwidth *2 units*
   Slew Rate; effect of slew rate on pulse type and sinusoidal signals
   Combination of linear bandwidth and Slew rate; 3 *units*
   Noise in op-amps.

7. **Non Linear Op-Amp Circuits:**
   Comparators with zero reference; inverting and non-inverting comparators; input / output characteristics;

   Comparators with non-zero references (voltage level detectors); specifications and applications; Comparators with hysteresis (Schmidt trigger circuits); 3 *units*

8. **Oscillators**: (Operational amplifiers based)
   Introduction; Oscillator principles; positive feedback in amplifier; Barkhausen criterion; RC oscillators**:** Wien Bridge and phase shift oscillators; LC- Hartley and Colpitt's oscillators; piezoelectric effect and crystal oscillators 3 *units*
   Non-sinusoidal oscillators**:** IC 555 Timer as Astable and Monostable multi-vibrators; 3 *units*

UPHY-504 Contd….

KEYED TEXTS:

1. Malvino, A. P., **Electronics Principles, III Edition, 7th** ed**,** Tata-McGraw Hill, 2007

2. Stanley, W. D, **Operational amplifiers with linear integrated circuits**, Ed IV, Merril, 2002

REFERENCES:

1. Coughlin, R. F. and Driscoll, F. F., **Operational Amplifiers and Linear Integrated Circuits**, IV Edition, Prentice Hall India, 2003

2. Fiore, M J., **Op-Amps and Linear Integrated Circuits**, Delmar (2001)

3. Floyd, L T.: **Electronic Devices**, Pearson education, Ed VI, 2002

4. Gayakwad R, **Op-Amps and linear Integrated circuits**, Ed VI, Prentice Hall of India, 2003

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UPHY-507 ELECTRONICS LABORATORY-II **2 Credits**

1. Electronic Power Supplies: Unregulated supply
2. Design of Regulated power supply (fixed and variable, Use of 78XX series and 317 regulator)
3. Design and study of CE and Swamped amplifier.
4. Design and study of CC/Emitter follower amplifier.
6. Registers 7495 (Shift right, Shift left, serial and parallel loading)
7. Counters: 7490, 7492 & 7493 (÷10, ÷12 & ÷16)
8. Decoder driver 7448 & seven segment display.
9. Study of FET characteristics

Op-Amp (741) based experiments:

9. VCVS (Inverting and Non-inverting): Design, fabricate and study gain and small signal band-width
10. VCIS (Grounded Load), ICVS& ICIS: Fabricate and study
11. a) Voltage offset Null Circuit for 741
    b) Closed Loop Differential. Amplifier
12 a) Measurement of DC input offset Voltage and b) Measurement of DC bias and offset current for 741
13. Study Slew rate response of 741 op-amp to square wave and sinusoidal waveforms using a voltage follower circuit
14. Study of Comparators: a) Non-Inverting & Inverting (Open Loop)
    b) Comparators with bias
    c) Inverting and Non Inverting Schmitt trigger
15. Integrator and Differentiator
16. 555 Timer: Design and study of astable operation
17. 555 Timer: Design and study of monostable operation
18. Wein bridge oscillator
19. Hartley and Colpitt's oscillator

Experiments numbers 1 - 4 may be soldered on a lug board. All other experiments are bread-board based.

Note: Students should complete experiments 1-8 and at least 8 op-amp based experiments

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UPHY-505 COMPUTATIONAL TECHNIQUES IN PHYSICS

3 Credits

Course objectives:

The objective of the course is to:

- make the student appreciate the limitations of analytical methods in solving problems
- introduce various computational methods and use them to solve problems, such as, linear algebraic equations, integrals, differential equations, etc.

Learning outcomes:

On completion of the course, the student must be able to:

- appreciate the computational approach to problem solving and data analysis
- numerically solve non-linear equations, system of linear equations, integrals and differential equations
- to describe the algorithms used to compute the Fast Fourier Transform
- employ appropriate methods to fit and interpolate data
- appreciate the use of random numbers to Monte-Carlo simulation methods

Course content:

1. Error Analysis:
Significant figures; Accuracy and precision; Error definition; Round off errors and truncation errors; Taylor series *4 units*

2. Non- linear Equations:
Bracketing methods; Bisection; False Position Methods 2 *units*
Open Methods; Newton Raphson, Secant method and Simple One Point Iteration Methods 3 *units*

3. Linear Algebraic Equations:
Gauss Elimination; LU Decomposition; Gauss Jordan and matrix inverse 6 *units*

4. Numerical Integration:
Trapezoidal rule and Simpson’s Rules; Romberg Integration 4 *units*

5. **Least Square Regression and Interpolation**:
Linear regression; Interpolation by Newton’s divided difference interpolating Polynomials 2 *units*
Lagrange interpolating polynomials and Spline interpolation *4 units*

6. **Ordinary Differential Equations**:
One Step methods: Euler’s method and Runge Kutta methods *4 units*

UPHY-505 Contd…

Types of partial difference equations (PDEs) – Elliptic, parabolic and hyperbolic, Crank-Nicholson method and solution to heat diffusion equation, Application to Schrodinger equation; *5 units*

7. **Monte-Carlo Method:** Random number generation, tests for randomness, quasi-random sequences Monte Carlo Integration-Rejection method; *4 units*

8. **Fast Fourier Transforms:** Discrete Fourier Transform, Fast Fourier Transform by Sande-Tukey Algorithm. *4 units*

KEYED TEXTS:

1. Chapra S. C. and Canale R. P., **Numerical Methods for Engineers**; McGraw Hill Book Company, 1990

2. Press W. H. et al., **Numerical Recipes in C;** Cambridge University Press (1988).

3. R.C.Verma, P.K.Ahluwalia and K.C. Sharma, **Computational Physics, An Introduction**; New Age International Publishers

REFERENCES:

1. Gerald C. F. and Wheatley P. O., **Applied Numerical Analysis,** Pearson Education(2003)

2. Griffiths, D. V. and Smith, I.M., **Numerical methods for engineers**, Blackwell Scientific, 1991

3. Ralston, A. and Rabinowtz, P., **A First Course in Numerical Analysis**, II Ed, McGraw Hill, Kogakusha, 1978

4. Atkinson, K. E., **An Introduction to Numerical Analysis**, John Wiley, 1978

5. Jain, M. K., Iyengar, S.R. K. and Jain, R. K., **Numerical Methods for Scientific and Engineering Computation**, Wiley Eastern, 1985

6. Hildebrand, F. B., **Introduction to Numerical Analysis**, II Ed, Tata Mc Graw Hill, 1979

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UPHY-506 GENERAL PHYSICS LABORATORY-I 2 credits

Course objectives:

The objectives of this lab course are to:

- Illustrate and reinforce the concepts of interference, diffraction and polarization with advanced experiments in optics.
- Impart the thrill of experimental physics by determining fundamental constants using the laboratory equipment.

Learning outcomes:

On completion of this lab course students must be able to:

- carry out basic experimental investigations in physics
- use instruments for various measurements and troubleshoot the same
- analyze experimental data with appropriate treatment of errors and uncertainties
- apply analytical techniques and graphical analysis to the experimental data to elicit suitable conclusions.

Lab Course content:

Optics

1. Determination of wavelength of He- Ne Laser using
   (a) Michelson Interferometer
   (b) Lloyd's mirror method
   (c) modified Newton's ring set up
2. Specific rotation of optically active liquid using polarimeter
3. Variation of reflectance with angle of incidence
4. Verification of Fresnel's equations of EM theory
5. Study of Ultrasonic diffraction – determination of velocity of ultrasound in liquids

Fundamental constants / Modern Physics

6. Determination of electronic charge 'e' - Millikan's oil drop experiment
7. Determination of Rydberg's constant
8. Determination of Stefan's constant
9. Study of Photoelectric effect and determination of Planck's constant
10. Determination of Boltzmann constant*
11. Determination of the gravitational constant *
12. Determination of the speed of light*
13. Study of Frank Hertz Experiment*
14. Study of Black body radiation*
15. Study of Electron Diffraction*

UPHY-506 Contd….

Software based experiments

16. Simulations using Scilab / X-COS
17. Familiarization of data acquisition systems – LABVIEW
18. Experiments using Python*

Note: Student should do a minimum of 12 experiments

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UPHY-508 SOFTWARE LABORATORY-I **2 Credits**

(Python Programming language to be taught through examples)

Course objectives:

The objectives of this lab course are to:

- inculcate a "programming way of thinking" in students
- introduce Python as a programming language
- write programs in Python for implementing computational techniques learnt in UPHY-505
- use Python as a visualization tool in physics

Learning outcomes:

On completion of this lab course students must be able to:

- have a firm grip over the basics concepts of programming, such as, print command input statements, arithmetic operations and fundamental datatypes
- write and execute basic python programs using functions, loops and conditional constructs
- implement the complex datatype - list
- plot expressions involving concepts in Physics, using appropriate python libraries, and interpret them for better understanding
- write and execute programs to solve non-linear equations, system of linear equations, integrals and differential equations

Lab Course content:

- Introduction to python programming, basic arithmetic and Hello world programs
- Variables, Operators and Datatypes; Operations on datatypes; Input and Output
- Functions: Modules, Built-in functions, User defined functions, keyword arguments
- Conditional statements (if, elif, else) and Loops
- Lists, Introduction to numpy and matplotlib for basic plotting

(Examples from UPHY 505 – Computational Techniques in Physics)

- Non-Linear Equations: Bisection, False-Position, Newton Raphson and Secant Methods
- Numerical Integration: Trapezoidal and Simpson's Rules
- Linear Regression and Spline Interpolation
- Euler's Method and Runge-Kutta Methods
- Monte-Carlo Methods and Random number generation
- Linear Algebraic Equations: Gauss Elimination method with Partial Pivoting

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UPHY-601 **SOLID STATE PHYSICS** **4 Credits**

Course objectives:

The objectives of the course are to:

- introduce solid state systems
- give an in-depth knowledge of various crystalline structures and experimental techniques like X-ray diffraction
- provide an understanding of thermal, electrical, optical and magnetic properties of solid state matter

Learning outcomes:

Upon completion of this course, student must be able to:

- appreciate the physics of materials and understand the importance of solid state physics in current technology
- describe different types of crystal structures in terms of the crystal lattice and basis
- formulate the theory of X-ray diffraction in reciprocal lattice formalism and explain the concepts like form factor, structure factor, scattering amplitude, etc.
- understand the different physical mechanisms involved in crystal binding
- comprehend the concept of phonons and thereby the thermal properties of solids.
- explain electrical, optical and magnetic properties of solids based on theoretical models

Course content:

1. **Crystal Structure**:
   Lattice concept; lattice types; index system for system planes,
   Simple crystal structures; Lattice symmetries; absence of five-fold symmetry *7 units*

2. **Crystal Diffraction and the Reciprocal Lattice**:
   Experimental techniques using X-rays, neutrons, and electrons *1 unit*
   Bragg law; experimental diffraction methods: Laue method, rotating crystal method, powder method *3 units*
   Laue Equations; Bragg's Law and Ewald's Construction 3 *units*
   Reciprocal lattice; Brillouin zone, construction, Brillouin zone of SC, BCC and FCC lattice; Fourier analysis of basis. *5 units*

3. **Crystal Types and Crystal Binding**:
   The five crystal types; inert gas crystals – properties *2 unit*
   Van der waals– London Interaction; Lennard Jones potential *2 units*
   Cohesive energy; bulk modulus and compressibility; ionic crystals-
   Madelung energy and Madelung constant *2 units*

UPHY-601 Contd….

4. Lattice vibrations: and Thermal Properties:

Vibrations of mono atomic lattices; lattice with two atoms per primitive cell; quantization of lattice vibrations *4 units*

Phonon momentum *1 unit*

Lattice heat capacity; Planck distribution; Einstein's model *2 units*

Enumeration of normal modes; density of modes in one and three dimensions 3 *units*

Debye model of lattice specific heat capacity; Debye T^3 law *2 units*

5. Free Electron Fermi gas:

Energy levels and density of orbitals in 1-D *2 units*

Free electron gas in 3-D; effect of temperature on Fermi – Dirac distribution *2 unit*

Heat capacity of electron gas; electrical conductivity and Ohm's law *2 units*

Hall effect and magneto-resistance; Mattheissan's rule; thermal conductivity of a metal *1 units*

6. Optical properties: refractive index, extinction coefficient, absorption coefficient and relation between them *3 units*

7. Magnetic properties:

Diamagnetism, paramagnetism due to free ions and conduction electrons, Curie's law, ferromagnetism, domains, hysteresis loop, outline of antiferro- and ferrimagnetism; ferrites *7 units*

8. Superconductivity:

Introduction; experimental facts, zero resistivity, critical temperature, critical B field *1 unit*

Effect of magnetic field; Meissner effect *1 unit*

KEYED TEXTS:

1. Kittel, C.: **Introduction to Solid State Physics**, V Edition, Wiley Eastern, 1976
2. Ashcroft, N. W and Mermin, N. D., **Solid State Physics,** Harcourt Asia Pvt. Ltd. 2001
3. Rolf E. Hummel, Electronic Properties of Materials, Fourth Edition, Springer, 2011
4. Mark Fox, Optical Properties of Solids, Second Edition, Oxford University Press, 2010
5. Omar Ali, **Introduction to Solid state Physics,** Pearson Education, 2003
6. Pillai S. O., **Solid State Physics**, New Age Science, Ed 6, 2009.

REFERENCES:

1. Blakemore J. S.: **Solid State Physics**, II Edition, Cambridge University Press, 1985
2. Azaroff, L. V.: **Introduction to Solids**, Tata-McGraw Hill, 1978

UPHY-602 **NUCLEAR PHYSICS** **3 Credits**

Course objectives:

The objectives of this course are to:

- provide an understanding of radioactive phenomena
- explore the nuclear properties and understand them through nuclear models
- impart knowledge of the nuclear processes that yield nuclear energy
- introduce the experimental tools used for studying nuclear physics

Learning outcomes:

On completion of the course, students must be able to:

- appreciate the importance of nuclear physics and its applications
- understand radioactive decay modes and nuclear reactions
- discuss nuclear properties
- explain the principle, construction and working of detectors and accelerators
- describe fission and fusion reactions and nuclear power production
- have a basic idea of elementary particles and their conservation laws

Course content:

1. **Radioactivity**:
The radioactive decay law; half-life and mean life; *1 unit*
Statistical nature of radioactivity; statistical errors in nuclear physics *1 unit*
Radioactive growth and decay; transient and secular equilibrium *1 unit*
Natural radioactivity and radioactive series *1 unit*
Artificial radioactivity; Determination of age of the Earth, Carbon dating; Units for measuring radiation *1 unit*

2. **Nuclear Reactions**:
Introduction; nomenclature; Types of nuclear reactions *1 unit*
Balance of mass and energy in nuclear reactions; the Q-equation; solution of the Q equation; Threshold energy; *2 units*

3. **Nuclear Properties:**
Constituents of a nucleus; Discovery of neutron; *1 unit*
Nuclear radius; distribution of nuclear charge; Measurement of nuclear radius; *1 unit*
Nuclear mass and abundance of nuclides; Mass spectrometer *1 unit*
Nuclear binding energy; Nuclear angular momentum and parity; statistics, Nuclear Magnetic moment; Nuclear electric quadrupole moment *2 units*
Nuclear excited states; failure of proton-electron hypothesis *1 unit*

4. **Nuclear decays:**
   Alpha decay: Basic alpha decay process; Disintegration energy of spontaneous alpha decay *1 unit*
   Geiger Nuttal law; Alpha spectrum *1 unit*
   Decay scheme of alpha decaying nucleus; Alpha decay paradox; Barrier penetration as applied to alpha decay theory *2 units*
   Beta Decay: Continuous beta ray spectrum; Pauli's neutrino hypothesis *1 unit*
   Detection of neutrino; Cowan and Reines experiment *1 unit*
   Types of beta decay; Energy release in beta decay; Decay scheme of a beta decaying nucleus, *1 unit*
   Gamma decay: Energetics of gamma decay; Gamma spectrum; Angular momentum and parity selection rules; multipolarity of gamma transitions; *1 unit*
   Internal conversion; Internal conversion coefficient; Level scheme of gamma emitting nucleus *1 unit*

5. **Liquid Drop Model**:
   Binding energies of nuclei; plot of B/A against A *1 unit*
   Weizsacker's semi-empirical mass formula: volume energy, surface energy, asymmetry energy, pairing energy *2 units*

6. **Nuclear Force**:
   Few properties of nucleon-nucleon force; the deuteron; Binding energy, spin and parity, magnetic dipole moment, electric quadrupole moment *1 unit*
   Ground state of deuteron; spin dependence; charge independence; short range and tensor nature *1 unit*
   Square-well solution for the deuteron *1 unit*
   Exchange force: meson theory of nuclear force; Estimation of mass of a meson using uncertainty principle *1 unit*

7. **Nuclear Energy**:
   Characteristics of Nuclear fission; mass distribution of fragments; number of emitted neutrons; delayed neutrons; radioactive decay processes; fission cross section; energy in fission *2 units*
   Controlled fission reactions; neutron moderators; fission reactors, types of reactors, type of fuel; moderator; assembly; coolant *1 unit*
   Neutron cycle in a thermal nuclear reactor and the four factor formula, fission explosives *1 unit*
   Basic fusion processes; energy release; solar fusion; proton-proton cycle; carbon or CNO cycle; controlled fusion reactors; *1 unit*

8. **Charged Particle Accelerators and Detectors**:
   Van de Graff generator; Tandem Van de Graff accelerator *1 unit*
   The cyclotron and synchrotron; linear accelerator *2 units*
   Gas filled counters-principle; pulse height vs. applied voltage graph; Geiger counter and proportional counter *1 unit*

9. Elementary Particles:

Particles and fields; classification *1 unit*

Conservation laws of particles: energy and momentum, angular momentum, parity, baryon number, lepton number, strangeness *1 unit*

The quark model of baryons, hyperons and mesons; *1 unit*

KEYED TEXTS:

1. Patel, S. B., **Nuclear Physics, An Introduction**, Wiley Eastern, 1991
2. Krane, K. S., **Introductory Nuclear Physics**, John Wiley, 1987
3. Krane, K.S., **Modern Physics**, John Wiley, 1983

REFERENCES:

1. Evans, R. D., **Atomic Nucleus**, Tata McGraw Hill, 1982
2. Enge, H., **Introduction to Nuclear physics**, Addison Wesley, 1969

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UPHY-603 THERMAL AND STATISTICAL PHYSICS **3 Credits**

Course Objectives:

The objectives of this course are to:

- give the fundamentals of thermodynamic systems, the laws of thermodynamics and their application to thermodynamic problems
- provide essential tools to analyze carnot engine, heat engines and refrigerators with the help of their thermodynamic cycles
- highlight the use of mathematical methods to derive thermodynamic relationships
- introduce the microscopic approach through kinetic theory of gases and basic statistical thermodynamics

Learning outcomes:

Upon completion of the course, students must be able to:

- have a fundamental understanding of thermodynamic quantities and the laws of thermodynamics
- to calculate work and heat transfers, efficiency of ideal heat engines and refrigerators, and entropy changes
- represent thermodynamic processes on appropriate thermodynamic diagrams
- appreciate the application of thermodynamic laws to liquefaction of gases for low temperature production
- use kinetic theory of gases to derive expressions for pressure of an ideal gas, heat capacities of solids and gases and transport properties
- explain the properties of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac distributions and identify systems where they are applicable

Course content:

1. Introduction:

Macroscopic and microscopic point of view; thermal equilibrium and Zeroth law, concept of temperature; Thermodynamic equilibrium *1 unit*

Concept of work; different types of processes; Quasi-static process *1 unit*

Example of work in changing the volume of a hydrostatic system; PV diagram and calculation of PdV integral for quasi static processes *1 unit*

2. First Law of Thermodynamics:

Work and heat; the concept of heat; modes of heat transfer *1 unit*

Adiabatic work, internal energy function; mathematical formulation of first law; differential form of first law *2 units*

Definition of heat capacity; specific heat of water; equations for hydrostatic system; thermal energy reservoirs *1 unit*

UPHY-603 Contd….

3. Second Law:

Conversion of heat to work; Heat engine; different types of engines- diesel and steam engines *2 units*

Kelvin-Planck statement of second law; refrigerators; Clausius statement of second law; equivalence of the two statements *2 units*

Reversibility and irreversibility and its types; Conditions for reversibility *1 unit*

4. The Carnot cycle:

The Carnot cycle and the Carnot principles; Carnot heat engine and refrigerators *2 units*

Heat pumps, Carnot theorem; thermodynamic temperature scale; absolute zero and Carnot efficiency *4 units*

5. Entropy:

Reversible part of second law; entropy; entropy of an ideal gas, T-S diagrams; entropy and reversibility; entropy and irreversibility; irreversible part of second law; principle of increase of entropy; entropy and disorder. *4 units*

6. Thermodynamic Functions:

Characteristic functions; enthalpy; Gibbs and Helmholtz function; Maxwell's Thermodynamic relations; T-dS equations; Clausius-Clapeyron equation; Internal energy equations; ratio of heat capacities; difference in heat capacities *3 units*

7. Application:

Joule-Kelvin effect expansion; The Joule- Kelvin Coefficient; Joule-Kelvin Coefficient for a Van der Waals' gas; Liquefaction of gases; Adiabatic demagnetization *3 units*

8. Kinetic theory of gases:

Basic assumptions; Maxwellian distribution of velocities, molecular flux; equation of state of an ideal gas; principle of Equipartition of energy; intermolecular forces; *3 units*

Classical theory of specific heat; specific heat of a solid; Van der Waals' equation of state; *2 units*

Collision cross section; mean free path *1 unit*

9. Statistical Thermodynamics:

Introduction; Energy states; energy levels; macro and micro states; thermodynamic probability; statistical interpretation of entropy; *3 units*

Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac Statistics and an example for each *3 units*

KEYED TEXTS:

1. Zemansky, M.W.: **Heat and Thermodynamics**, IV Edition, McGraw-Hill (1978).

2. Sears, F.W., and Sallinger, G.L.: **Thermodynamics, Kinetic theory and Statistical Thermodynamics,** III Edition, Narosa (1988).

UPHY-603 Contd….

3. Beiser, A.: **Concepts of Modern Physics**, IV Edition, McGraw Hill, (1987)

REFERENCES:

1. Evelyn Guha, **Basic Thermodynamics**, Narosa Publications.

2. Cengel A Y, and Boles A M, **Thermodynamics: an engineering approach**, III edition, TMH

3. Aruldhas G and Rajagopal P, **Modern Physics,** Prentice hall of India, 2005

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UPHY-604 ELEMENTS OF ATOMIC AND MOLECULAR SPECTROSCOPY AND LASERS

3 Credits

Course objectives:

The objectives of this course are to:

- develop an understanding of the structure of matter through the study of atoms and molecules
- give the basics of atomic and molecular spectroscopy and to gain a clear understanding of the principles and processes involved in spectroscopy
- understand the fundamentals of lasers, to study their unique properties and learn the techniques used in different laser designs

Learning outcomes:

At the end of the course, the student should be able to:

- describe the atomic spectra of one and two valence electron systems/atoms
- explain the change in behavior of atoms in external magnetic fields
- explain the details of rotational, vibrational and Raman spectra of molecules, evaluate the bond length and force constant of diatomic molecules
- discuss the principles involved in lasing action, describe the requirements of a laser system and the properties of laser radiations

Course content:

1. **Atomic Spectra**:
Alkali atoms; residual coulomb and spin-orbit interactions; spin coupling;
LS coupling; *2 units*
Spin and orbital angular momenta and related quantum numbers; jj coupling *2 units*
Lande's interval rule; energy levels of carbon atom; Zeeman effect *2 units*

2. Elements of Molecular Spectroscopy:
Characterization of electromagnetic radiation; quantization of energy; representation of spectra; elements of practical spectroscopy *2 units*
Signal to noise ratio, resolving power; width and intensity of spectral transitions; Fourier transform spectroscopy *2 units*

3. Microwave Spectroscopy:
Rotation of molecules; rotational spectra; diatomic molecules *1 unit*
The rigid diatomic molecule; intensities of spectral lines; the effect of isotopic substitution *2 units*
The non-rigid rotator; the spectrum of non-rigid rotator *1 units*
Polyatomic molecules: Linear molecules; symmetric top molecule; the microwave oven *2 units*

UPHY-604 Contd….

4. Infrared Spectroscopy:

Vibrating diatomic molecule; energy of a diatomic molecule; the simple harmonic Oscillator *2 units*

The anharmonic oscillator *1 units*

The diatomic vibrating rotator; vibration rotation spectrum of carbon monoxide *2 units*

Breakdown of the Born-Oppenheimer approximation: the interaction of rotations and vibrations *2 units*

5. Elements of Raman Spectroscopy:

Quantum theory of Raman effect; classical theory of Raman effect *2 units*

Pure rotational Raman spectra: Linear molecules, symmetric top molecules *2 units*

Spherical top molecules; asymmetric top molecules *2 units*

Vibrational Raman spectra: Raman activity of vibrations, rule of mutual exclusion, overtone and combination vibrations *2 units*

Vibrational Raman spectra- rotational fine structure *2 units*

6. Lasers I:

Quantum theory of radiation; Einstein A and B coefficients *2 units*

Essential elements of a laser; laser operation; characteristics of laser light *2 units*

7. Lasers II:

Laser types and parameters *2 unit*

Ruby laser, He-Ne, Ar^+-ion and CO_2 lasers *2 units*

8. Other Spectroscopic Techniques:

Principles of NMR, ESR and Mossbauer spectroscopy *3 units*

KEYED TEXTS:

1. Eisberg, R. and Resnick, R., **Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles**, II Edition, John Wiley, 1985

2. Banwell, C.N., **Fundamentals of Molecular Spectroscopy**, III Edition, Tata-McGraw Hill, 1972

3. Wilson, J. and Hawkes, J. F. B., **Optoelectronics- An Introduction**, Prentice Hall, 1983

REFERENCES:

1. Pedrotti, F.L. and Pedrotti, L.S., **Introduction to Optics**, Prentice Hall, 1987

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UPHY-605 **MICROPROCESSORS** **3 Credits**

Pre-requisites:

This course assumes a sound understanding of digital electronics and binary and hexadecimal number systems covered in UPHY-101

Course objectives:

The objective of this **lab-based** course is to:

- impart a comprehensive knowledge about the working of a microprocessor, both hardware and software, with particular reference to Intel's 8085 microprocessor

Learning outcomes:

At the end of the course, the student must be able to:

- describe the architecture of the 8085 microprocessor and list its operations
- discuss various types of memory, explain memory organization and memory mapping
- design counters and time delays using the concepts of looping and counting
- explain the concept of the stack, stack pointer and subroutine
- explain the concept of interrupts in microprocessors, describe the types of interrupts and the interrupt structure of 8085
- describe the interface between the microprocessor and the physical world using data converters and the general - purpose programmable device- 8255 chip
- write and execute assembly language programs using the instruction set for 8085 system categorized under data transfer, arithmetic, logical, branch and machine controlled instructions using the stand-alone 8085 kits

Course content:

1. **General features of a digital computer and microprocessors:** Hardware, Software, CPU, Memory, Input/output devices. Type of memory: RAM ROM, SDRAM, PROM, EPROM etc. Flash memory, magnetic memory, Cache memory; *2 units*

2. **Interfacing devices & Memory mapping**: Tristate devices, buffers, Decoders, Latches. Hexadecimal counting; Conversion to Binary and decimal. Address space. Memory mapping; Peripheral I/O and memory mapped I/O. *4 units*

3. **Architecture of 8085**: Multiplexing; Address-data bus, Control and status signals. Timing diagram of op-code fetch machine cycle. Registers: general purpose and special purpose. ALU, Control unit. Instruction cycle, Machine cycle, T-state; *4 units*

UPHY-605 Contd….

4. **Assembly Language Programming for 8085**: Instruction set. Classification. Instruction format; Opcode format. Examples of 1-byte, 2-byte and 3-byte instructions. Addressing modes: Register, Register indirect, direct, immediate, Implied. Programs using data transfer, arithmetic and logic instructions. Branching instructions: Unconditional and conditional. *5 units*

5. **Programming techniques**: Looping, Counting and Indexing, Use of register pairs-Additional data transfer and 16 – bit arithmetic instructions, arithmetic and logic operations related to memory *5 units*

6. **Counters and time delays**: Time delay loops: using a register, register pair and nested loops, counter design with time delay *2 units*

7. **Stack and Subroutines:** Stack: Definition, Initialization; PUSH and POP instructions; Program status word. Subroutine: CALL and RET: Stepwise execution in terms of machine cycles. *3 units*

8. **Interrupts:** Types of interrupt: Maskable and Non-maskable; INTR and INTA signals; RST instructions. Vectored interrupts: RST7.5, RST6.5, RST5.5 and TRAP. *4 units*
9. **Data Converters:** D/A and A/D converters *3 units*

10. **Programmable interfacing devices**: Requirements of a programmable peripheral device, Control register, Status register; Role of handshake signals. Block diagram of 8255; Control word; Mode 0 and BSR mode. *7 units*

11. **Introduction to other Microprocessors:** Overview of Advanced processors: 8088/8086, 286, 386, 486, Pentium I, II, dual core, Core 2 duo, quad core *3 units*

KEYED TEXTS:

1. R.S. Gaonkar, **Microprocessor architecture, Programming and applications with the 8085** (5^{th} Edition), Penram International Publishing India Pvt. Ltd.

REFERENCES:

1. B. Ram, Fundamentals of microprocessors and microcontrollers, D Rai Publications, 2001.

2. W. A. Triebal, Avatar Singh, ,**The 8088 and 8086 microprocessor**, IV ed., 2003

3. K.J. Ayala, “The 8086 microprocessor: programming and interfacing the PC”, Penram International. 1995

4. Yu. Cheng Liu, Glenn A. Gibson, “**Microcontroller systems: the 8086/88 family**” II ed., Prentice Hall India, 2003

5. J. Uffenbeck, “**The 80x86 family”** III ed., Pearson ed., 2003

UPHY-607 MICROPROCESSOR LABORATORY 2 Credits

Preparation: Introduction to the 8085 kit and to basic programming with the kit

Sample programs with Microprocessor 8085:

1. Transfer of a block of numbers.
2. Addition of n 8-bit numbers.
3. a) Multiplication by repeated addition.
   b) Multiplication by shift and add method.
4. Sorting to arrange in ascending order.
5. Delay routine for a specified time.
6. 16-bit arithmetic (Register pair operations)
7. Using subroutines: main program to display hex-numbers continuously with delay subroutine.
8. Introduction to interfacing with IC 8255.

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UPHY-606 GENERAL PHYSICS LABORATORY-II **2 credits**

Course objectives:

The objectives of this lab course are to:

- strengthen the general concepts by carrying out experiments that probe various aspects of modern physics namely solid state physics, thermal physics, spectroscopy and nuclear physics
- introduce students to independently design and set up a few experiments
- familiarize students with Latex/Libre office/MS Office for scientific report writing

Learning outcomes:

On completion of this lab course students must be able to:

- carry out experimental investigations which will broaden their perspectives of physics
- to independently prepare a scientific report from conception to completion.
- make a presentation of their scientific findings

Lab Course content:

Solid State Physics

1. Measurement of susceptibility of paramagnetic material using
   (a) Quincke's method
   (b) Guoy's method
2. Energy band gap and resistivity measurement – Four Probe method
3. Determination of thermal and electrical conductivities of copper and hence the Lorentz number
4. Verification of Curie Weiss law

Spectroscopy

5. Determination of wavelengths of emission spectral lines of metal arc sources (Cu, Br, Fe)
6. Study of Zeeman Effect
7. Determination of the absorption lines in the rotational spectrum of $KMnO_4$*

Nuclear Physics: GM counter based experiments

8. Characterization of the GM counter
9. Verification of the inverse square law
10. Determination of the linear absorption coefficient of aluminium
11. Counting statistics
12. Verification of half-life of Potassium

UPHY-606 Contd….

Thermal Physics

13. Characterization of temperature sensors (thermocouples, thermistor and RTD)
14. Determination of coefficient of thermal conductivity of a bad conductor
15. Determination of coefficient of thermal conductivity of a good conductor –
    a. Forbe's method
    b. Searle's method
16. Verification of Clausius-Clapeyron equation
17. Determination of Specific heat of solids and Determination of Specific heat of water
18. Determination of γ (specific heat ratio) - Clement & De'sormes apparatus

Note:

- Student should do a minimum of 10 experiments (inclusive of few open-ended experiments)
- Student shall use Latex/Libreoffice/MS Office to submit the report of open-ended experiments only.

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UPHY-608 SOFTWARE LABORATORY-II 2 Credits

Course objectives:

The objective of this lab course is to:

- introduce students to advanced features of Python, such as complex datatypes (Strings, Dicts and Tuples), classes and file handling.

Learning outcomes:

On completion of this lab course, students must be able to:

- write and execute simple programs using strings, dicts and tuples, and on classes and file handling in Python
- simulate examples from Physics, using advanced features of numpy, scipy and matplotlib and visualize them for better understanding

Lab Course content:

Advanced Programming in Python and Physics Simulations using Python

- Strings, Tuples and Dicts
- Object Oriented Programming: Classes, Inheritance
- File Handling
- Basics of GUI Programming using tkinter
- Advanced features of numpy, scipy and matplotlib

Examples of Physics Simulations

- Projectile Motion
- Motion of charged particle in fields
- Plotting of Electric Field / Potential for a 2-D charge distribution
- Plotting of wave functions for different Quantum Mechanical systems

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