DEPARTMENT OF PHYSICS
Rabindranath Thakur Vishwavidyalaya
Hojai, Assam, India

Syllabus for Four Year Under Graduate Programme (FYUGP) in Physics of
Rabindranath Thakur Vishwavidyalaya and its affiliated Colleges

As per NEP-2020 Guidelines

<u>General structure and distribution of number of Courses in the FYUGP in Physics</u>

Semester		Core (4)	Minor (4)	AECC (2)	IDC (3)	SEC (3)	VAC (4)	Internship (2)	Research	Total Credit
1st		1	1	1	1	1	1	×	×	20
2nd		1	1	1	1	1	1	×	×	20
3rd		2	1	1	1	1	×	×	×	20
4th		3	1	1	×	×	×	1	×	20
5th		4	1	×	×	×	×	×	×	20
6th		4	1	×	×	×	×	×	×	20
***7th**	**(i)**	3	1	×	×	×	×	×	RM (4)	20
	(ii)	4	1	×	×	×	×	×	×	
***8th**	**(i)**	1	1	×	×	×	×	×	Diss. (12)	20
	(ii)	4	1	×	×	×	×	×	×	

NB: Students of the 7th & 8th semesters can opt for either category (i) or (ii) of their respective semester.

Program Structure

Year	Semester	Course		Title of the Course	Total Credits
1st Year	1st Sem	**DSC-101**		Mechanics and Properties of Matter	4
		DSM-101		Mechanics (for disciplines other than Physics)	4
		IDC-101		Inter-disciplinary Course	3
		AECC-101		Modern Indian Language/ Alt English	2
		SEC-101		Solar Energy	3
		VAC -101		EVS- Theory (2) + *Project (2) *NB: *Project should be a kind of Experimental learning.*	4
				Total of Semester 1	**20**
	2nd Sem	**DSC-151**		Waves and Optics	4
		DSM-151		Waves and Optics (for disciplines other thanPhysics)	4
		IDC-151		Inter-disciplinary Course	3
		AECC-151		English Language and Communication Skills	2
		SEC-151		Basic Instrumentation Skills	3
		VAC-151	**VAC-151.1**	Understanding India(2)	4
			VAC-151.2	Constitutional Values and Fundamental Duties(2)	
				Total of Semester 2	**20**
		Grand Total (Semester 1 and Semester 2)			**40**
Students on exit shall be awarded Undergraduate Certificate (in the field of study/ discipline) after securing the requisite 44 credits including Vocational 4 credits mandatory on the completion of 2nd Semester					
	3rd Sem	**DSC-201**		Mathematical Physics I	4
		DSC-202		Thermal Physics	4
		DSM-201		Thermal Physics (for disciplines other than Physics)	4
		IDC-201		Inter-disciplinary Course	3
		AECC-201		MIL / Alt English	2

2nd Year		**SEC-201**	Renewable Energyand Energy harvesting / Computational Physics Skills	3
			Total of Semester 3	**20**
	4th Sem	**DSC-251**	Electricity and magnetism	4
		DSC-252	Elements of Modern Physics	4
		DSC-253	Physics Lab Practical-I	4
		DSM-251	Electricity and magnetism	4
		AECC-251	English Language	2
		Internship	Summer Internship	2
			Total of Semester 4	**20**
		Grand Total (Semester 1 to Semester 4)		**80**
Students on exit shall be awarded Undergraduate Diploma (in the field of study/ discipline) after securing the requisite 84 credits including Vocational 4 credits mandatory on the completion of 4th Semester.				
3rd Year	**5th Sem**	**DSC-301**	Mathematical Physics II	4
		DSC-302	Electromagnetic Theory	4
		DSC-303	Solid State Physics-I	4
		DSC-304	Analog Electronics	4
		DSM-301	Nuclear Physics & Electronics-I	4
			Total of Semester 5	**20**
	6th Sem	**DSC-351**	Quantum Mechanics-I	4
		DSC-352	Statistical Mechanics-I	4
		DSC-353	Digital Electronics	4
		DSC-354	Physics Lab Practical-II	4
		DSM-351	Atomic & Solid State Physics	4
			Total of Semester 6	**20**
	Grand Total (Semester 1 to Semester 6)			**120**
Students on exit shall be awarded Bachelor of (in the field of study/ discipline) Honours (3 years) after securing the requisite 120 credits on completion of 6th Semester.				
		DSC-401	Solid State Physics II	4
		DSC-402	Quantum Mechanics-II	4

4th Year	**7th Sem**	**DSC-403**	Physics Lab Practical-III	4
		RM-401/ DSC-404	Research Methodology / Atomic & Molecular Physics	4
		DSM-401	Atomic Physics	4
			Total of Semester 7	**20**
	8th Sem	**DSC-451**	Classical Mechanics	4
		DSC-452*	Mathematical Physics III	4
		DSC-453*	Nuclear physics	4
		DSC-454*	Electronics	4
		DSR-452	Dissertation (only for those who are selected for honours with Research) in lieu of DSC-452*,DSC-453*,DSC-454*)	12
		DSM-451	Nuclear Physics & Electronics- II	4
			Total of Semester 8	**20**
	Grand Total (Semester 1 to Semester 8)			**160**

Students on exit shall be awarded Bachelor of (in the field of study/ discipline) Honours / Honours with Research (4 years)after securing the requisite 160 credits on completion of 8th semester.

Detailed Syllabus of 1st Semester Major Courses

Course Title: Mechanics and Properties of matter
Course Code: MAJ PHY-1.1/ DSC-101
Nature of course: Major/Core
Total credits: 4 (Theory-3, Practical-1)
Total marks = 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to impart knowledge of Newtonian mechanics and its applications, explore the properties of matter, and develop a foundational understanding of the special theory of relativity.

Course Outlines

Units	Content	L	M	H
Unit 1: Newtonian Mechanics	1.1: Frames of Reference, Inertial Frames, Galilean Transformations, Galilean Invariance; Dynamics of a System of Particles, Centre of Mass, centre of mass of a half-ring, half-disc and hemisphere. Principle of Conservation of Linear Momentum. Momentum of variable mass: motion of rocket.	6	6	6
	1.2: The Work-Energy Theorem, Conservative and Non-conservative Forces, Conservation of Mechanical Energy, Work done by non-conservative forces, Force as gradient of potential energy, Energy Diagram.	6	6	6
	1.3: Principle of Conservation of Angular Momentum, Rotation about a fixed axis, Moment of Inertia, Calculation of Moment of Inertia for rectangular, cylindrical and spherical bodies, Kinetic Energy of Rotation, Motion involving both translation and rotation.	6	6	6
Unit 2: Properties of Matter	2.1: Relation between Elastic constants, Twisting torque on a Cylinder or Wire.	3	3	3
	2.2: Kinematics of Moving Fluids, Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.	3	3	3
Unit 3: Oscillations	Simple Harmonic Motion (SHM) and Oscillations, Differential Equation of SHM and its solution, Kinetic Energy, Potential Energy, Total energy and their time-average values, Damped oscillation, Forced oscillations, Resonance, Power Dissipation and Quality Factor.	7	7	7
Unit 4: Non-Inertial Systems	Non-inertial Frames and Fictitious Forces, Uniformly Rotating Frame, Laws of Physics in rotating coordinate systems, Centrifugal Force, Coriolis Force and its applications, Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.	6	6	6

Unit 5: Special Theory of Relativity	Michelson-Morley Experiment and its outcome, Postulates of Special Theory of Relativity, Lorentz Transformations, Simultaneity and order of events, Lorentz contraction, Time dilation. Twin paradox. Relativistic Transformation of Velocity, Frequency and Wave-number, Relativistic addition of Velocities, Variation of Mass with Velocity, Mass-energy Equivalence. Relativistic Kinematics, Transformation of Energy and Momentum, Relativistic Doppler effect.	8	8	8
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
(Minimum five experiments are to be performed)
One experiment is to be performed in Examination.

1. To determine the Young's modulus of a given material by Searle's apparatus.
2. To determine the Modulus of rigidity of a given wire by static method.
3. To determine the value of 'g' using Bar Pendulum.
4. To determine the value of 'g' using Kater's Pendulum.
5. To determine the Moment of inertia of a body about an axis by torsional oscillation method.
6. To determine the height of a building using Sextant device.
7. To measure the dimension of various objects using vernier caliper, screw gauge and spherometer.
8. To determine spring constant of a given spring by static method.

Course Outcomes: At the completion of this course, a student will be able to
CO1: Understand the basic concepts of mechanics by parallel studies of linear dynamics and dynamics.
CO2: Understand the basic conservation laws by studying them in various mechanicalsystems including collisions, oscillations, gravitational systems etc.
CO3: Analyze simple harmonic oscillators in detail.
CO4: Understand the concept of frame of reference, importance of relative transformations and invariance of laws of Physics.
CO5: Realize the consequences of a non-inertial frame in our real physical world.
CO6: Know about the peculiar phenomena of special relativity which are not seen in Newtonian relativity.

Suggested Readings:

1. Kleppner, D., & Kolenkow, R. J. (1973). *An Introduction to Mechanics*. McGraw-Hill.
2. Kittel, C., Knight, W., et al. (2007). *Mechanics* (Berkeley Physics, Vol. 1). Tata McGraw-Hill.
3. Resnick, R., Halliday, D., & Walker, J. (2008). *Physics* (8th ed.). Wiley.
4. Feynman, R. P., Leighton, R. B., & Sands, M. (2008). *The Feynman Lectures on Physics, Vol. I*. Pearson Education.
5. Resnick, R. (2005). *Introduction to Special Relativity*. John Wiley and Sons.
6. Mathur, D. S. (2000). *Mechanics*. S. Chand and Company Limited

Detailed Syllabus of 1st semester Minor Course

Course Title: Mechanics
Course Code: MIN PHY-1.1 / DSM-101
Nature of course: Minor
Total credits: 4 (Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to impart knowledge of Newtonian mechanics and the properties of matter, along with the fundamental concepts of the special theory of relativity.

Course Outlines

Units	Content	L	M	H
Unit 1: Newtonian Mechanics	1.1: Frames of Reference, Inertial Frames, Galilean Transformations, Galilean Invariance; Dynamics of a System of Particles, Centre of Mass, Principle of Conservation of Linear Momentum. Momentum of variable mass: motion of rocket	7	7	7
	1.2: The Work-Energy Theorem, Conservative and Non-conservative Forces, Conservation of Mechanical Energy, Work done by non-conservative forces, Force as gradient of potential energy, Energy Diagram.	6	6	6
	1.3: Principle of Conservation of Angular Momentum, Rotation about a fixed axis, Moment of Inertia, Calculation of Moment of Inertia for rectangular, cylindrical and spherical bodies, Kinetic Energy of Rotation, Motion involving both translation and rotation.	9	9	9
Unit 2: Properties of Matter	2.1: Relation between Elastic constants, Twisting torque on a Cylinder or Wire.	4	4	4
	2.2: Kinematics of Moving Fluids, Poiseuille's Equationfor Flow of a Liquid through a Capillary Tube	4	4	4
Unit 3: Oscillations	Simple Harmonic Motion (SHM) and Oscillations, Differential Equation of SHM and its solution, Kinetic Energy, Potential Energy, Total energy and their time-average values, Damped oscillation, Forced oscillations, Resonance, Power Dissipation and Quality Factor.	8	8	8

Unit 4: Special Theory of Relativity	Michelson-Morley Experiment and its outcome, Postulates of Special Theory of Relativity, Lorentz Transformations, Simultaneity and order of events, Lorentz contraction, Time dilation. Relativistic addition of Velocities, Variation of Mass with Velocity, Mass-energy Equivalence.	7	7	7
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
(Minimum five experiments are to be performed)
One experiment is to be performed in Examination.

1. To determine the Young's modulus of a given material by Searle's apparatus.
2. To determine the Modulus of rigidity of a given wire by static method.
3. To determine the value of 'g' using Bar Pendulum.
4. To determine the value of 'g' using Kater's Pendulum.
5. To determine the Moment of inertia of a body about an axis by torsional oscillation method.
6. To determine the height of a building using Sextant device.
7. To measure the dimension of various objects using vernier caliper, screw gauge and spherometer.
8. To determine spring constant of a given spring by static method.

Course Outcomes: At the completion of this course, a student will be able to
CO1: Understand the basic concepts and ideas in mechanics- e.g. motion, force and torque, mass and moment of inertia, linear and angular momentum, kinetic energyand potential energy etc. by parallel studies of linear dynamics and rotational dynamics.
CO2: Understand the basic conservation laws by studying them in various mechanical systems including collisions, oscillations, gravitational systems etc.
CO3: Analyze simple harmonic oscillator in detail.
CO4: Understand the concept of frame of reference, importance of relative transformations and invariance of laws of Physics.
CO5: Realize the consequences of a non-inertial frame in our real physical world.

Suggested Readings:
1. Kleppner, D., & Kolenkow, R. J. (1973). *An Introduction to Mechanics*. McGraw-Hill.
2. Kittel, C., Knight, W., et al. (2007). *Mechanics* (Berkeley Physics, Vol. 1). Tata McGraw-Hill.
3. Resnick, R., Halliday, D., & Walker, J. (2008). *Physics* (8th ed.). Wiley.
4. Fowles, G. R., & Cassiday, G. L. (2005). *Analytical Mechanics*. Cengage Learning.
5. Feynman, R. P., Leighton, R. B., & Sands, M. (2008). *The Feynman Lectures on Physics, Vol. I*. Pearson Education.
6. Mathur, D. S. (2000). *Mechanics*. S. Chand and Company Limited.
7. Resnick, R. (2005). *Introduction to Special Relativity*. John Wiley and Sons.
8. Reese, R. L. (2003). *University Physics*. Thomson Brooks/Cole.

Detailed Syllabus of 1st Sem Skill Enhancement Course (SEC)

Course Title: Solar Energy
Course code: SEC PHY-1.1 / SEC-101
Nature of course: Skill Enhancement Course
Total credits: 3 (Theory-2, Practical-1)
Total Marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course Objective: To impart fundamental knowledge and practical skills on solar energy technologies, including solar thermal and photovoltaic systems, their components, applications, and performance evaluation

Course Outlines

Units	Content	L	M	H
Unit 1: Introduction to Solar Energy	Solar energy and its importance, Solar constant, sun as a ultimate source of energy. Comparison of Solar energy to other sources of energy.	4	8	4
Unit 2: Solar Radiation	Solar radiation at the Earth's surface, Measurement of Solar radiation- Pyroheliometer, Pyranometer, Sunshine recorder, Sun tracking system	7	10	7
Unit 3: Solar Thermal Systems	Principle of conversion of solar radiation into heat, Various types of storage of solar energy, solar pond: convective and non-convective type, Collectors used for solar thermal conversion: Flat plate collectors and Concentrating collectors, Solar Thermal Power Plant, Solar cookers, Solar hot water systems, Solar dryers, Solar Distillation, Solar greenhouses.	10	17	10
Unit 4: Solar Photovoltaic Systems	Conversion of Solar energy into Electricity - Photovoltaic Effect, Solar photovoltaic cell and its working principle, Characteristics of PV system, Types of Solar cells, Series and parallel connections, Photovoltaic applications: Battery chargers, Domestic lighting, Street lighting and water pumping.	9	15	9
Total		**30**	**50**	**30**

Activities /Demonstration/Practical /Project: L 30, M 25, H 30
(Any two of the following are to be performed)

1. Plot sun chart and locate the sun at your location for a given time of the day.
2. To draw the characteristics of solar cell and find out the fill factor.
3. Connect solar panels in series & parallel and measure voltage and current.
4. Measure intensity of solar radiation using Pyranometer and radiometers.

5. Construct a solar lantern using Solar PV panel (15W)
6. Assemble solar cooker
7. Designing and constructing photovoltaic system for a domestic house requiring 5kVA.

Course Outcomes: After successful completion of the course, students will be able to
CO1: Explain the basic concepts, importance, and applications of solar energy and different methods of solar energy storage.
CO2: Analyze solar radiation characteristics, measurement techniques, and predict solar energy availability for various locations.
CO3: Demonstrate understanding of solar thermal systems, including collectors, solar cookers, heaters, and solar power generation systems.
CO4: Illustrate the working principles and configurations of solar photovoltaic systems and evaluate their practical applications.
CO5: Develop hands-on skills through activities and projects related to solar energy system design, assembly, and performance analysis.

Suggested Readings:

1. Rai, G. D. (1995). *Solar Energy Utilization*. Khanna Publishers.
2. Tiwari, G. N. (2002). *Solar Energy: Fundamentals, Design, Modeling & Applications*. Narosa Publishing House.
3. Sukhatme, S. P. (2009). *Solar Energy: Principles of Thermal Energy Collection & Storage*. McGraw-Hill Education.
4. Solanki, C. S. (2015). *Solar Photovoltaics: Fundamentals, Technologies and Applications*. PHI Learning Pvt. Ltd.
5. Reddy, P. Jayarama. (2010). *Science and Technology of Photovoltaics* (2nd ed.). BS Publications.
6. Agarwal, M. P. (1983). *Solar Energy*. S. Chand & Co.
7. Sukhatme, S. P. (2009). *Solar Energy: Principles of Thermal Collection and Storage* (3rd ed.). Tata McGraw-Hill.
8. Rai, G. D. (2005). *Non-Conventional Energy Sources* (4th ed.). Khanna Publishers.

Detailed Syllabus of 2nd Semester Major Courses

Course title: Waves and Optics
Course code: MAJ PHY-2.1 / DSC-151
Nature of the course: Major/Core
Total credits: 4 (Theory-3, Practical-1)
Total Marks: **100**
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The course aims to develop theoretical knowledge of waves, oscillations, and the superposition principle, acquaint learners with fascinating light phenomena, and build a strong foundation in the functioning of various optical instruments.

Course Outlines

Units	Content	L	M	H
Unit 1: Superposition of Harmonic Oscillations	1.1: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.	5	5	5
	1.2: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.	3	3	3
Unit 2: WaveMotion	2.1: Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation of a Wave, Pressure of a Longitudinal Wave, Energy Transport. Water waves: Ripple and gravity waves.	5	5	5
	2.2: Velocity of Transverse Vibrations of Stretched Strings, Velocity of Longitudinal Waves in a Fluid in a Pipe, Newton’s Formula for Velocity of Sound, Laplace’s Correction.	4	4	4
Unit 3: Harmonic Waves	Standing (Stationary) Waves in a String: Fixed and Free Ends, Analytical Treatment, Phase and Group Velocities, Changes with respect to Position and Time, Energy of Vibrating String, Transfer of Energy, Normal Modes of Stretched Strings, Plucked and Struck Strings, Melde’s Experiment, Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes, Superposition of N Harmonic Waves.	6	6	6
Unit 4: Wave optics	Electromagnetic nature of light, definition and properties of wave front, Huygens principle, Temporal and Spatial coherence.	2	2	2

Unit 5: Interference	5.1: Division of amplitude and wavefront, Young's double slit experiment, Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: Measurement of wavelength and refractive index.	5	5	5
	5.2: Michelson Interferometer- (i) Idea of form of fringes (theory not required), (ii) Determination of Wavelength, (iii) Wavelength Difference, (iv) Refractive Index and (v) Visibility of Fringes. Fabry-Perot interferometer.	4	4	4
Unit 6: Diffraction	6.1:Kirchhoff's Integral Theorem, Fresnel Kirchhoff's Integral formula (Qualitative discussion only)	2	2	2
	6.2: Fraunhofer Diffraction: Single slit, Circular aperture. Resolving Power of a telescope, Double slit, Multiple slits. Diffraction grating, Resolving power of grating.	4	4	4
	6.3: Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.	5	5	5
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
(Minimum five experiments are to be performed)
One experiment is to be performed in Examination.

1. To determine the Frequency of an electrically maintained tuning fork by Melde's experiment and to verify $Z^2 – T$ law.
2. To study of Lissajous Figure of two different waves using CRO and find out the unknown frequency of an electric signal.
3. To familiarize with Schuster's focusing, and determine angle of prism.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine the Refractive index of the material of a prism using sodium light.
6. To determine the wavelength of sodium light using Newton's ring.
7. To determine wavelength of light using Fresnel Biprism.

Course Outcomes: After successful completion of the course, students will be able to
CO1: Understand and analyze the principle of superposition in harmonic oscillations and visualize their results using Lissajous figures.
CO2: Describe and derive the properties of various types of waves, including longitudinal, transverse, and water waves, and understand the mathematical form of the wave equation.
CO3: Explain the formation and characteristics of stationary waves in strings and pipes, and

evaluate energy transfer and normal modes in vibrating systems.
CO4: Understand the electromagnetic nature of light, wavefronts, coherence, and apply Huygens' principle to explain wave propagation.
CO5: Analyze interference patterns resulting from division of wavefront and amplitude, and apply principles to measure physical parameters using devices like the Michelson and Fabry-Perot interferometers.
CO6: Examine diffraction phenomena using Fresnel and Fraunhofer theories, and determine resolving power of optical instruments including telescopes and diffraction gratings.
CO7: Understand the basic principles and applications of holography, including recording and reconstruction techniques and the theory behind point-source holograms.

Suggested Readings:

1. Crawford, F. S. (1968). *Waves: Berkeley Physics Course, Vol. 3*. McGraw-Hill.
2. Jenkins, F. A., & White, H. E. (1976). *Fundamentals of Optics* (4th ed.). McGraw-Hill.
3. Born, M., & Wolf, E. (1999). *Principles of Optics* (7th ed.). Cambridge University Press.
4. Ghatak, A. (2005). *Optics*. Tata McGraw-Hill.
5. Gupta, A. B., & Islam, N. (2006). *Modern Optics*. Books & Allied.
6. Pain, H. J. (1999). *The Physics of Vibrations and Waves* (5th ed.). John Wiley & Sons.
7. Bajaj, N. K. (1988). *The Physics of Waves and Oscillations*. Tata McGraw-Hill.
8. Kumar, A., Gulati, H. R., & Khanna, D. R. (2011). *Fundamentals of Optics*. R. Chand & Co.

Detailed Syllabus of 2nd Sem Minor Course

Course title: Waves and Optics
Course code: MIN PHY-2.1/ DSM-151
Nature of the course: Minor
Total credits: 4 (Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: This course will enable students to analyze phenomena arising from the interaction of light with light and matter, train them in the use of various optical instruments, and help them understand natural phenomena through laboratory experiments.

Course Outlines

Units	Content	L	M	H
Unit 1: Superposition of Harmonic Oscillations	1.1: Linearity and Superposition Principle, Superposition of two collinear oscillations having (i)equal frequencies and (ii) different frequencies (Beats), Superposition of N collinear Harmonic Oscillations with (i) equal phase differences and (2) equal frequency differences.	7	7	7
	1.2: Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures with equal and unequal frequencyand their use.	5	5	5
Unit 2: Wave Motion	2.1: Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Travelling) Waves, Wave Equation, Particle and Wave Velocities, Differential Equation of a Wave, Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave.	7	7	7
	2.2: Velocity of Transverse Vibrations of Stretched strings. Velocity of longitudinal waves in a fluid in pipe. Newton's formula for velocity of sound, Laplace's correction.	5	5	5
Unit 3: Superposition of Harmonic Waves	Standing (Stationary) Waves in a String: Fixed and Free Ends, Analytical Treatment, Phase and Group Velocities, Changes with respect to Position and Time, Energy of Vibrating String, Transfer of Energy, Normal Modes of Stretched Strings, Plucked and Struck Strings, Melde's Experiment, Longitudinal Standing Waves and Normal Modes, Open and Closed Pipes, Superposition of N Harmonic Waves.	9	9	9
Unit 4: Wave optics	Electromagnetic nature of light, definition and properties of wave front, Huygens principle, Temporal and Spatial coherence	3	3	3

Unit 5: Interference	Division of amplitude and wavefront, Young's double slit experiment, Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: Measurement of wavelength and refractive index	9	9	9
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
(Minimum five experiments are to be performed)
One experiment is to be performed in Examination

1. To determine the Frequency of an electrically maintained tuning fork by Melde's experiment and to verify Z^2 – T law.
2. To determine the focal length of a convex mirror with the help of convex lens.
3. To determine the refractive index of a liquid by using plane mirror and convex lens.
4. To determine the focal length of two lenses and their combination by displacement method.
5. To determine the Refractive index of the material of a prism using sodium light.
6. To determine the wavelength of sodium light using Newton's ring.
7. To familiarize with Schuster's focusing; determination of angle of prism.

Course outcomes: At the completion of this course, a student will be able to
CO1: Understand and apply the principles of superposition in harmonic oscillations, including the formation and analysis of Lissajous figures.
CO2: Explain the nature and properties of different types of waves and derive key equations governing wave motion, velocity, and energy transport.
CO3: Analyze the behavior of standing waves and harmonic wave superposition in strings and pipes, and interpret experimental results from setups like Melde's experiment.
CO4: Describe the wave nature of light, apply Huygens' principle, and distinguish between temporal and spatial coherence.
CO5: Interpret and evaluate interference phenomena through various experimental setups, including thin film interference, Newton's Rings, and interferometers like Michelson and Fabry-Perot.

Suggested Readings:

1. Crawford, F. S. (2007). *Waves: Berkeley Physics Course, Vol. 3*. Tata McGraw-Hill.
2. Jenkins, F. A., & White, H. E. (1981). *Fundamentals of Optics*. McGraw-Hill.
3. Born, M., & Wolf, E. (1999). *Principles of Optics* (7th ed.). Pergamon Press.
4. Ghatak, A. (2008). *Optics*. Tata McGraw-Hill.
5. Pain, H. J. (2013). *The Physics of Vibrations and Waves*. John Wiley and Sons.

Detailed Syllabus of 2nd Semester Skill Enhancement Course (SEC)

Course Title: Basic Instrumentation Skills
Course Code: SEC PHY-2.1 / SEC-151
Nature of course: Skill Enhancement Course
Total credits: 3 (Theory-2, Practical-1)
Total Marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course Objective: This course aims to provide exposure to various aspects of instruments, offer hands-on experience in handling them, and teach effective debugging techniques.

Course Outlines

Units	Content	L	M	H
Unit 1: Basic of Measurement	Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Comparison of analog & digital instruments.	6	10	6
Unit 2: Electronic Voltmeter	Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. AC millivoltmeter: amplifier-rectifier type and rectifier-amplifier. Block diagram ac millivoltmeter, specifications and their significance.	8	11	8
Unit 3: Cathode Ray Oscilloscope	Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, Front panel controls. Specifications of a CRO and their significance.	7	10	7
Unit 4: Signal Generators and Analysis Instruments	Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter.	3	6	3
Unit 5: LCR Bridge & Q-Meters	Block diagram of bridge. working principles of basic (balancing type) LCR bridge. Specifications of LCR bridge. Block diagram & working principles of a Q- Meter.	3	6	3
Unit 6: Digital Multimeter	Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequencycounter, time- base stability, accuracy and resolution.	3	7	3
Total		**30**	**50**	**30**

Physics Lab Practical: L 30, M 25, H 30
The test of lab skills will be of the following test items:

1. Use of an CRO.
2. Circuit tracing of Laboratory electronic equipment.
3. Use of Digital multimeter / VTVM.
4. Circuit tracing of Laboratory electronic equipment,
5. Winding a coil / transformer.
6. Study the layout of a receiver circuit.
7. Troubleshooting a circuit
8. Balancing of bridges

Laboratory Exercises:
1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. To measure the voltage, frequency, time period and phase angle using CRO.
5. To measure the time period, frequency, average period using universal counter/ frequency counter.
6. To measure the rise, fall and delay times using a CRO.
7. To measure the distortion of a RF signal generator using distortion factor meter.
8. To measure R, L and C using a LCR bridge / universal bridge.

Course outcomes: After completing this course the students will be able to
CO1: Understand fundamental measurement concepts including accuracy, precision, sensitivity, and errors.
CO2: Explain the working principles and specifications of multimeters and electronic voltmeters.
CO3: Describe the construction and operation of Cathode Ray Oscilloscopes (CRO) and interpret their specifications.
CO4: Analyze the functioning and applications of signal generators and wave analysis instruments.
CO5: Understand the principles of impedance bridges, Q-meters, and digital LCR bridges.
CO6: Compare analog and digital instruments, and explain the working of digital meters and digital voltmeters.
CO7: Demonstrate knowledge of digital multimeter and frequency/time measurement using universal counters.

Suggested Readings:
1. Theraja, B. L. (Year). *A Textbook in Electrical Technology*. S. Chand and Co.
2. Venugopal, K. (2011). *Digital Circuits and Systems*. Tata McGraw Hill.
3. Vingron, S. P. (2012). *Logic Circuit Design*. Springer.
4. Ghoshal, S. (2012). *Digital Electronics*. Cengage Learning.
5. Salivahanan, S., & Kumar, N. S. (2012). *Electronic Devices and Circuits* (3rd ed.). Tata McGraw Hill.
6. Tietze, U., & Schenk, C. (2008). *Electronic Circuits: Handbook of Design and Applications*. Springer.

Detailed Syllabus of 3rd Semester Major Courses

Course Title: Mathematical Physics I
Course Code: MAJ PHY- 3.1 / DSC-201
Nature of course: Major/Core
Total Credits: 4 (Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: This course will develop the requisite mathematical skills of a student to understand the fundamental topics in vector algebra, applications of vectors in different fields, differential equation & its applications, different coordinate systems and idea of probability etc.

Course Outlines

Units	Content	L	M	H
Unit 1: Vector algebra	Recapitulation of vector algebra. Scalar products, Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Cartesean components of a vector, Scalar and vector fields. Directional derivatives and normal derivatives. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. Ordinary integrals of vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line integral, surface integral and volume integral of vector fields. Flux of a vector field. Gauss' divergence theorem, Green's theorem, Stokes theorem and their applications (proofs not necessary).	15	15	15
Unit 2: Differential Equations	First Order Differential Equations, Integrating Factor. Second order Differential equations. Homogeneous and Inhomogeneous Equations with constant coefficients. Wronskian and general solution. Calculus of functions of more than one variable: Partial derivatives, Exact differentials, Inexact differentials. Constrained maximization using Lagrange Multipliers.	10	10	10
Unit 3: Orthogonal Curvilinear Coordinates	Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.	8	8	8
Unit 4: Dirac Delta function	Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function	6	6	6
Unit 5: Introduction to Probability	Independent random variables: Probability distribution functions; binomial, Gaussian and Poisson, with examples. Mean and variance.	6	6	6
Total		**45**	**45**	**45**

Physics Computer Lab Practical: L 30, M 25, H 30

The aim of this Lab is to teach computer programming, numerical analysis and to emphasize its role in solving problems in Physics.

1. Highlights the use of computational methods to solve physical problems
2. The course will consist of lectures (both theory and practical) in the Lab
3. Evaluation done not on the programming but on the basis of formulating the problem
4. Aim at teaching students to construct the computational problem to be solved
5. Students can use any one operating system Linux or Microsoft Windows.

Introduction and Overview Computer architecture and organization, memory and Input/output devices.
Basics of scientific computing Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.

Review of C & C++/Python/ Matlab/ Mathematica Programming fundamentals Introduction to Programming, constants, variables and data types, operators and Expressions I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (if statement. if-else Statement. Nested if Structure. else-if Statement. Ternary Operator. goto Statement. switch Statement. Unconditional and Conditional Looping. while Loop. do-while Loop. for Loop. break and continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects.

Programs Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation Area of circle, area of square, volume of sphere, value of pi (π)

Introduction to Numerical computation softwares Introduction to Scilab/Mathematica/Matlab/Python, Advantages and disadvantages, Scilab / Mathematica / Matlab/ Python environment, Command window, Figure window, Edit window, Variables and arrays, initializing variables in Scilab / Mathematica / Matlab/ Python, Multidimensional arrays, Subarray, Special values, displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab / Mathematica / Matlab/Python functions,
Introduction to plotting, 2D and 3D plotting. **Curve fitting, least square fit, Goodness of fit, standard deviation** Ohms law to calculate R, Hooke's law to calculate spring constant.

Course outcomes: This course will enable the students to
CO1: Apply vector algebra and vector calculus concepts to physical problems, including computation of gradients, divergence, curl, and use of vector integral theorems.
CO2: Solve first and second order differential equations, including homogeneous and inhomogeneous cases, and apply techniques like integrating factors and Wronskian.
CO3: Understand and use orthogonal curvilinear coordinate systems to derive differential operators in Cartesian, spherical, and cylindrical coordinates.
CO4: Comprehend the definition, properties, and applications of the Dirac delta function in physics and engineering contexts.

CO5: Analyze basic probability distributions (binomial, Gaussian, Poisson), their properties, and apply statistical measures like mean and variance.
CO6: Develop computational problem-solving skills using programming languages (C/C++, Python, Matlab, Mathematica, Scilab) for numerical analysis relevant to physics.
CO7: Implement basic programming constructs (loops, conditional statements, arrays, functions, structures) to solve scientific computing problems.
CO8: Utilize numerical computation software for mathematical modeling, data visualization, curve fitting, and simulation of physical laws (e.g., Ohm's and Hooke's laws).

Recommended readings:

1. Arfken, G. B., Weber, H. F., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier.
2. Riley, K. F., Hobson, M. P., & Bence, S. J. (Year). *Mathematical Methods for Physics and Engineering*. Cambridge University Press.
3. Coddington, E. A. (2009). *An Introduction to Ordinary Differential Equations*. PHI Learning.
4. Simmons, G. F. (2007). *Differential Equations*. McGraw Hill.
5. Rajput, D. S. (Year). *Mathematical Physics*.
6. Kreyszig, E. (2008). *Advanced Engineering Mathematics*. Wiley India.
7. Riley, K. F., & Hobson, M. P. (2011). *Essential Mathematical Methods*. Cambridge University Press.

Course Title: Thermal Physics
Course Code: MAJ PHY- 3.2 / DSC-202
Nature of course: Major/Core
Total Credits: 4 (Theory-3, Practical-1)
Total marks: **100**
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: To provide students with a comprehensive understanding of the fundamental laws of thermodynamics and kinetic theory of gases, enabling them to analyze thermal systems, gas behaviors, and energy transformations both qualitatively and quantitatively.

Course Outlines

Units	Content	L	M	H
Unit 1: Fundamentals of Thermodynamics	Review of basic concepts: Systems, variables, equilibrium. Zeroth Law of Thermodynamics and concept of temperature. First Law of Thermodynamics: Heat, work, and internal energy, Applications: Relation between Cp and Cv. Work done in isothermal and adiabatic processes. Compressibility and expansion coefficient. Second Law of Thermodynamics: Kelvin-Planck and Clausius statements. Carnot cycle, Carnot engine and efficiency. Thermodynamic temperature scale and equivalence with perfect gas scale	9	9	9
Unit 2: Entropy and the Second & Third Laws	Concept of entropy and Clausius theorem, Clausius inequality and the Second Law in terms of entropy, Entropy of a perfect gas, Entropy changes in reversible and irreversible processes. (with examples), Entropy of the universe; Principle of increase of entropy, Temperature–Entropy (T-S) diagrams for Carnot cycle, Third Law of Thermodynamics and unattainability of absolute zero	9	9	9
Unit 3: Thermodynamic Potentials and Phase Transitions	Thermodynamic potentials: Internal energy, Enthalpy, Helmholtz and Gibbs free energies, Properties and applications of potentials, Maxwell's thermodynamic relations: derivations and applications, TdS equations, Clausius-Clapeyron equation, Joule-Kelvin coefficient (ideal and Van der Waals gases), Cp - Cv relation, energy equations, adiabatic temperature changes, Phase transitions: First and second order (with examples), Clausius-Clapeyron and Ehrenfest equations, Magnetic work and adiabatic demagnetization, Surface tension variation with temperature	9	9	9

Unit 4: Kinetic Theory of Gases I	Maxwell-Boltzmann distribution of velocities and experimental verification, Mean, RMS, and most probable speeds, Doppler broadening and Stern's experiment, Degrees of freedom; Law of equipartition of energy (qualitative), Specific heats of gases, Molecular collisions: Mean free path and collision probability, Transport phenomena: Viscosity, Thermal conductivity, Diffusion. Brownian motion and its significance.	9	9	9
Unit 5: Real Gases and Joule-Thomson Effect	Deviations from ideal gas behavior, Van der Waals equation of state and critical constants, Andrews' experiments on CO_2 and continuity of gas-liquid phase, Law of corresponding states, Boyle temperature, P-V diagrams, Virial equation of state, Joule's experiment and free adiabatic expansion, Joule-Thomson porous plug experiment, Joule-Thomson effect in real and Van der Waals gases, Inversion temperature and cooling.	9	9	9
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
(A minimum of five experiments to be performed in classes)
One experiment is to be performed in Examination.

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its two Junctions.
7. To record and analyze the cooling temperature of a hot body as a function of time using thermocouple.
8. To determine Stefan's Constant by electric bulb method.

Course Outcomes:
CO1: Understand and apply the Zeroth, First, and Second Laws of Thermodynamics to analyze heat, work, and internal energy changes in various thermodynamic processes, including Carnot cycles and temperature scales.
CO2: Explain the concept of entropy and its implications in reversible and irreversible processes, and evaluate the significance of the Second and Third Laws of Thermodynamics in real-world thermodynamic systems.
CO3: Analyze thermodynamic potentials and derive Maxwell's relations to evaluate phase transitions, energy equations, and the thermodynamic behavior of systems under different constraints.

CO4: Describe the kinetic theory of gases by applying the Maxwell-Boltzmann distribution and relate microscopic molecular behavior to macroscopic transport properties such as viscosity, diffusion, and thermal conductivity.
CO5: Evaluate the behavior of real gases using the Van der Waals equation, interpret phase transitions and Joule-Thomson effects, and differentiate between ideal and non-ideal gas.

Suggested Readings:

1. Zemansky, M. W., & Dittman, R. (1981). *Heat and Thermodynamics*. McGraw-Hill.
2. Saha, M., & Srivastava, B. N. (1958). *A Treatise on Heat*. Indian Press.
3. Garg, S., Bansal, R., & Ghosh, (1993). *Thermal Physics* (2nd ed.). Tata McGraw-Hill.
4. Helrich, C. S. (2009). *Modern Thermodynamics with Statistical Mechanics*. Springer.
5. Prakash, I., & Ramkrishna. (2011). *A Textbook of Practical Physics*. Kitab Mahal.

Detailed Syllabus of 3rd Semester Minor Courses

Course Title: Thermal Physics
Nature of Course: Minor
Course Code: MIN PHY-3.1 / DSM-201
Total credits: 4 (Theory-3, practical-1)
Total marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objective: The aim of the course is to To equip students with a critical understanding of thermodynamic principles, enabling them to analyze statistical interpretations of thermodynamic laws and comprehend key thermodynamic properties and potentials.

Course Outlines

Units	Content	L	M	H
Unit 1: Basic Laws and First Law of Thermodynamics	Thermodynamic Equilibrium, Zeroth Law of Thermodynamics and Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy and First Law for various processes, Applications of First Law: Relation between CPC_PCP and CVC_VCV Work done in isothermal and adiabatic processes	9	9	9
Unit 2: Second Law of Thermodynamics and Entropy	Reversible and Irreversible processes, Heat Engines, Carnot's Cycle and Efficiency, Refrigerators and Coefficient of Performance, Second Law: Kelvin-Planck and Clausius Statements, their equivalence, Carnot's Theorem, Thermodynamic Scale of Temperature, Concept of Entropy, Clausius Theorem and Inequality, Entropy in reversible and irreversible processes, Entropy of a perfect gas and entropy of the universe.	9	9	9
Unit 3: Thermodynaic Potentials and Phase Transitions	Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Definitions, Properties and Significance, Magnetic Work and Adiabatic Demagnetization. First and Second Order Phase Transitions (with examples), Temperature– Entropy diagram for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.	9	9	9
Unit 4: Maxwell's Relations and Applicatios	Derivation of Maxwell's Relations, Applications: Clausius-Clapeyron Equation, Calculation of C_P-C_V, TdS Equations, Joule-Kelvin Coefficient for Ideal and Van der Waals gases, Energy Equations	9	9	9

Unit 5: Kinetic Theory of Gases and Real Gases	Maxwell-Boltzmann Distribution and Experimental Verification, Doppler Broadening, Stern's Experiment, Mean, RMS and Most Probable Speeds, Degrees of Freedom and Law of Equipartition (qualitative), Behaviour of Real Gases, Virial Equation, Andrew's Experiment on CO_2, Van der Waals Equation, Critical Constants, P-V Diagrams, Continuity of States, Joule's and Joule-Thomson Experiments, Joule-Thomson Effect for Real and Van der Waals Gases.	9	9	9
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
(Minimum five experiments are to be performed in classes)
One experiment is to be performed in the Examination

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal conductivity of a bad conductor by Lee and Charlton's disc method.
5. To study the variation of Thermo-emf of a Thermocouple with Difference of Temperature of its two Junctions.
6. To record and analyze the cooling temperature of a hot body as a function of time using thermocouple.
7. To determine Stefan's Constant by electric bulb method.

Course outcomes: After completing this course the students will be able to
CO1: Understand and apply the zeroth and first laws of thermodynamics to different thermodynamic systems and processes.
CO2: Evaluate the implications of the second and third laws of thermodynamics, including entropy changes in reversible and irreversible processes.
CO3: Analyze thermodynamic potentials and their applications in physical and magnetic systems, including phase transitions.
CO4: Derive and utilize Maxwell's relations and related equations to study energy changes and properties of thermodynamic systems.
CO5: Interpret kinetic theory and real gas behavior, including molecular velocity distributions and deviations from ideal gas laws.

Suggested Readings:

1. Worsnop, B. L., & Flint, H. T. (1923). *Advanced Practical Physics for Students*. Asia Publishing House.
2. Nelson, M., & Ogborn, J. M. (1985). *Advanced Level Physics Practicals* (4th ed.). Heinemann Educational Publishers.
3. Prakash, I., & Ramakrishna. (2011). *A Textbook of Practical Physics* (11th ed.). Kitab Mahal.
4. Panigrahi, S., & Mallick, B. (2015). *Engineering Practical Physics*. Cengage Learning India Pvt. Ltd.

Detailed Syllabus of 3rd Semester Skill Enhancement Course (SEC) :

Option 1
Course Title: Renewable Energy and Energy Harvesting
Course Code: SEC PHY- 3.1 / SEC-201
Nature of Course: Skill Enhancement
Credits: 3 (Theory-2, Practical-1) Total marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course objectives: The aim of this course is not just to impart theoretical knowledge to the students about the various energy sources in nature, but to provide them with exposure and hands-on learning wherever possible.

Course Outlines

Units	Content	L	M	H
Unit 1: Energy Sources – Fundamentals and Applications	**Non-renewable and renewable energy sources:** Limitations and the need for renewable alternatives. Overview: Wind energy, ocean energy, hydro-energy, Solar energy. Biomass, Biochemical Conversion, Biogas Generation **Solar Energy Systems**: Solar ponds (convective and non-convective), Solar cookers, solar distillation, greenhouses, Solar cells, PV systems and characteristics	10	18	10
Unit 2: Solar, Wind, Ocean, and Hydro Energy Systems	**Wind Energy**: Fundamentals, Wind turbines, Electrical machines used in wind turbines, Power electronic interfaces and grid integration **Ocean Energy**: Ocean energy potential compared to wind and solar, Wave characteristics and wave energy devices, Tidal characteristics, tidal energy technologies, Ocean Thermal Energy Conversion (OTEC), Osmotic Power, Ocean Biomass **Hydropower**: Resources and technologies, Environmental impact of hydro energy.	10	15	10
Unit 3: Emerging Energy Harvesting Technologies and Sustainability	**Geothermal Energy**: Geothermal resources and technologies **Piezoelectric Energy Harvesting**: Physics of piezoelectric effect, materials, modeling, generators, Applications: wearable, human-powered systems **Electromagnetic Energy Harvesting**: Linear generators, mathematical models Carbon Capture Technologies **Energy Storage & Devices**: Cells, batteries, power consumption trends **Environmental Issues and Energy Sustainability**: Role of renewable energy in addressing environmental concerns, Sustainable development goals and energy.	10	17	10
Total		**30**	**50**	**30**

Physics Lab Practical: L 30, M 25, H 30
Demonstration and Experiment/Project

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials.
3. Conversion of thermal energy into voltage using thermoelectric modules.
4. Project Preparation

Course outcomes: After completion of this course the students will be able to
CO1: Understand the limitations of conventional energy sources and explain the working principles, technologies, and applications of major renewable energy systems including solar, wind, hydro, ocean, and geothermal energy.
CO2: Analyze the design, operation, and integration of energy harvesting technologies such as photovoltaic systems, piezoelectric and electromagnetic harvesters, and evaluate their potential in modern energy systems.
CO3: Assess the environmental impact of different energy sources and demonstrate an understanding of sustainable energy practices and emerging technologies for clean energy transition.

Suggested Readings:

1. Worsnop, B. L., & Flint, H. T. (1923). *Advanced Practical Physics for Students*. Asia Publishing House.
2. Nelson, M., & Ogborn, J. M. (1985). *Advanced Level Physics Practicals* (4th ed., reprinted). Heinemann Educational Publishers.
3. Prakash, I., & Ramkrishna. (2011). *A Textbook of Practical Physics* (11th ed.). Kitab Mahal.
4. Panigrahi, S., & Mallik, B. (2015). *Engineering Practical Physics*. Cengage Learning India Pvt. Ltd.
5. Squires, G. L. (2015). *Practical Physics* (4th ed.). Cambridge University Press.

Option 2
Course Title: Computational Physics Skills
Course Code: SEC PHY-3.1 / SEC-201
Nature of Course: Skill Enhancement
Credits: 3 (Theory-2, Practical-1)
Total Marks: 75
Distribution of Marks: End Sem: Th=50, Pr=25

Course objectives: The objective of this course is to equip students with the skills to use computer programming and numerical analysis as practical tools for solving physics problems through computational methods and hands-on problem-solving training.

Course Outlines

Units	Content	L	M	H
Unit 1: Fundamentals of Computational Physics and Programming Basics	**Importance of Computers in Physics**: Role in problem-solving and simulation. **Problem-Solving Paradigm**: Steps from problem definition to solution. **Introduction to Linux as a Working Environment**: Editors and basic usage. **Algorithms and Flowcharts**: Definitions, properties, and development of algorithms Flowcharts: concepts, symbols, guidelines, types **Examples**: Cartesian to Spherical Coordinates, Roots of a Quadratic Equation, Matrix operations, Sin(x) as a series, Lissajous figures and projectile motion **Introduction to FORTRAN**: History and significance in scientific computing, Basic syntax: character set, constants, variables, keywords, Arithmetic, relational, logical, and assignment operators, Simple I/O statements and examples from physics.	10	18	10
Unit 2: Programmig Structures and Applications in Physics	**Control Structures and Logic**: Sequential, selection, and repetition logic, Branching statements: IF types, SELECT CASE, Looping statements: DO, WHILE, Nested loops, Jumping statements: GOTO (all types) **Arrays and Subscripted Variables**: Types, DIMENSION statements, input/output operations **Functions and Subroutines**: Statement functions, subprograms, subroutines, Statements: RETURN, CALL, COMMON, EQUIVALENCE **File Operations**: OPEN, READ, WRITE for disk I/O **Applications**: Solving real physics problems using structured programming	10	17	10
Unit 3: Scientific Documentati-on and Visualization Tools	**Scientific Word Processing with LaTeX**: Basics: document class, structure, environments, compilation, Equations and formulae, figures, tables, symbols, Advanced features: bibliography, citations, indexing, glossaries **Visualization with Gnuplot**: Role of data visualization in physics, Basic commands: plotting data, exporting graphs, Curve fitting: straight line, polynomial, user-defined functions, Application: using Gnuplot for plotting physical data and simulations	6	15	6
Total		**30**	**50**	**30**

Physics Computer Lab Practical: L 30, M 25, H 30

Programming:

1. Exercises on syntax on usage of FORTRAN, usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write source codes in FORTRAN.
2. To print out all natural even/ odd numbers between given limits.
3. To find maximum, minimum and range of a given set of numbers.
4. Calculating Euler number using exp(x) series evaluated at x=1

Hands on Exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices.
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation. 10. Motion of a projectile using simulation and plot the output for visualization.
10. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
11. Motion of particle in a central force field and plot the output for visualization.

Course Outcomes: The completion of the course will enable the students to
CO1: Understand and apply algorithmic approaches, flowcharts, and programming constructs to solve fundamental problems in physics using FORTRAN.
CO2: Develop structured scientific programs incorporating control statements, functions, subroutines, arrays, and file handling to model and simulate physical systems.
CO3: Use LaTeX for scientific documentation and Gnuplot for visualization of computational results, enhancing the ability to present scientific data effectively.

Suggested Readings:

1. Sastry, S. S. (2012). *Introduction to Numerical Analysis* (5th ed.). PHI Learning Pvt. Ltd.
2. Rajaraman, V. (n.d.). *Computer Programming in Fortran 77*. PHI.
3. Lamport, L. (1994). *LaTeX–A Document Preparation System* (2nd ed.). Addison-Wesley.
4. Janert, P. K. (2010). *Gnuplot in Action: Understanding Data with Graphs*. Manning.
5. Lipschutz, S., & Poe, A. (1986). *Schaum's Outline of Theory and Problems of Programming with Fortran*. McGraw-Hill Book Co.
6. Verma, R. C., et al. (1999). *Computational Physics: An Introduction*. New Age International Publishers.
7. Ascher, U. M., & Greif, C. (2012). *A First Course in Numerical Methods*. PHI Learning.
8. Atkinson, K. E. (2007). *Elementary Numerical Analysis* (3rd ed.). Wiley India Edition.

Detailed Syllabus of 4th Semester Major Courses

Course Title: Electricity and Magnetism
Course Code: MAJ-PHY-4.1 / DSC-251
Nature of Course: Major/Core
Credits: 4
Total marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objectives: The objective of this course is to enable students to understand the behavior of electric and magnetic fields in matter, including dielectric and magnetic properties, electromagnetic induction, Kirchhoff's laws, and network theorems in electrical circuits.

Course Outlines

Units	Content	L	M	H
Unit 1: Electric field and Potential	Electric field: Electric field lines, Electric flux, Gauss' law and its applications to charge distribution with spherical, cylindrical and planer symmetry. Conservative nature of Electrostatic field. Electrostatic potential. Laplace's equation, Poisson's equation. The Uniqueness theorem. Potential and Electric field of a dipole. Force and torque on dipole. Electrostatic energy of a system of charges. Electrostatic energy of charged sphere. Conductors in an electrostatic field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to (i) Plane infinite sheet and (ii) Sphere	15	15	15
Unit 2: Dielectric properties of matter	Electric field in matter. Polarization, Polarization charges. Electrical Susceptibility and Dielectric constant. Capacitors (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. relation between electric field **E**, polarization vector **P** and displacement vector **D**.	8	8	8
Unit 3: Magnetic field and Ballistic galvanometer	Magnetic force on a point charge. Definition and properties of a magnetic field B. curl and divergence. vector potential. Magnetic force on (i) a current carrying wire (ii) between current elements. Torque on a current loop in a uniform magnetic field. Biot-Savert law and its applications to (i) straight wire and (ii) circular loop. Current loop as magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application to (i) Solenoid and (ii) Torus. Torque on a current loop. Ballistic galvanometer: current and charge sensitivity. Electromagnetic damping. Logarithmic damping. CDR.	12	12	12
Unit 4: Magnetic properties of matter	Magnetization vector (**M**). Magnetic Intensity (**H**). Magnetic Susceptibility and permeability. Magnetic flux density (**B**). Relation among **B**, **H** and **M**. Ferromagnetism. B-H curve and hysteresis.	6	6	6

Unit 5: Electromagnetic induction.	Faraday's law. Lenz's law. Self-inductance and Mutual inductance. Reciprocity theorem. Energy stored in a magnetic field.	4	4	4
Unit 6: Maxwell's Equations and EM Wave	Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.	7	7	7
Unit 7: Electrical circuits and Network Theorems	AC circuits: Kirchhoff's laws for ac circuits. Complex reactance and impedance. Series LCR circuit: Resonance, Power dissipation, Quality factor and Band width. Parallel LCR circuit. Ideal constant voltage and constant current sources. Netwok theorems: Thevenin theorem, Norton theorem, Superposition theorem, reciprocity theorem. Maximum power transfer theorem. Application to dc circuits.	8	8	8
Total		**60**	**60**	**60**

Course Outcomes: At the completion this course the students will able to
CO1: Apply Gauss's law and potential theory to solve electrostatics problems.
CO2: Explain dielectric behavior and analyze capacitors with dielectrics.
CO3: Use Biot–Savart and Ampère's laws to calculate magnetic fields.
CO4: Describe magnetic material properties and interpret B-H curves.
CO5: Understand electromagnetic induction and Maxwell's equations.
CO6: Solve AC/DC circuits using network theorems and resonance concepts.

Suggested Readings:

1. Electricity, Magnetism and electromagnetic Theory, S Mahajan and Choudhury, 2012, Tata Mc Graw hill.
2. Electricity and Magnetism, Edward M Purcell, 1986, Tata Mc Graw hill Education.
3. Introduction to Electrodynamics, D J Griffiths, 3rd Edition, 1998, Benjamin Cummings.
4. Feynman lectures Vol 2. R P Feynman, M Sands, 2008, Pearson Education.
5. Elements of Electromagnetics, M N O Sadiku, 2010, Oxford University Press.
6. Electricity and Magnetism, J H Fewkes & J Yarwood, Vol 1, 1991, Oxford University Press.

Course Title: Elements of Modern Physics
Course Code: MAJ PHY-4.2 / DSC-252
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objectives: The objective of the course is to introduce students to the foundational principles of quantum mechanics and nuclear physics, exploring wave-particle duality, nuclear structure and decay, detection techniques, nuclear energy processes, and the fundamentals of laser physics.

Course Outlines

Units	Content	L	M	H
Unit 1: Quantum Theory	Quantum theory of light; photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. group and phase velocities and relation between them. Two-slit experiment with electrons. Probability. wave amplitude and wave functions.	12	12	12
Unit 2: Uncertainty and Wave-Particle Duality	Position measurement: gamma ray microscope thought experiment; wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from wave packets, impossibility of a particle following a trajectory; estimating minimum energy of a confined particle using uncertainty principle; energy-time uncertainty principle- application to virtual particles and range of an interaction.	7	7	7
Unit 3: Structure of the Atomic Nucleus	Size and structure of atomic nucleus and its relation with atomic weight; impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Atomic Mass Unit. Mass defect and binding energy Nuclear forces, Nature of nuclear forces, N–Z graph, liquid drop model: semi-empirical mass formula and binding energy, nuclear shell model (qualitative discussions) and magic numbers.	8	8	8
Unit 4: Radioactivity	Stability curve and stability of nuclei, Law of radioactive decay, disintegration constant, half-life and mean life. Activity unit. Law of successive disintegration, Secular equilibrium, Transient equilibrium. Alpha decay, Range of alpha particles, Range energy relation, Fine structure of alpha energy spectrum. Beta decay energy released, continuous beta spectrum and Pauli's prediction of neutrino. Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.	10	10	10

Unit 5: Detection of nuclear radiation	Method of energy loss by charged particles and gamma photons. Photoelectric, Compton and Pair-production processes Gas filled detectors – principle and construction of a gas filled detector, Ionization, proportional, GM and spark region.	5	5	5
Unit 6: Nuclear Reactions	Nuclear Reactions, Energy consideration in Nuclear Reaction, Q-value of nuclear reaction, Mass deficit in nuclear reaction, Einstein's mass-energy equivalence principle and generation of nuclear energy. Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235. Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).	8	8	8
Unit 7: Laser and Holography	Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Characteristics of LASER. Three-Level and Four-Level Lasers. Basic lasing. Ruby Laser and He-Ne Laser. Principle of Holography, Recording and Reconstruction Method, Theory of Holography as Interference between two Plane Waves, Point Source Holograms.	10	10	10
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of the course students will be able to
CO1: Explain the quantum theory of light, photoelectric effect, and matter waves using key experiments and wave-packet concepts.
CO2: Apply Heisenberg's uncertainty principle to physical scenarios and understand its implications on particle behavior and measurement.
CO3: Describe the structure of the atomic nucleus, calculate binding energies, and interpret nuclear models qualitatively.
CO4: Analyze radioactive decay processes and characterize alpha, beta, and gamma emissions and their properties.
CO5: Identify nuclear radiation detection techniques and explain the working principles of gas-filled detectors.
CO6: Evaluate nuclear reactions in terms of Q-values and energy generation through fission and fusion processes.
CO7: Understand the principles of laser operation, including population inversion, stimulated emission, and construction of common lasers.

Suggested Readings:
1. Krane, K. S. (1983). *Introduction to Modern Physics*. Wiley.
2. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). McGraw-Hill.
3. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
4. Bransden, B. H., & Joachain, C. J. (2000). *Quantum Mechanics* (2nd ed.). Pearson.
5. Silfvast, W. T. (2004). *Laser Fundamentals* (2nd ed.). Cambridge University Press

Course Title: Physics Lab Practical-I
Course Code: MAJ PHY-4.3 / DSC-253
Nature of Course: Major / Core
Credits: 4
Total Mark :100
Distribution of Marks: 100 = 50 (Unit-I) + 50 (Unit-II)

Minimum five experiments are to be performed in classes from each Unit (One experiment is to be performed from each unit in examination).

Unit –I: L 60, M 50, H 60
Electricity & Magnetism (Mark: 50)

1. To study the function of multimeter and use it for measuring
   (a) Resistances, (b) AC and DC Voltages (c) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength **B** and its variation in a solenoid (determine dB/dx).
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self-inductance of a coil by Anderson's bridge.
10. To study response curve of a Series or parallel LCR circuit and hence determine
    (a) Resonant frequency, (b) Band Width (c) Quality factor Q

Unit-II: L 60, M 50, H 60
Modern Physics (Marks: 50)

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. To draw the characteristic curve of a photo cell and find the maximum velocity of emitted electron.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine e/m by bar magnet.
6. To determine the ionization potential of mercury.
7. To determine the wavelength of Laser light using diffraction grating.
8. To determine the wavelength of Laser light using diffraction of single slit.
9. To draw the V— I characteristic of tunnel diode

Detailed Syllabus of 4th Semester Minor Course

Course Title: Electricity and Magnetism
Course Code: MIN PHY-4.1 / DSM-251
Nature of Course: Minor
Credits: 4 (Theory-3, practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objectives: The objective of this course is to provide a comprehensive understanding of vector calculus and its application to electrostatics, magnetism, electromagnetic induction, and Maxwell's equations, enabling students to analyze and solve fundamental problems in classical electromagnetism and electromagnetic wave propagation.

Course Outlines

Units	Content	L	M	H
Unit 1: Electrostatics	Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem – Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.	15	15	15
Unit 2: Magnetism	Magnetostatics: Biot-Savart's law, and its applications to (i) straight conductor, (ii) circular coil and (iii) solenoid carrying current. Divergence and curl of a magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia, para, and ferro-magnetic materials.	10	10	10
Unit 3: Electromagnetic Induction	Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.	8	8	8
Unit 4: Maxwell's Equations and EM Wave	Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.	12	12	12
	Total	**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
Minimum five experiments are to be performed in classes
(One experiment is to be performed in examination)

1. To study the function of Multimeter and use it for measuring
   (a) Resistances, (b) AC and DC Voltages, (c) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De' Sauty's bridge.
6. Measurement of field strength **B** and its variation in a solenoid (determine dB/dx).
7. To determine self-inductance of a coil by Anderson's bridge.
8. To study response curve of a Series or Parallel LCR circuit and determine
   (a) Resonant frequency (b) Band width (c) Quality factor Q

Course Outcomes: Upon completion of this course, students are expected to
CO1: Understand and apply vector algebra, differential operators, and vector theorems to physical problems.
CO2: Analyze electrostatic fields and potentials for various charge distributions and dielectric media.
CO3: Explain magnetostatics concepts including Biot-Savart law, Ampere's law, and magnetic properties of materials.
CO4: Describe electromagnetic induction phenomena including self and mutual inductance and energy stored in magnetic fields.
CO5: Comprehend Maxwell's equations, electromagnetic wave propagation, and associated energy and polarization concepts.

Suggested Readings:
Griffiths, D. J. (2013). *Introduction to Electrodynamics* (4th ed.). Pearson.
Sadiku, M. N. O. (2014). *Elements of Electromagnetics* (6th ed.). Oxford University Press.
Hayt, W. H., & Buck, J. A. (2012). *Engineering Electromagnetics* (8th ed.). McGraw-Hill.
Balanis, C. A. (2012). *Advanced Engineering Electromagnetics* (2nd ed.). Wiley.
Jackson, J. D. (1999). *Classical Electrodynamics* (3rd ed.). Wiley.

Detailed Syllabus of 4th Semester Major Courses

Course Title: Mathematical Physics II
Course Code: MAJ PHY-5.1 / DSC-301
Nature of Course: Major / Core
Credits: 4(Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objective: The objectives of this course are to offer the students the knowledge to solve differential equations using power series solution method, solve differential equation using separation of variables method, special integrals, different properties of matrix, Fourier series etc.

Course Outlines

Units	Content	L	M	H
Unit 1: IKS-1	Definition and scope of Indian knowledge systems in the context of physics. 1. Key texts and scholars in Indian physics. 2. Study of the philosophical and metaphysical foundations of Indian physics. 3. Concepts like Prakriti (nature), Purusha (consciousness), and their relevance to physics. 4. Detailed exploration of classical Indian physics principles. 5. Theory of five elements (Panchabhuta) and the concept of ether (Akasha). 6. Concepts like sound (Nada), light (Prakasha), and heat (Tejas) in Indian physics.	12	12	12
Unit 2: Frobenius Method and Special Functions	Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials.	12	12	12
Unit 3: Partial Differential Equations	Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.	7	7	7

Unit 4: Matrices	Matrix algebra using index notation, Properties of matrices, Special matrix with their properties: Transpose matrix, complex conjugate matrix, Hermitian matrix, Anti-Hermitian matrix, special square matrix, unit matrix, diagonal matrix, co-factor matrix, adjoint of a matrix, self-adjoint matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix. Determinant, Rank, Eigen value, Eigen vector and diagonalization of matrix.	9	9	9
Unit 5: Fourier Series	Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients.	5	5	5
Total		**45**	**45**	**45**

Physics Computer Lab Practical: L 30, M 25, H 30

Course objectives: The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem.

Introduction to Numerical computation softwares: Introduction to Scilab/Mathematica/Matlab/Python, Advantages and disadvantages, Scilab / Mathematica / Matlab/ Python environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab / Mathematica / Matlab/ Python, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab / Mathematica / Matlab/Python functions, Introduction to plotting, 2D and 3D plotting.

Curve fitting, least square fit, Goodness of fit, standard deviation Ohms law to calculate R, Hooke's law to calculate spring constant.

Solution of Linear system of equations Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalisation of matrices, Inverse of a matrix, Eigen vectors, eigenvalues problems. Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses).

Generation of Special functions Generation of Special functions using User defined functions in Scilab / Mathematica / Matlab. Generating and plotting Legendre Polynomials Generating and plotting Hermite function.

First order ODE Solution of first order Differential equation Euler, modified Euler and Runge-Kutta second order methods. First order differential equation (a) Current in RC, LC circuits with DC source (b) Classical equations of motion.

Second order ODE Second order differential equation. Fixed difference method. Second order Differential Equation (a) Harmonic oscillator (no friction) (b) Damped Harmonic oscillator (c)

Over damped (d) Critical damped.

Partial Differential Equation (PDE) Solution of Partial Differential Equation: (a) Wave equation (b) Heat equation.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand key concepts of Indian Knowledge Systems and their relevance to physics.
CO2: Solve second-order differential equations using Frobenius method and apply special functions like Legendre, Hermite, and Laguerre.
CO3: Use separation of variables to solve Laplace, wave, and diffusion equations in various symmetries.
CO4: Apply matrix algebra and analyze properties of special matrices, eigenvalues, and eigenvectors.
CO5: Expand periodic functions using Fourier series and compute Fourier coefficients.

Suggested Readings:

1. Arfken, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier.
2. Coddington, E. A. (2009). *An Introduction to Ordinary Differential Equations*. PHI Learning.
3. Simmons, G. F. (2007). *Learning Differential Equations*. McGraw-Hill.
4. Nearing, J. (2010). *Mathematical Tools for Physics*. Dover Publications.
5. McQuarrie, D. A. (2003). *Mathematical Methods for Scientists and Engineers*. Viva Books.
6. Zill, D. G., & Wright, W. S. (2012). *Advanced Engineering Mathematics* (5th ed.). Jones and Bartlett Learning.
7. Goswami, B. K. (n.d.). *Mathematical Physics* (1st ed.). Cengage Learning.
8. Pal, S., & Bhunia, S. C. (2015). *Engineering Mathematics*. Oxford University Press.
9. Kreyszig, E. (2008). *Advanced Engineering Mathematics*. Wiley India.
10. Riley, K. F., & Hobson, M. P. (2011). *Essential Mathematical Methods*. Cambridge University Press.

Course Title: Electromagnetic Theory
Course Code: MAJ PHY-5.2 / DSC-302
Nature of Course: Major / Core
Credits: 4
Total Marks: 100

Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course objective: The objectives of this course are to offer the students the knowledge of Maxwell's equations, propagation of EM waves in different media, production and detection of different types of polarized EM waves, general information as waveguides and fiber optics.

Course Outlines

Units	Content	L	M	H
Unit 1: Maxwell's equations	Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector.	7	7	7
Unit 2: EM Wave Propagation in unbounded Media	Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.	10	10	10
Unit 3: EM Wave Propagation in bounded Media	Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence).	11	11	11
Unit 4: Polarization of Electromagnetic Waves	Uniaxial and Biaxial Crystals. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Mathematical treatment for the production of different type of polarized light. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Optical Rotation: Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.	12	12	12

Unit 5: Optical Fibres	Definitions of various optical fibers. Numerical Aperture. Step and Graded Indices. Concept of Single and Multiple Mode fibers and their uses.	5	5	5
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
Minimum five experiments are to be performed in classes.
(One experiment is to be performed in examination)

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To study the reflection, refraction of microwaves.
6. To study Polarization and double slit interference in microwaves.
7. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
8. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
9. To verify the Stefan's law of radiation and to determine Stefan's constant.
10. To determine the Boltzmann constant using V−I characteristics of PN junction diode.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Apply Maxwell's equations and displacement current to derive wave equations.
CO2: Analyze EM wave propagation in dielectric, conducting, and plasma media.
CO3: Explain reflection, refraction, and polarization using boundary conditions and Fresnel's laws.
CO4: Understand production, detection, and analysis of polarized light.
CO5: Describe wave propagation in optical waveguides and fibers, and compute numerical aperture and mode types.

Suggested Readings:

1. Griffiths, D. J. (1998). *Introduction to Electrodynamics* (3rd ed.). Benjamin Cummings.
2. Sadiku, M. N. O. (2001). *Elements of Electromagnetics*. Oxford University Press.
3. Chow, T. L. (2006). *Introduction to Electromagnetic Theory*. Jones & Bartlett Learning.
4. Miah, M. A. W. (1982). *Fundamentals of Electromagnetics*. Tata McGraw-Hill.
5. Kshetrimayun, R. S. (2012). *Electromagnetic Field Theory*. Cengage Learning.
6. Hayt, W. H. (2012). *Engineering Electromagnetics* (8th ed.). McGraw-Hill

Course Title: Solid State Physics I
Course Code: MAJ PHY-5.3 / DSC-303
Nature of Course: Major / Core
Credits: 4(Theory-3, Practical-1)
Total Marks: **100**
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam=15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: On successful completion of the course students will understand to explain the crystal lattices and its features; elementary lattice dynamics and its influence on the properties of materials; describe the main features of the physics of electrons in solids; the dielectric ferroelectric and magnetic properties of solids and the basic concept in superconductivity.

Course Outlines

Units	Content	L	M	H
Unit 1: Crystal Structure	Amorphous and Crystalline Materials. Lattice Translation Vectors. Symmetry operations, Lattice with a Basis - Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.	8	8	8
Unit 2: Elementary Lattice Dynamics	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law.	8	8	8
Unit 3: Magnetic Properties of Matter	Dia, Para, Ferri, and Ferromagnetic materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Quantum Mechanical Treatment of Para-magnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.	6	6	6
Unit 4: Dielectric Properties of Materials	Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena.	6	6	6
Unit 5: Ferroelectri c Properties of Materials	Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electro strictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.	4	4	4

Unit 6: Free Electron Theory of Metals	Electrical and thermal conductivity of metals, Wiedemann-Franz law. Elementary band theory: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (4-probe method) & Hall coefficient.	9	9	9
Unit 7: Supercondu – ctivity	Experimental Results. Critical temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (Qualitative Discussion Only).	4	4	4
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
A minimum of five experiments are to be performed in classes
(One experiment is to be performed in the examination).

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method).
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Materials with frequency.
4. To study the *PE* Hysteresis loop of a Ferroelectric crystal.
5. To draw the B – H curve of Fe using Solenoid & determine energy loss from Hysteresis.
6. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method and to determine its band gap.
7. To determine the Hall coefficient of a semiconductor sample.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Explain the main features of crystal lattices and the concept of phonons.
CO2: Understand elementary lattice dynamics and its effects on material properties.
CO3: Describe the basic physics of electrons in solids.
CO4: Explain dielectric, ferroelectric, and magnetic properties of solids.
CO5: Understand the fundamental concepts of superconductivity.

Suggested Readings:

1. Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley India Pvt. Ltd.
2. Srivastava, J. P. (2015). *Elements of Solid-State Physics* (4th ed.). Prentice-Hall of India.
3. Azaroff, L. V. (2004). *Introduction to Solids*. Tata McGraw-Hill.
4. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Cengage Learning.
5. Ibach, H., & Lüth, H. (2009). *Solid-State Physics*. Springer.
6. John, R. (2014). *Solid State Physics*. McGraw-Hill.
7. Omar, M. A. (1999). *Elementary Solid-State Physics* (1st ed.). Pearson India.
8. Wahab, M. A. (2011). *Solid State Physics*. Narosa Publishing House.

Course Title: Analog Electronics
Course Code: MAJ PHY-5.4 / DSC- 304
Nature of Course: Major / Core
Credits: 4(Theory-3, Practical-1)
Total Marks: 100
Distribution of Marks: End Sem: Th=45, Pr=25
In Sem: Sessional Exam =15, Activity (assignment, Quiz, seminar etc) =15

Course Objective: The objective of the course is to offer the students the knowledge of physics of semiconductor p-n junction, rectifier diodes, zener diode, photodiode, bipolar junction transistors, transistor biasing and stabilization circuits, the concept of feedback in amplifiers and the oscillator circuits.

Course Outlines

Units	Content	L	M	H
Unit 1: Two-terminal semiconductor Devices	P and N type semiconductors. Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Principle and structure of LEDs, Photodiode.	8	8	8
Unit 2: Bipolar Junction Transistors	n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.	7	7	7
Unit 3: Amplifiers	Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Two stage RC- coupled amplifier and its frequency response. Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.	13	13	13
Unit 4: Sinusoidal Oscillators	Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.	6	6	6
Unit 5: Operational Amplifiers & Applications	Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. 74 (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Conversion: Resistive network (Weighted and Ladder). Accuracy and Resolution.A/D Conversion (successive approximation).	11	11	11
Total		**45**	**45**	**45**

Physics Lab Practical: L 30, M 25, H 30
A minimum of five experiments are to be performed in classes
(One experiment is to be performed in the examination)

1. To study V - I characteristics of PN junction diode, and Light emitting diode.
2. To study the V -I characteristics of a Zener diode and its use as voltage regulator.
3. To study the characteristics of a Bipolar Junction Transistor in CE/CB configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To design a Wien bridge oscillator for given frequency using an op-amp.
7. To design a phase shift oscillator of given specifications using BJT.
8. To design inverting amplifier using OPAM (741/351) and study its frequency response.
9. To design non-inverting amplifier using OPAM (741/351) & study its frequency response.
10. To study the zero-crossing detector and comparator.
11. To add two dc voltages using Op-amp in inverting and non-inverting mode.

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the physics of semiconductor p-n junctions and their characteristics.
CO2: Analyze the working and applications of devices like rectifier diodes, Zener diodes, and photodiodes.
CO3: Explain the operation of bipolar junction transistors and design biasing and stabilization circuits.
CO4: Understand the concept of feedback in amplifiers and study different types of oscillator circuits.
CO5: Learn the basics of operational amplifiers and their various practical applications.

Suggested Readings:

1. Millman, J., & Halkias, C. C. (1991). *Integrated Electronics*. Tata McGraw-Hill.
2. Ryder, J. D. (2004). *Electronics: Fundamentals and Applications*. Prentice Hall.
3. Streetman, B. G., & Banerjee, S. K. (2009). *Solid State Electronic Devices* (6th ed.).
4. Salivahanan & Kumar. *Electronic Devices & Circuits* (3rd ed.). Tata McGraw-Hill.
5. Gayakwad, R. A. *OP-Amps and Linear Integrated Circuit* (4th ed.). Prentice Hall.
6. Sedra, A. S., Smith, K. C., & Chandorkar, A. N. (2014). *Microelectronic Circuits* (6th ed.). Oxford University Press.
7. *Electronic Circuits: Handbook of Design & Applications*. Springer.
8. Sze, S. M. (2002). *Semiconductor Devices: Physics and Technology* (2nd ed.). Wiley

Detailed Syllabus of 5th Semester Minor Course

Course Title: Nuclear Physics and Electronics -I
Course Code: MIN PHY-5.1 / DSM-301
Nature of Course: Minor
Credits: 4
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course is to offer the students the knowledge of general properties of nucleus, radioactivity, particle accelerator and detector etc.

Course Outlines

Units	Content	L	M	H
Unit 1: General Properties of Nuclei	Constituents of a nucleus. Mass, volume, density, radius, charge of a nucleus. Atomic mass unit (amu). Mass-defect, binding energy, packing fraction, average binding energy, binding energy curve and its significance. Nuclear reactions, fission and fusion reactions. Q value of a nuclear reaction. Endothermic and exothermic reactions	12	12	12
Unit 2: Radioactivity	Types of radioactive decay. Soddy–Fazan's displacement law. Radioactive decay law. Half-life and mean life of a radioelement. Radioactive dating. Unit of radioactivity. Activity of radioactive sources. Radioisotopes, their production and uses. Alpha (α) decay. Range of an α particle. Geiger Nuttall law, (b) -decay: energy kinematics for -decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.	15	15	15
Unit 3: Accelerators and detectors	Need of particle accelerators. Linear accelerator – construction and working principle. Nuclear detectors. Ionization chamber- construction and working principle.	7	7	7
Unit 4: Semi-conductors	P and N type semiconductors, P-N junction diodes, unbiased and biased P-N junctions, depletion layer, barrier potential, diode characteristics, photo-diode, Zenter diode and their uses, LED and their uses	7	7	7
Unit 5: Rectifiers	Rectifier: half wave and full wave rectifier. Efficiency of rectification, ripple factor, shunt capacitor filter.	6	6	6
Unit 6: Transistors	Transistors. Different configurations and characteristics of transistors. Alpha and beta of a transistor and their relations. Transistor as amplifier. DC load line and Q-point of a transistor, Biasing and stability factors of a circuit. h parameter and its equivalent circuit. Classification of amplifiers: Class A, B and C.	13	13	13
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand nuclear properties, binding energy concepts, and nuclear reactions including fission, fusion, and Q-value.
CO2: Explain types of radioactive decay, laws of radioactivity, and applications of radioisotopes.
CO3: Describe α, β, and γ decay mechanisms along with related laws and concepts like neutrino hypothesis and internal conversion.
CO4: Understand the working of particle accelerators and nuclear detectors such as ionization chambers.
CO5: Analyze semiconductor devices, rectifiers and transistors including their configuration, biasing, amplifier classes, and applications.

Suggested readings:
1. Millman, J., & Halkias, C. C. (1991). *Integrated Electronics*. Tata McGraw-Hill.
2. Beiser, A. (2002). *Concepts of Modern Physics*. Tata McGraw-Hill.
3. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
4. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory*. Pearson Education.
5. Enge, H. A. (1986). *Introduction to Nuclear Physics*. Addison-Wesley.
6. Theraja, B. L. (2006). *Basic Electronics*. S. Chand & Company.
7. Neamen, D. A. (2012). *Semiconductor Physics and Devices*. McGraw-Hill Education.

Detailed Syllabus of 6th Semester Major Courses

Course Title: Quantum Mechanics I
Course Code: MAJ PHY-6.1 / DSC-351
Nature of Course: Major / Core
Credits: 4
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: On successful completion of the course students will able to understand the modern development of physics, starting from Planck's law, its development of the idea of probability interpretation and the formulation of Schrodinger equation, wave functions etc.

Course Outlines

Units	Content	L	M	H
Unit 1: IKS-2	Ancient Indian contributions to Physics. Study of scientific treatises such as Aryabhatya, Brahmagupta and Acharya Kanad Vedic cosmology and its connection to modern cosmological theories. Exploration of the Indian concept of time, measurement, and cosmology. Study of ancient Indian astronomical knowledge, including the Siddhantas and planetary calculations.	12	12	12
Unit 1: Introductory Quantum Mechanics	Development of quantum mechanics in light of black body radiation. Failure of classical idea. Plank's quantum hypothesis. Photoelectric effect and Compton effect. Matter wave: Wave particle duality, De Broglie wave associated with moving particles – (i) non relativistic case and (ii) relativistic case. G.P. Thomson's electron diffraction experiment. Complimentary principle of Neils Bohr. Gamma ray microscope experiment, application of uncertainty principle.	14	14	14
Unit 2: Schrödinger Equation	Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrödinger equation for non- relativistic particles; expectation value, momentum and energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; probability and probability current densities in one dimension. Schrodinger wave equation- (i) time dependent and (ii) time independent. Corresponding principle.	14	14	14
Unit 3: Wave function	Wave function and its probabilistic interpretation as probability amplitude. Continuity equation, probability density and probability current density. Normalized wave function, properties of well-behaved wave functions in quantum mechanics.	8	8	8

Unit 4: One-dimensional Box	Introduction to operator formalism, Dynamical variable as operator (position, momentum and Hamiltonian). One dimensional infinitely rigid box- energy eigen values and eigen functions, Expectation values, Ehrenfest's theorem. Normalization; quantum dot as example; quantum mechanical scattering and tunneling in one dimension-across a step potential and rectangular potential barrier.	12	12	12
Total		**60**	**60**	**60**

Course outcomes: After successful completion of this course, students will be able to
CO1: Understand ancient Indian contributions to physics, including key scientific texts and Vedic cosmology's links to modern theories.
CO2: Explain the development of quantum mechanics from classical failures, including Planck's hypothesis, photoelectric and Compton effects, and wave-particle duality.
CO3: Analyze key quantum experiments and principles, such as electron diffraction, Bohr's complementarity, uncertainty principle, and two-slit interference.
CO4: Apply Schrödinger's wave equation (time-dependent and independent) and interpret the wave function and related quantum concepts.
CO5: Use operator formalism to solve quantum problems like the infinite potential well, and understand quantum tunneling and scattering phenomena.

Suggested Readings:
Sakurai, J. J. (1994). *Modern Quantum Mechanics*. Addison-Wesley.
Schiff, L. I. (1968). *Quantum Mechanics*. McGraw-Hill.
Bransden, B. H., & Joachain, C. J. (2000). *Quantum Mechanics* (2nd ed.). Pearson Education.
Powell, J. L., & Craseman, B. (1993). *Quantum Mechanics*. Narosa Publishing House.
Shankar, R. (1994). *Quantum Mechanics*. Kluwer Academic.
Griffiths, D. J. (2004). *Quantum Mechanics* (2nd ed.). Pearson Education.
Mathews, P. M., & Venkatesan, K. (1976). *Quantum Mechanics*. McGraw-Hill.
Liboff, R. L. (2002). *Quantum Mechanics* (3rd ed.). Pearson Education.

Course Title: Statistical Mechanics-I
Course Code: MAJ PHY-6.2 / DSC-352
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objectives of this course are to offer the students the knowledge of the techniques of Statistical Mechanics to apply in various fields including Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, Chemistry and in many other directions.

Course Outlines

Units	Content	L	M	H
Unit 1: Classical Statistics	Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.	14	14	14
Unit 2: Classical Theory of Radiation	Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.	10	10	10
Unit 3: Quantum Theory of Radiation	Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radi-ation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.	11	11	11
Unit 4: Bose-Einstein Statistics	Bose-Einstein (B-E) distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.	12	12	12
Unit 5: Fermi-Dirac Statistics	Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.	13	13	13
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the concepts of macrostate, microstate, ensembles, entropy, and thermodynamic probability in statistical mechanics.
CO2: Explain the laws of thermal radiation, blackbody radiation, and derive key radiation laws including Planck's law and its consequences.
CO3: Analyze the Maxwell-Boltzmann distribution, partition function, and thermodynamic functions for ideal gases and two-level systems.
CO4: Describe Bose-Einstein and Fermi-Dirac distribution laws, their thermodynamic functions, and applications like Bose-Einstein condensation and electron gas in metals.
CO5: Apply quantum statistical mechanics to astrophysical phenomena such as white dwarf stars and understand related concepts like Fermi energy and Chandrasekhar limit.

Suggested Readings:

1. Pathria, R. K. (1996). *Statistical Mechanics* (2nd ed.). Oxford University Press.
2. Reif, F. (2008). *Statistical Physics*. Tata McGraw-Hill.
3. Lokanathan, S., & Gambhir, R. S. (1991). *Statistical and Thermal Physics*. Prentice Hall.
4. Sears, F. W., & Salinger, G. L. (1986). *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*. Narosa.
5. Helrich, C. S. (2009). *Modern Thermodynamics with Statistical Mechanics*. Springer.
6. Swendsen, R. H. (2012). *An Introduction to Statistical Mechanics & Thermodynamics*. Oxford University Press.

Course Title: Digital Electronics
Course Code: MAJ PHY-6.3 / DSC-353
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The aim of this course is to provide students with a fundamental understanding of digital electronics concepts, including number systems, logic gates, Boolean algebra, combinational and sequential circuits, and the architecture and components of basic computer systems.

Course Outlines

Units	Content	L	M	H
Unit 1: Digital circuits	Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. Boolean algebra AND, OR, NOT gates, NAND and NOR Gates as Universal Gates, XOR gate	9	9	9
Unit 2: Boolean algebra	De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.	7	7	7
Unit 3: Arithmetic and Data Processing Circuits	Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders with examples.	9	9	9
Unit 4: Sequential Circuits	SR, D and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.	10	10	10
Unit 5: Timers: IC 555	Block diagram and applications: Astable multivibrator and Monostable multivibrator.	9	9	9
Unit 6: Shift registers	Basic idea of Shift registers (serial and parallel form) Counters: Ring Counter. Asynchronous and Synchronous Counter.	8	8	8
Unit 7: Basic Computer Organization	Vonn Newmann and Havard architecture, Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory types, speed and organization. Basic features of 8085 as examples of CPU. Components: Buses, Registers, ALU	8	8	8
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the difference between analog and digital circuits and convert between various number systems.
CO2: Apply Boolean algebra and De Morgan's theorems to simplify logic circuits and design using universal gates.
CO3: Design and analyze combinational circuits such as adders, subtractors, multiplexers, and decoders.
CO4: Understand and implement sequential circuits including flip-flops, counters, and shift registers.
CO5: Describe basic computer architecture concepts, including Von Neumann and Harvard architectures, memory types, and components of a CPU like the 8085.

Suggested Readings:

1. Malvino, A. P., Leach, D. P., & Saha. (2011). *Digital Principles and Applications* (7th ed.). Tata McGraw-Hill.
2. Kumar, A. (2009). *Fundamentals of Digital Circuits* (2nd ed.). PHI Learning Pvt. Ltd.
3. Venugopal. (2011). *Digital Circuits and Systems*. Tata McGraw-Hill.
4. Kharate, G. K. (2010). *Digital Electronics*. Oxford University Press.
5. Tocci, R. J., & Widmer, N. S. (2001). *Digital Systems: Principles & Applications*. PHI Learning.
6. Vingron, S. P. (2012). *Logic Circuit Design*. Springer.
7. Ghoshal, S. (2012). *Digital Electronics*. Cengage Learning.
8. Mandal, S. K. (2010). *Digital Electronics* (1st ed.). McGraw-Hill.
9. Chattopadhyay, D., & Rakshit, P. C. (2023). *Electronics Fundamentals and Applications* (17th ed.). New Age International Publishers.

Course Title: Physics Laboratory Practical-II
Course Code: MAJ PHY-6.4 / DSC-354
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: 50 (Unit -I) + 50 (Unit -II)

Course Objective: The aim of this course is to develop practical skills in designing and analyzing digital electronic circuits and applying computational techniques for solving mathematical problems related to differential equations, special functions, and signal processing.

Unit –I: L 60, M 50, H 60
Digital electronics (Marks: 50)
Minimum of five experiments are to be performed in classes
(One experiment is to be performed in the examination)

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT, and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into a logic circuit and design it using logic gate ICs.
5. To design a Half Adder and Full Adder
6. To design a 4-bit binary Adder.
7. To design Half Subtractor and Full Subtractor
8. To design Adder-Subtractor using Full Adder IC.
9. To build SR flip-flop circuit using NAND gates
10. To build a D flip-flop circuit using NAND gates.
11. To build a JK flip-flop circuit using NAND gates.
12. To build JK Master-slave flip-flop using flip-flop ICs.

Unit- II: Unit –I: L 60, M 50, H 60
Computer lab Practical (Marks: 50)
Minimum of five experiments are to be performed in classes

1. Solve differential equations

$$\frac{dy}{dx} = e^x \text{ with } y = 0 \text{ for } x = 0$$
$$\frac{dy}{dx} + e^{-x}y = x^2$$
$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$$
$$\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$$

2. Dirac delta function
Evaluate the integral I

$I = \frac{1}{\sqrt{2\pi\sigma^2}} \int \exp\left[-\frac{(x-2)^2}{2\sigma^2}\right](x+3)dx$ for $\sigma = 1.0, 0.1, 0.01$ and show the $I \to 5$

3. Fourier Series

Make a program to evaluate

$$\sum_{n=1}^{\infty} 0.2)^{n}$$

Evaluate the Fourier coefficients of a given periodic function (square wave)
4. Frobenius method and Special Functions

Evaluate

$$\int_{-1}^{1} P_n(x)\mathrm{P_m}(x)\mathrm{dx} = \delta_{n,m}$$

Plot $P_n(x), j_\vartheta(x)$ and show the recursion relation.
5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two)
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions e.g. sinθ, , given Bessel'sfunctionat N points find its value at an intermediate point.
8. Integrate

$$\frac{1}{(x^2+2)}$$

Numerically in a given interval.
9. Compute the nth roots of unity for $\mathrm{n} = 2, 3$ and 4 .
10. Find the two square roots of $5 + 12j$.
11. Integral transform

Evaluate FFT of e^{-x^2}
12. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform

Course Outcomes: After successful completion of this course, students will be able to
CO1: Design and implement fundamental digital logic circuits using transistors and logic gate ICs, including combinational and sequential circuits.
CO2: Construct and analyze flip-flops, shift registers, and timer-based circuits to understand timing and memory elements in digital electronics.
CO3: Apply programming skills to solve differential equations, compute Fourier series, and evaluate special functions using computational tools.
CO4: Perform numerical methods including error analysis, least square fitting, and numerical integration to analyze experimental data.

Detailed Syllabus of 6th Semester Minor Course

Course Title: Atomic and Solid State Physics
Course Code: MIN PHY-6.1 / DSM-351
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The objective of the course is to offer the students to acquire the knowledge of positive rays, Bohr's theory of hydrogen atom, vector atom model, X-rays etc. of atomic physics; and the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials, explain the dielectric ferroelectric and magnetic properties of solid.

Course Outlines

Units	Content	L	M	H
Unit 1: Positive rays	Positive rays: analysis of positive rays. Properties of positive rays. Production of positive rays. Aston and Bainbridge mass spectrographs.	6	6	6
Unit 2: Bohr's theory	Bohr's theory of hydrogen atom. Energy level diagram. Ritz combination principle. Excitation potential, critical potential and ionization potential. Fine structures of the spectral lines. Sommerfield's extension of the Bohr's theory (qualitative only).	10	10	10
Unit 3: Vector atom model	Vector atom model. Bohr magneton, spinning electron. Quantum numbers. Pauli's exclusion principle, source of radiation in external fields – normal Zeeman effect.	8	8	8
Unit 4: X-rays and matter wave	Origin and production of X-rays. Continuous and characteristic X-rays. Moseley's law, diffraction of X-rays by crystals, Bragg's law, Compton effect. Frank and Hertz experiment, matter wave, Davisson and Germar experiment.	10	10	10
Unit 5: Crystal Structure	Amorphous and Crystalline Materials. Lattice Translation Vectors. Symmetry operations, Lattice with a Basis - Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law.	10	10	10
Unit 6: Elementary Lattice Dynamics	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.	8	8	8

Unit 7: Magnetic Properties of Matter	Dia, Para, Ferri, and Ferromagnetic Materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Hysteresis and B-H Curve.	8	8	8
Total		**60**	**60**	**60**

Course Outcomes: After successful completion of this course, students will be able to
CO1: Understand the fundamental concepts of positive rays, Bohr's hydrogen atom theory, and the vector atom model.
CO2: Explain the nature and properties of X-rays and their applications.
CO3: Describe the structure and characteristics of crystal lattices and phonons in solids.
CO4: Analyze elementary lattice dynamics and their impact on material properties.
CO5: Explain the dielectric, ferroelectric, and magnetic properties of solids and the behavior of electrons in solids.

Suggested Readings:

1. White, H. E. (1934). *Introduction to Atomic Spectra*. Tata McGraw-Hill.
2. Kumar, R. (1990). *Atomic and Molecular Spectra*.
3. Beiser, A. (1987). *Concepts of Modern Physics*. McGraw-Hill.
4. Rajam, J. B. (2007). *Atomic Physics*. S. Chand & Co.
5. Kittel, C. (2004). *Introduction to Solid State Physics* (8th ed.). Wiley India Pvt. Ltd.
6. Ghatak, A. K., & Kothari, L. S. (1970). *Lattice Dynamics*. Tata McGraw-Hill.
7. Dekker, A. J. (1966). *Solid State Physics*. Macmillan.
8. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Saunders College.
9. Pillai, S. O. (2005). *Solid State Physics*. New Age International Publishers.

Detailed Syllabus of 7th Sem FYUGP/1st Sem PG Core Courses

Course Title: Solid State Physics II
Course Code: MAJ PHY-7.1 / DSC-401
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: The objective of the course is to equip a student with basic concepts of Condensed Matter Physics so that the knowledge can be applied for further development of the subject, enable a student to work in both theoretical and experimental aspects of Condensed Matter Physics and help the students in thorough learning of the concepts associated with the course through numerical problems.

Course Outlines

Units	Content	L	M	H
Unit 1: Crystal Defects and Diffusion	Imperfections in crystals, Origin of defects, Point defects, Schottky defects, Frenkel defects, Color centers, Line defects and dislocations, Surface and volume defects, Defect formation energy, Diffusion in solids, Fick's first and second laws	10	10	10
Unit 2: Advanced Diffraction Techniques	Review of Bragg diffraction, Crystal structure determination, X-ray diffraction methods (Laue method, Powder method, Rotating crystal method), Structure factor, Atomic scattering factor, Electron diffraction, Neutron diffraction, Comparison of X-ray, electron and neutron diffraction, Applications of diffraction techniques	10	10	10
Unit 3: Advanced Electronic Band Theory and Semiconductor Physics	Electrons in periodic potential, Kronig-Penney model (brief review), E–k relation, Effective mass, Density of states (qualitative), Fermi energy and Fermi surface (introductory), Direct and indirect band-gap semiconductors, Charge carrier concentration, Electrical conductivity and mobility, Hall effect, Hall coefficient, Four-probe method, Applications of semiconductors	12	12	12
Unit 4: Advanced Magnetism	Quantum origin of magnetic moments, Pauli paramagnetism, Exchange interaction, Weiss molecular field theory, Ferromagnetic domains, Magnetic anisotropy, Antiferromagnetism, Ferrimagnetism, Soft and hard magnetic materials, Magnetoresistance (introductory)	8	8	8
Unit 5: Advanced Ferroelectric and Functional Materials	Structural phase transitions, Ferroelectric domains, Domain switching, Curie-Weiss law, Relaxor ferroelectrics, Multiferroic materials, Piezoelectric ceramics, Electrostrictive materials, Ferroelectric thin films, Applications in sensors, actuators, memories and energy harvesting	10	10	10

Unit 6: Advanced Superconductivi-ty	Thermodynamics of superconducting transition, London equations, Penetration depth, Coherence length (qualitative), Cooper pair concept, BCS theory (qualitative), Flux quantization, Josephson effect, SQUID, High-temperature superconductors, Applications of superconductivity	10	10	10
Total		**60**	**60**	**60**

Course Outcomes: Upon completion of this course, students will be able to
CO1: Identify and explain different types of crystal defects and their effects on material properties.
CO2: Apply diffraction techniques to determine crystal structures.
CO3: Analyze electronic properties in solids using band theory and related models.
CO4: Understand magnetic behavior in materials and related phenomena.
CO5: Explain ferroelectric and superconducting properties and their underlying mechanisms.

Suggested Readings:

1. Kittel, C. (2005). *Introduction to Solid State Physics* (8th ed.). John Wiley & Sons.
2. Dekker, A. J. (1986). *Solid State Physics*. Macmillan India Ltd.
3. Omar, M. A. (2001). *Elementary Solid-State Physics: Principles and Applications*. Pearson Education.
4. Verma, A. R., & Srivastava, O. N. (1991). *Crystallography Applied to Solid State Physics*. New Age International.
5. Ashcroft, N. W., & Mermin, N. D. (1976). *Solid State Physics*. Brooks/Cole.

Course Title: Quantum Mechanics II
Course Code: MAJ PHY-7.2 / DSC-402
Nature of Course: Major / Core
Credits: 4
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The aim of the course is to the knowledge to the students so that they can be able to understand Fundamental concepts of Quantum Mechanics. Acquaint the learners with Dirac notation. Formulation of quantum mechanics in terms of operators. Enable the learners to solve simple quantum mechanical problems. Introduce the techniques of angular momentum algebra. Students acquire the idea of understanding of angular momentum and spin, as well as different approximation methods of quantum mechanics.

Course Outlines

Units	Content	L	M	H
Unit I: Fundamental Concepts	Overview of wave mechanics, Schrödinger equation (time dependent & time independent), application to some important physical problems: particle in a box, simple harmonic oscillator, spherical well potential, hydrogen atom- radial solution, spherical harmonics, angular momentum operator and different quantum numbers, radial distribution function and shapes of the probability densities for ground & first excited states; degeneracy of states: s, p, d states. Wave functions in Position and Momentum Space, wave description of particles by wave packets; Uncertainty principle from wave packet description, Gaussian wave packet and its wave function.	18	18	18
Unit– II: Dynamical Variables As Operators	Dynamical variables as operators, definition of an operator, different types of operators and their properties, position, energy and momentum operator; commutation relations; introduction to Hilbert space, Dirac notation, eigenvalue and eigenfunctions; expectation value of an operator e.g. position, momentum operator etc, orthonormality condition.	14	14	14
Unit-III: Angular Momentum	Rotation, Angular Momentum and Unitary groups, commutation relations, Eigenvalues and Eigenstates of Angular Momentum, Ladder operators and their matrix representations, the Stern Gerlach Experiment, Spin angular momentum and Pauli matrices, Addition of Angular momentum, Clebcsh Gordon Coefficients.	16	16	16
Unit-IV: Approximation methods in quantum mechanics	Time independent perturbation theory, Stark and Zeeman effects, variational method and its applications, WKB approximation, time dependent perturbation theory, transition to continuum states, Fermi's Golden rule, adiabatic and sudden approximation.	12	12	12
Total		**60**	**60**	**60**

Course Outcomes: On successful completion of the course students will be able to

CO1: Understand and apply the time-dependent Schrödinger equation and interpret the physical meaning of the wave function.

CO2: Analyze operators, eigenvalues, eigenfunctions, and use superposition principles to solve quantum systems including free particles and wave packets.

CO3: Solve quantum mechanical problems with boundary conditions, including the one-dimensional potential well and harmonic oscillator using appropriate mathematical methods.

CO4: Apply the time-independent Schrödinger equation in spherical coordinates to understand angular momentum, quantum numbers, and radial wave functions.

CO5: Explain electron spin, magnetic moments, and related phenomena such as the Stern-Gerlach experiment and Zeeman effects qualitatively.

Suggested Readings

1. Sakurai, J. J. (1994). *Modern Quantum Mechanics* (Revised ed.). Addison-Wesley.
2. Schiff, L. I. (1968). *Quantum Mechanics* (3rd ed.). McGraw-Hill.
3. Bransden, B. H., & Joachain, C. J. (2000). *Quantum Mechanics* (2nd ed.). Pearson Education.
4. Powell, J. L., & Crasemann, B. (1995). *Quantum Mechanics*. Narosa Publishing House.
5. Shankar, R. (1994). *Principles of Quantum Mechanics* (2nd ed.). Springer (formerly Kluwer Academic).
6. Griffiths, D. J., & Schroeter, D. F. (2018). *Introduction to Quantum Mechanics* (3rd ed.). Cambridge University Press. *(Earlier editions were published by Pearson Education.)*
7. Mathews, P. M., & Venkatesan, K. (1976). *A Textbook of Quantum Mechanics*. McGraw-Hill Education.
8. Liboff, R. L. (2003). *Introductory Quantum Mechanics* (4th ed.). Addison-Wesley. *(Earlier Indian editions were published by Pearson Education.)*
9. Feynman, R. P., & Hibbs, A. R. (2010). *Quantum Mechanics and Path Integrals* (Emended ed.). Dover Publications.

Course Title: Physics laboratory Practical-III
Course Code: MAJ PHY-7.3 / DSC-403
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: 100 = 50 (Unit-I) + 50 (Unit-II)

[A minimum of seven experiments are to be performed in classes taking at least three from each Group.]

Unit –I: L 60, M 50, H 60
Atomic & molecular Physics (Mark :50)

1. To draw the calibration curve of the Jamin's interferometer and then to find the refractive index of air at room temperature and pressure.
2. To determine the thickness of a given mica sheet by using Jamin's interferometer.
3. To determine wavelength of a given light source using the Michelson interferometer.
4. To determine the wavelength of light from a monochromatic source using Fabry-Perot interferometer.
5. To determine the grating element of the double slit by observing interference and using lamp and scale method.
6. To study the normal and anomalous Zeeman effects.
7. To determine the wavelength of He-Ne laser light.
8. To determine the value e/m by magnetron method.
9. To verify the Heisenberg's uncertainty principle using He-Ne laser.

Unit –I: L 60, M 50, H 60
Solid State Physics (Mark :50)

1. To find the constant of ballistic galvanometer using i-H and d-H curves.
2. To measure the resistivity and hence the band gap of a semiconductor using four-probe method.
3. To determine the Stefan's constant using ballistic galvanometer.
4. To determine the coercivity, retentivity, and saturation magnetization of a given ferromagnetic specimen using B–H loop curve.
5. To perform the Hall Effect experiment by recording the Hall voltage at different sample currents under different magnetic field strengths. Plot suitable graph and hence determine Hall coefficients.
6. To study the dispersion relation for the monoatomic and diatomic lattice.
7. To determine the energy band gap of a semiconductor using p-n junction diode.
8. To determine the Coupling Coefficient of a Piezoelectric crystal.

Course Title: Atomic and Molecular Physics
Course Code: MAJ PHY- 7.4 / DSC-404 (In lieu of RM)
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th = 60
In Sem: Sessional Exam =20, Activity (assignment, Quiz, seminar etc) =20

Course Objective: To provide students with a comprehensive understanding of atomic and molecular spectra, their interaction with external fields, and various spectroscopic techniques for probing structural and dynamical properties of atoms and molecules.

Course Outlines

Unit	Topics	L	M	H
Unit I: Atomic Spectra	Quantum states of electron in atoms – hydrogen atom spectrum – electron spin – Stern Gerlach Experiment – spin-orbit interaction – Lande interval rule – two electron systems – LS-JJ coupling schemes – fine structure – spectroscopic terms and selection rules – hyperfine structure – exchange symmetry of wave function – Pauli's exclusion principle – periodic table – alkali type spectra – equivalent electrons.	15	15	15
Unit II: Atoms in External Fields and Resonance Spectroscopy	Zeeman and Paschen Back Effect of one and two electron systems – selection rules – Stark effect – inner shell vacancy – X-ray – Auger transitions – Compton Effect – NMR – basic principles – classical and quantum mechanical description – spin-spin and spin-lattice relaxation times – magnetic dipole coupling – chemical shift – Knight shift – ESR – basic principles – nuclear interaction and hyperfine structure – g-factor – zero field splitting.	15	15	15
Unit III: Microwave Spectroscopy and IR Spectroscopy	Rotational spectra of diatomic molecules – rigid rotator – effect of isotropic substitution – non-rigid rotator – rotation spectra of polyatomic molecules – linear, symmetric top and asymmetric top molecules – experimental techniques – diatomic vibrating rotator – linear, symmetric top molecule – analysis by infrared techniques – characteristic and group frequencies.	12	12	12
Unit IV: Raman Spectroscopy	Raman effect – quantum theory of Raman effect – rotational Raman spectra – vibrational Raman apectra – Raman spectra of polyatomic molecules – Raman spectrometer – hyper- Raman effect – experimental techniques.	8	8	8
Unit V: Electronic Spectroscopy	Electronic spectra of diatomic molecules – Frank-Condon principle – dissociation energy and dissociation products – rotational fine structure of electronic vibration transitions – Fortrat Diagram – predissociation.	10	10	10
Total		**60**	**60**	**60**

Course Outcomes: By the end of this course, students will be able to

CO1: Explain the origin of atomic spectra, electron spin phenomena, fine and hyperfine structures, and their significance in atomic models.

CO2: Analyze the effects of external fields on atoms, including Zeeman, Paschen-Back, and Stark effects, and interpret resonance spectroscopic techniques like NMR and ESR.

CO3: Interpret microwave and infrared spectra of diatomic and polyatomic molecules, and deduce molecular structure and vibrational modes.

CO4: Apply the principles of Raman spectroscopy to study rotational and vibrational spectra of molecules, and evaluate experimental techniques for Raman effect.

CO5: Understand and assess electronic spectra of molecules using concepts like Franck–Condon principle, dissociation energy, Fortrat diagrams, and predissociation mechanisms.

Suggested Readings:

1. Chanda, M. (2003). *Atomic Structure and Chemical Bond*. Tata McGraw-Hill, New Delhi.
2. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). Tata McGraw-Hill, New Delhi.
3. Aruldhas, G. (2002). *Molecular Structure and Spectroscopy*. Prentice Hall of India, New Delhi.
4. Aruldhas, G. (2002). *Molecular Structure and Spectroscopy*. Prentice Hall of India, New Delhi.
5. Barrow, G. M. (1986). *Introduction to Molecular Spectroscopy*. McGraw-Hill Ltd., Singapore.

Course Title: Research Methodology
Course Code: RM PHY- 7.1 / RM-401
Nature of Course: Research Component
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course Objectives: The objective of this course is to equip students with foundational knowledge and practical skills in research methodology and ethics, enabling them to design, conduct, and report scientific research responsibly and effectively.

Course Outlines

Units	Content	L	M	H
Unit 1: Fundamentals of Research	Introduction to research: Meaning, purpose, and types of research, Scientific method and its applications, Interdisciplinary and multidisciplinary research, Hypothesis: Definition, formulation, and types, Research problem identification and formulation, Objectives and significance of research.	12	12	12
Unit 2: Literature Survey and Review Writing	Importance of literature review, Sources of scientific information: journals, databases (Scopus, Web of Science, arXiv, etc.), How to read a scientific paper, Use of reference management tools (e.g., Mendeley, Zotero), Writing a review report	12	12	12
Unit 3: Research Ethics and Integrity	Definition and importance of research ethics, Plagiarism: definition, types, consequences; use of plagiarism detection software, Authorship and publication ethics, Data fabrication and falsification, Institutional Ethics Committees and ethical clearances, Intellectual Property Rights (IPR) and patents (basic introduction)	12	12	12
Unit 4: Experimental Methods and Data Handling in Physics	Designing experiments and recording observations, Statistical analysis: mean, standard deviation, error analysis, curve fitting, Graphical representation of data using software tools (Excel, Python, Origin, etc.), Uncertainty and propagation of errors	12	12	12
Unit 5: Scientific Writing and Communication	Structure and components of research reports, and scientific papers, technical writing skills and style (LaTeX), writing project proposals and abstracts, Preparing presentations and posters for seminars/conferences, Communication skills for interviews and research discussions.	12	12	12
Total		**60**	**60**	**60**

Course outcomes: By the end of the course, students will be able to
CO1: Understand the fundamental principles and types of scientific research in physics.

CO2: Recognize and address ethical issues such as plagiarism and data integrity.
CO3: Conduct effective literature reviews using scientific databases and referencing tools.
CO4: Apply suitable experimental methods and statistical techniques for data analysis.
CO5: Develop strong scientific writing and communication skills for preparing research proposals, reports, and presentations.

Suggested Readings:

1. Kothari, C. R., & Garg, G. (2019). *Research Methodology: Methods and Techniques*. New Age International.
2. Kumar, P. (2014). *Research Methodology: A Step-by-Step Guide for Beginners*. SAGE Publications.
3. Steneck, N. H. (2007). *ORI Introduction to the Responsible Conduct of Research*. U.S. Department of Health and Human Services.
4. Day, R. A., & Gastel, B. (2006). *How to Write and Publish a Scientific Paper* (7th ed.). Cambridge University Press.
5. Selected research articles and ethical guidelines from UGC, DST, CSIR, and INSA (various years).

Detailed Syllabus of 7th Sem FYUGP/1st Sem PG Minor Course

(For disciplines other than Physics)
Course Title: Atomic Physics
Course Code: MIN PHY-7.1 / DSM-401
Nature of Course: Minor
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of the course is to provide a conceptual understanding of atomic structure and spectra, highlighting key experiments and applications relevant to various scientific and technological fields.

Course Outlines

Units	Content	L	M	H
Unit 1: Foundations of Atomic Structure	Discovery of electron, proton, neutron, Rutherford's alpha particle experiment and nuclear model, Bohr's atomic model: postulates, hydrogen spectrum, energy levels, Limitations of Bohr's model, Basic idea of quantization in atoms.	12	12	12
Unit 2: Quantum View of Atoms	Introduction to quantum numbers: n, l, m, s (without Schrödinger equation), Electronic configuration of elements (up to Z = 30), Pauli Exclusion Principle and Hund's Rule (qualitative), Shapes and significance of s, p, d orbitals (conceptual only).	10	10	10
Unit 3: Atomic Spectra and Excitation	Emission and absorption spectra: line vs continuous spectra, Explanation of spectral lines using Bohr model, Hydrogen spectral series: Lyman, Balmer, Paschen (qualitative idea), Introduction to X-rays: production and characteristics, Applications in astronomy, material science, and medicine.	14	14	14
Unit 4: Electron Spin and Magnetic Effects	Concept of electron spin and magnetic moment, Stern-Gerlach experiment, Introduction to Zeeman effect (normal only), Role of magnetic fields in atomic transitions, Magnetic resonance and its applications (e.g., MRI – qualitative only).	12	12	12
Unit 5: Modern Applications of Atomic Physics	Lasers: basic principle of stimulated emission, population inversion, Types and applications of lasers (medical, industrial, communication), Atomic clocks and GPS, Atomic absorption and emission spectroscopy in material analysis, Role of atomic physics in modern technology (overview).	12	12	12
Total		**60**	**60**	**60**

Course Outcomes: On successful completion of this course students will be able to
CO1: Understand the historical development and basic models of atomic structure.
CO2: Describe quantum numbers and explain the arrangement of electrons in atoms.
CO3: Interpret atomic spectra and relate them to energy levels in atoms.

CO4: Explain electron spin and its role in magnetic and spectroscopic phenomena.
CO5: Identify the relevance of atomic physics in modern applications such as lasers, spectroscopy, and atomic clocks.

Suggested Readings:

1. Beiser, A. (2003). *Concepts of Modern Physics* (6th ed.). McGraw-Hill.
2. Mani, H. S., & Mehta, G. K. (2000). *Introduction to Modern Physics*. Affiliated East-West Press.
3. Ghoshal, S. N. (2010). *Atomic and Nuclear Physics*. S. Chand & Company.
4. Verma, R. M. (2011). *Atomic and Molecular Physics*. Ane Books Pvt. Ltd.
5. Brij Lal & N. Subrahmanyam. (2010). *Atomic and Molecular Physics*. S. Chand & Company.
6. Young, H. D., & Freedman, R. A. (2012). *University Physics with Modern Physics* (13th ed.). Pearson.
7. Singh, R. (2009). *Physics for Degree Students – B.Sc. Second Year*. S. Chand.

Detailed Syllabus of 8th Sem FYUGP/2nd Sem PG Major Courses

Course Title: Classical Mechanics
Course Code: MAJ PHY-8.1 / DSC-451
Nature of Course: Major
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The aim of this course is to offer the students the knowledge to overview of Newton's Laws of Motion, the knowledge of understanding of the Lagrangian and Hamiltonian of a system. Finally, after completion of the course, students will be able to solve the seen or unseen problems/numerical in classical mechanics.

Course Outlines

Units	Content	L	M	H
Unit 1: Review of Newtonian mechanics	Mechanics of a system of particles, Constraints of motion and their classification, Generalised co-ordinates, D' Alembert's principle, Lagrange's equations of motion and its simple applications: (i) Atwood machine, (ii) Simple pendulum, (iii) Compound pendulum, (iv) Keplarian motion and (v) Linear harmonic oscillator. Hamilton's principle, Calculus of variation, shortest distabce between two points. Lagranges equations from Hamiltion's principle. Cyclic coordinates.	10	10	10
Unit 2: Motion in central potential	Maps, winding numbers and orbital stability, Hidden symmetry in the Kepler problem, Small Oscillations, Solution of one-dimensional harmonic oscillator problem, Forced oscillations in one dimension, Damped harmonic motion in one dimension general solution of the problem, Displacement as a function of time, Systems with many degrees of freedom, Eigen value equation and normal co-ordinates.	12	12	12
Unit 3: Lagrangian dynamics	Lagrangian dynamics and transformations in configuration space, geometry of motion in configuration space, canonical moment and covariance of Lagrange's equation in configuration space. Hamiltonian dynamics and transformations in phase space, Generating functions, Poisson brackets, Integrable canonical flows, Hamilton-Jacobi equation, Action-angle variables.	13	13	13
Unit 4: Linear transfor-mations	Linear transformations, rotations and rotating frames, similarity transformations, linear transformations and eigen value problem, dynamics in rotating reference frames. Rigid Body Dynamics, Definition of Rigid body, Eulerian Angles, Euler's theorem, Angular momentum and kinetic energy, Moment of inertia tensor, Euler's equation of motion, Symmetrical top.	15	15	15

Unit 5: Fluid dynamics	Definition of a fluid; idea fluids; density and pressure of a fluid; velocity of a fluid element and its time derivative; mass conservation and equation of continuity; incompressible fluid; Euler's equation of fluid dynamics; Navier-Stokes equation (introduction only)	10	10	10
Total		**60**	**60**	**60**

Course outcomes: Upon completion of this course, students will be able to
CO1: Apply Newtonian, Lagrangian, and Hamiltonian mechanics to particle systems with constraints.
CO2: Analyze central force motion and small oscillations using appropriate mathematical tools.
CO3: Use advanced Lagrangian and Hamiltonian formalisms including Poisson brackets and action-angle variables.
CO4: Solve problems in rigid body dynamics using linear transformations and Euler's equations.
CO5: Understand and analyze fluids.

Suggested Readings:

1. Goldstein, H., Poole, C., & Safko, J. (2002). *Classical Mechanics* (3rd ed.). Pearson Education.
2. Landau, L. D., & Lifshitz, E. M. (1976). *Mechanics* (3rd ed., Vol. 1 of Course of Theoretical Physics). Butterworth-Heinemann.
3. Arnold, V. I. (1989). *Mathematical Methods of Classical Mechanics* (2nd ed.). Springer.
4. Thornton, S. T., & Marion, J. B. (2003). *Classical Dynamics of Particles and Systems* (5th ed.). Cengage Learning.
5. Fowles, G. R., & Cassiday, G. L. (2004). *Analytical Mechanics* (7th ed.). Thomson Brooks/Cole.
6. V.B. Bhatia, Classical Mechanics: With introduction to non-linear oscillations and chaos, (Narosa Publishing House)

Course Title: Mathematical Physics III
Course Code: MAJ PHY-8.2 / DSC-452
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of the course is to offer the students the knowledge to solve complex integrals using residue theorem, apply Fourier and Laplace transforms in solving differential equations, understand properties of Tensors, Transformation of coordinates, contra variant and co-variant tensors, indices rules for combining tensors.

Course Outlines

Units	Content	L	M	H
Unit 1: Fourier Transforms	Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier trans- form of trigonometric, Gaussian functions Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem (Statement only). Properties of Fourier transforms (translation, change of scale, complex conjugation).	15	15	15
Unit 2: Laplace Transforms	Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem (Statement only). Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator.	15	15	15
Unit 3: Linear Vector Spaces	Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.	20	20	20
Unit 4: General Tensors	Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.	10	10	10
Total		**60**	**60**	**60**

Course Outcomes: On successful completion of the course students will able to

CO1: Understand the theory of complex functions, including analyticity, Cauchy-Riemann conditions, and classification of singularities such as poles and branch points.

CO2: Apply complex integration techniques, including Cauchy's integral formula, Laurent and Taylor expansions, and use the residue theorem for evaluating complex integrals.

CO3: Master Fourier transform methods, including the Fourier integral theorem, transform properties, and applications to functions and derivatives, along with the representation of the Dirac delta function.

CO4: Learn Laplace transform techniques and properties, and apply them to solve differential equations, including unit step and delta functions and the damped harmonic oscillator problem.

CO5: Gain foundational knowledge of tensor analysis, including coordinate transformations, tensor operations, and physical tensor quantities, using Einstein summation convention and related tensor properties.

Suggested Readings:

1. Arfken, G. B., Weber, H. J., & Harris, F. E. (2013). *Mathematical Methods for Physicists* (7th ed.). Elsevier.
2. Coddington, E. A. (2009). *An Introduction to Ordinary Differential Equations*. PHI.
3. Simmons, G. F. (2007). *Learning Differential Equations*. McGraw-Hill.
4. Nearing, J. (2010). *Mathematical Tools for Physics*. Dover Publications.
5. McQuarrie, D. A. (2003). *Mathematical Methods for Scientists and Engineers*. Viva Books.
6. Zill, D. G., & Wright, W. S. (2012). *Advanced Engineering Mathematics* (5th ed.). Jones and Bartlett Learning.
7. Goswami, D. N. (n.d.). *Mathematical Physics* (1st ed.). Cengage Learning.
8. Pal, S., & Bhunia, S. C. (2015). *Engineering Mathematics*. Oxford University Press.
9. Kreyszig, E. (2008). *Advanced Engineering Mathematics*. Wiley India.
10. Riley, K. F., & Hobson, M. P. (2011). *Essential Mathematical Methods*. Cambridge University Press.

Course Title: Nuclear Physics
Course Code: MAJ PHY-8.3 / DSC-453
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: To impart knowledge about basic nuclear physics properties and nuclear models for understanding of related reaction dynamics.

Course outlines

Units	Content	L	M	H
Unit 1: Nuclear Properties and Nuclear Forces	Angular momentum, parity, magnetic dipole moment, electric quadrupole moment, simple theory of the deuteron, properties of nuclear forces, spin dependence of nuclear forces.	12	12	12
Unit 2: Nuclear Structure Models	Semi-empirical mass formula, single-particle model of the nucleus, magic numbers, spin-orbit coupling, angular momentum of the energy states, excited states and the shell model, magnetic moments and Schmidt lines, isospin.	12	12	12
Unit 3: Radioactivity and Nuclear Decay	Measurement of lifetimes, multipole moments, theoretical prediction of decay constants, selection rules, angular correlations, internal conversion, Geiger–Nuttall law, barrier penetration applied to alpha decay and beta decay, simple theory of beta decay, Kurie plots, comparative half-life, electron capture, parity violation.	12	12	12
Unit 4: Nuclear Reactions and Fission	Reaction dynamics, the Q-equation, theory of nuclear reactions, partial wave analysis, compound nucleus formation and breakup, resonance scattering and nuclear reactions, optical model theory, stripping reactions, fission process, neutron release in the fission process.	12	12	12
Unit 5: Elementary Particles and Quark Model	Classification of elementary particles, types of interactions, conservation laws, CPT theorem, strangeness, hypercharge, detection of neutrinos, concept of antiparticles, tau-theta puzzle, neutral kaons, strange hyperons, elementary idea of the quark model, SU (2) and SU (3) groups and their applications to baryon multiplet states.	12	12	12
Total		**60**	**60**	**60**

Course outcomes:
CO1: Gain a basic knowledge of nuclear size, shape, binding energy.etc and also the characteristics of nuclear force in detail.
CO2: Gain knowledge about various nuclear models and potentials associated.

CO3: Understand about nuclear decay processes and their outcomes.
CO4: Grasp knowledge about Nuclear reactions, Fission and Fusion and their characteristics.
CO5: Understand the basic forces in nature and classification of particles and study in detail conservations laws and quark models in detail**.**

Suggested Readings

1. Enge, H. A. (1981). *Introduction to Nuclear Physics*. Addison-Wesley.
2. Roy, R. R., & Nigam, B. P. (1983). *Nuclear Physics: Theory and Experiment*. New Age International Publishers.
3. Kaplan, I. (2002). *Nuclear Physics (2nd ed.)*. Narosa Publishing House.
4. Bianchini, L. (2017). *Selected Exercises in Particle and Nuclear Physics*. Springer.
5. Tayal, D. C. (1980*). Nuclear Physics (4th ed.)*. Himalaya Publishing

1. Krane, K. S. (2008). *Introductory Nuclear Physics*. Wiley India Pvt. Ltd.
2. Cohen, B. L. (1998). *Concepts of Nuclear Physics*. Tata McGraw-Hill.
3. Dunlap, R. A. (2004). *Introduction to the Physics of Nuclei & Particles*. Thomson Asia.
4. Perkins, D. H. (2000). *Introduction to High Energy Physics* (4th ed.). Cambridge University Press.
5. Griffith, D. (1987). *Introduction to Elementary Particles*. John Wiley & Sons.
6. Halzen, F., & Martin, A. D. (1984). *Quarks and Leptons: An Introductory Course in Modern Particle Physics*. Wiley India.

Course Title: Electronics
Course Code: MAJ PHY-8.4 / DSC-454
Nature of Course: Major / Core
Credits: 4
Total Marks: 100
Distribution of Marks: End Sem: Th=60
In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course is to equip students with fundamental and applied knowledge of analog and digital electronics—including semiconductor devices, microprocessors, and microcontrollers—enabling them to design small electronic systems through application-oriented learning.

Course Outlines

Units	Content	L	M	H
Unit 1: Transistor Fundamentals	BJT amplifier, Emitter follower, impedance matching application, ac models: T and π, analysis, IC circuit current mirror, open collector, pull up resistor. Bootstrapped and Darlington amplifier Field effect transistors: JFET, MESFET and MOSFET, structure, working, derivation of the equations of IV characteristics under different conditions, JFET as amplifiers and switch MOSFET, E-MOSFET, Digital switching, active load, introduction to CMOS and FINFET technology. Silicon Controlled Rectifier, Liquid Crystal Display, OLED, Solid State battery.	20	20	20
Unit 2: Integrated Circuits: Operational Amplifier	Differential amplifier: circuit configuration, dual input, balanced output differential amplifier, DC-AC analysis, inverting and non-inverting inputs, Review of applications of Operational amplifiers Applications of linear digital ICs Comparator, A/D, D/A, PLL, VCO, interfacing Circuit Instrumentation amplifier, Schmitt Trigger Circuits Active filters (Filter approximation,) Filtering and noise reduction.	15	15	15
Unit 3: Memory element, Microprocessor and Microcontroller	RAM and ROM as memory element. Introduction to microprocessor: Architecture of digital computer system, Von Neumann and Harvard architecture, different microprocessors, architecture, pin diagram, different bus, programming model using intel 8085, register set, memory organization, instruction set, simple programming: addition, subtraction, multiplication etc. Introduction to 8051 microcontroller and embedded systems, instruction set, addressing mode, programming, time delay generation, look up table implementation etc.	15	15	15
Unit 4: Digital transmission	Sampling theorem, quantization, Dynamic range, Companding, Pulse code modulation (PCM), Delta modulation, granular noise, slope overloading, adaptive delta modulation, differential PCM	10	10	10
Total		**60**	**60**	**60**

Course outcomes: After completion of the course the students will be able to

CO1: Understand and apply the working of BJT, FET, MOSFET, CMOS, and FINFET in amplifiers and digital circuits.
CO2: Design and analyze op-amp-based circuits and use linear ICs in instrumentation and filtering.
CO3: Explain microprocessor and microcontroller architecture and write simple programs using 8085 and 8051.
CO4: Understand digital transmission techniques like PCM, delta modulation, and apply sampling and quantization concepts.

Suggested Readings:

1. Malvino, A. P., & Bates, D. J. (2007). *Electronic Principles* (7th ed.). Tata McGraw-Hill.
2. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory* (10th ed.). Pearson India.
3. Gaekwad, R. A. (2000). *Op Amps and Linear Integrated Circuits* (4th ed.). Prentice Hall of India.
4. Jain, R. P. (2010). *Modern Digital Electronics* (4th ed.). Tata McGraw-Hill.
5. Millman, J., & Halkias, C. (1991). *Integrated Electronics: Analog and Digital Circuit Systems*. McGraw-Hill.
6. Leach, D. P., & Malvino, A. P. (2006). *Digital Principles and Applications* (7th ed.). Tata McGraw-Hill.
7. Neamen, D. A. (2012). *Semiconductor Physics and Devices* (4th ed.). Tata McGraw-Hill.
8. Horowitz, P., & Hill, W. (2015). *The Art of Electronics* (3rd ed.). Cambridge University Press.
9. Gaonkar, R. S. (2002). *Microprocessor Architecture, Programming & Applications with the 8085* (5th ed.). Prentice Hall.
10. Mazidi, M. A., Mazidi, J. G., & McKinlay, R. D. (2007). *The 8051 Microcontroller and Embedded Systems* (2nd ed.). Pearson Education.

Course Title: Dissertation (Collection of Data, Analysis, Report Preparation)
(In lieu of DSC-452, DSC-453, DSC-454)
Course Code: RP PHY-4.2 / DSR-452
Nature of Course: Research Project
Credits: 12
Total Marks: 300
Distribution of Marks: 3 X **[60** (End Sem) + **40** (In sem)]

Course Objective: To make the students understand how to use the basic knowledge of electronics, thermodynamics, optics, matter etc. in practical environment and proceed to do research on the subject.

Course Outcomes:
CO1: Collect data and revise an experimental procedure iteratively and reflectively.
CO2: Gain the ability to use the theoretical knowledge of physics to evaluate the process and outcome of an experiment quantitatively and qualitatively.
CO3: Extend the scope of investigation whether or not result come out as expected and communicate the process and outcome of an experiment.

Detailed Syllabus of 8th Sem FYUGP/2nd Sem PG Minor Course

(For disciplines other than Physics)

Course Title: Nuclear Physics & Electronics-II

Course Code: MIN PHY-8.1 / DSM-451

Nature of Course: Minor

Credits: 4

Total Marks: 100

Distribution of Marks: End Sem: Th=60

In Sem: Sessional Exam=20, Activity (assignment, Quiz, seminar etc) =20

Course objective: The objective of this course, is to offer the students the understanding of the different transistors with different configurations, transistor biasing etc. Moreover, they will have to gain knowledge about binding energy, nuclear models and their applications in different branches of Physics. The course will develop problem-based skills and the acquire knowledge can be applied in the areas of nuclear, medical, archeology, geology and other interdisciplinary fields of Physics and Chemistry.

Course Outlines

Units:	Content	L	M	H
Unit 1: Nuclear Properties, Models	Binding energy, average binding energy and its variation with mass number, angular momentum, magnetic moment, electric moments, nuclear excites. Semi empirical mass formula. Liquid drop model of nucleus, Shell model of nucleus, concept of nuclear force	15	15	15
Unit 2: Neutron, Positron	Neutron, Discovery of neutron by Chadwick. Properties of neutron: mass of neutron, charge of neutron. Discovery of positron.	6	6	6
Unit 3: Detectors and Accelertors	Gas detectors: Ionization chamber and GM Counter. Construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (idea only). Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.	13	13	13
Unit 4: Feedback in amplifiers & Sinusoidal Oscillators	Concept of feedback, different types of feedback, Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, Hartley, Colpitts oscillators and determination of Frequency oscillations.	10	10	10
Unit 6: Number system logic gates	Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates.	11	11	11
Unit 7: Logic circuit	De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra.	5	5	5
Total		**60**	**60**	**60**

Course Outcomes: After completion of this course the students
CO1: Understand nuclear properties, models, and nuclear forces.
CO2: Explain the discovery and properties of neutron and positron.
CO3: Describe working principles of detectors and particle accelerators.
CO4: Analyze feedback in amplifiers and design sinusoidal oscillators.
CO5: Differentiate analog and digital systems; convert between number systems.
CO6: Simplify logic circuits using Boolean algebra and universal gates.
CO7: Apply concepts to solve problems in nuclear physics and electronics.

Suggested Readings:

1. Lilley, J. (2001). *Nuclear Physics: Principles and Applications*. Wiley.
2. Krane, K. S. (1987). *Introductory Nuclear Physics*. Wiley.
3. Knoll, G. F. (2010). *Radiation Detection and Measurement* (4th ed.). Wiley.
4. Lee, S. Y. (2012). *Accelerator Physics* (3rd ed.). World Scientific.
5. Boylestad, R. L., & Nashelsky, L. (2009). *Electronic Devices and Circuit Theory* (10th ed.). Pearson Education.
6. Schilling, D. L., & Belove, C. (1989). *Electronic Circuits: Discrete and Integrated*. McGraw Hill.
7. Mano, M. M. (2004). *Digital Logic and Computer Design*. Pearson Education.