MASTER OF SCIENCE IN PHYSICS

M. Sc. (Physics)

कुमाऊँ विश्वविद्यालय
1973
सर्वं ज्ञाने परिसमाप्यते

SYLLABUS FRAMED AS PER THE

NATIONAL EDUCATION POLICY-2020

Year	Sem.	Course Code	Paper Title	Theory/ Practical	Credits
Bachelor (Research in Physics)					
FOURTH YEAR	VII		**Mathematical Physics**	Theory	(04)
			Classical Mechanics	Theory	(04)
			Quantum Mechanics	Theory	(04)
			Communication Electronics	Theory	(04)
			Practical	Practical	(04)
	VIII		**Atomic and Molecular Spectra**	Theory	(04)
			Electrodynamics	Theory	(04)
			Elementary Particle Physics	Theory	(04)
			Nuclear Physics	Theory	(04)
			Practical	Practical	(04)
Master in Physics					
FIFTH YEAR	IX		**Advanced Quantum Mechanics**	Theory	(04)
			Plasma Physics	Theory	(04)
			Advanced Electronics -I/Astrophysics -I/High Energy Physics-I/ Spectroscopy-I	Theory	(04)
			****Advanced Electronics -II/Astrophysics -II/High EnergyPhysics-II/ Spectroscopy-II**	Theory	(04)
			Practical	Practical	(04)
	X		**Condensed Matter Physics**	Theory	(04)
			Statistical Physics	Theory	(04)
			****Advanced Electronics -III/Astrophysics -III/High EnergyPhysics-III/ Spectroscopy-III**	Theory	(04)
			Advanced Electronics -IV/Astrophysics -IV/High Energy Physics-IV/ Spectroscopy-IV	Theory	(04)
			Practical	Practical	(02)

**** A Candidate is required to opt any one specialisation out of the available specialisations in fifth Year.**

Subject prerequisites:
Bachelor in Science with Physics as major subject.

Programme Outcomes (POs):	
Students having Degree in ***Bachelor (Research in Physics)*** should have knowledge of advanced concepts of Physics and ability to apply this knowledge in various fields of academics, research and industry. They may pursue their future career in the field of academics, research and industry.	
PO1	Competence in the methods and techniques of calculations using Mathematical Physics, Classical Mechanics, Quantum Mechanics and Communication Electronics. It will develope an analytical skill on an advanced level and will enable the student to have mathematical tools to solve complex problems of Physics. The Programme will motivate the student to know more about the matter, the universe and the recent developments in the field of science. The student will have adequate knowledge to work for the industry,, consultancy, education, and research
PO2	The students would gain substantial knowledge in various branches of physics. The programme will enable the student to explore more in the field of his/her choice like Advanced Electronics, Spectroscopy, Astrophysics and High energy Physics. The student will be well equipped with the knowledge required for different organizations, industry, R& D sector.

Programme specific outcomes (PSOs):
PG IST YEAR/ **Bachelor (Research in Physics)**
Bachelor (Research in Physics) programme provides the student the adequate knowledge, general competence, and analytical skills on an advanced level, needed in industry, consultancy, education, research, or in government organisation.

Programme specific outcomes (PSOs):
PG IIND YEAR/ **Master in Physics**
• The Master of Science in Physics programme provides student the adequate knowledge to use mathematical tools to solve complex physical problems and have the solid background and experience needed to analyze and solve advanced problems in physics. • This course would enable the student to acquire scientific skills and the practical knowledge by performing experiments in general physics and electronics. • The student would also get some research oriented experience by doing theoretical and experimental projects in the last semester under the supervision of faculty. • The course as a whole opens up several career doors for the students interested in various areas of science and technology in private, public and government sectors. Students may get job opportunities in higher education, research organizations, physics consultancy and many others. Some of the institutions where physics students can start their career are: BARC, DRDO, NPTC, IISc, ISRO, ONGC, BHEL, PRL, NPL, SINP, VECC, IITs, NITs, IIPR etc.

DETAILED SYLLABUS FOR BACHELOR (RESEARCH IN PHYSICS) OR P.G FIRST YEAR

BACHELOR (RESEARCH IN PHYSICS)		
Programme: BACHELOR (RESEARCH IN PHYSICS)	YEAR IV	SEMESTER VII/PAPER I
Subject: Physics		
Course code	Course Title: **Mathematical Physics**	

Course Outcomes

Students would be able to understand the mathematical methods essential for solving the advanced problems in physics. It would be helpful in the development of the ability to apply the mathematical concepts and techniques to solve the problems in theoretical and experimental physics. The knowledge of mathematical physics would be beneficial in further research and development as it serves as a tool in almost every branch of science and engineering Course.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Special Functions Series solution of differential equations, Legendre, Bessel, Hermite, and Laguerre differential equation and related polynomial, physical integral form of polynomials and their orthogonality relations. Generating Function and recurrence relation.	**15**
UNIT II	Curvilinear Coordinates and Tensors Curvilinear Coordinates and various operators in circular, cylindrical and spherical coordinate systems, classification of Tensors, Rank of a Tensor, covariant and contra-variant tensors, symmetric and anti-symmetric Tensors, Kronecker delta symbol. Contraction of Tensor, metric Tensor and Tensor densities, covariant differentiation and Geodesic equation (variational Method).	**15**
UNIT III	Complex Variables Function of complex variable, Cauchy's Riemann differential equation, Cauchy's integral theorem, residues and Cauchy's residues theorem, singularities, evolution of residues and definite integral.	**15**
UNIT IV	Integral Transforms Fourier integral and Fourier Transform, Fourier integral theorem, finite and infinite integral, Laplace transform of elementary function (Dirac delta & Green's function), Solution of simple differential equations.	**15**

Suggested Readings: B. S. Rajput: Mathematical Physics (Pragati Prakashan, Meerut) L. I. Pipes: Mathematical Physics (McGraw Hill) P. K. Chattopadhyay: Mathematical Physics (Wiley Eastern, New Delhi) Afriken.: Mathematical methods for Physics Harper Charlie: Introduction to Mathematical Physics Mathews and Walker: Mathematical Methods of Physics (Benjamin press) Horse and Feshbach : Methods of Theoretical Physics (McGraw Hill)	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VII/PAPER II</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Classical Mechanics</td></tr>
<tr><td colspan="4">Course Outcomes:
In this course students would learn to apply the Newtonian laws using various mathematical formulations to describe the motions of macroscopic objects using generalized coordinates, momentum, forces and energy. The classical mechanics would be helpful in understanding of advanced branches of modern physics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Mechanics of a System of Particles Constraints and generalized coordinates, D Alembert’s principle, Lagrange equations for holonomic and non holonomic systems and their applications, conservation laws of linear momentum, energy and angular momentum.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Hamiltonian Formulation and Hamilton Jacobi Theory Hamiltonian equations of motion and their physical significance, Hamilton’s principle, principle of least action, canonical transformations Hamilton-Jacobi theory, Poisson brackets, properties of Poisson bracket, Poisson’s Theorem, Lagrange bracket.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Dynamics of a Rigid Bodies Motion of a rigid body, body and space Reference system, angular momentum and Inertia tensor, Principle axes- Principle moments of Inertia, spinning tops, Euler angles, Infinitesimal rotations.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Central Force Problem Action and angle variables, phase integral, small oscillations, Kepler’s laws of Planetary motion and their deduction, scattering in a Central field, Rutherford scattering cross section</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
H. Goldstein : Classical Mechanics

N.C. Rana & P. S. Jog : Classical Mechanics

Landau and Lifshitz : Mechanics, Pergamon Sommerfeld : Mechanics, Academic Press</td><td></td></tr>
</table>

Whittaker : Analytical Dynamics of Particles and Rigid Bodies - Cambridge Raychaudhuri : Classical Mechanics, Oxford Bhatia : Classical Mechanics, Narosa. H.M. Agrawal: Classical Mechanics, New Age International	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VII/PAPER III</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code……</td><td colspan="3">Course Title: Quantum Mechanics</td></tr>
<tr><td colspan="4">Course Outcomes:

The course provides an understanding of the behaviour of the systems at microscopic (atomic and nuclear) scale and even smaller. Students would learn basic postulates and formulations of quantum Mechanics. The course, in fact, plays an important role in explaining the behaviour of all physical systems in the universe. The course includes the study of a brief review of foundations of quantum mechanics, matrix formulation of quantum mechanics, symmetry in quantum mechanics and approximation methods for bound states.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Non-Relativistic Quantum Mechanics and Schrödinger Equation
Schrödinger’s equation, Probability and current densities, continuity equation, physical interpretation of wave function, orthogonality of eigen functions, Principle of superposition, wave packet, normalization, Schrödinger’s equation in three dimensions, centrally symmetric square well and harmonic potentials, harmonic oscillator and its wave functions, Hydrogen atom.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Operator Formulation of Quantum Mechanics
State vectors and operators in Hilbert Space, Eigen values and Eigen vectors of an operator, Hermitian ,Unitary and Projection operators, commuting operators, BRA and KET Notations, Postulates of Quantum Mechanics, co-ordinate Momentum and Energy representations, dynamical behavior, Heisenberg, Schrödinger and interaction Pictures</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Theory of Angular Momentum
Orbital Angular momentum operator, its eigen value and eigen functions, space quantization, spin angular momentum, Pauli’s theory of spin, Addition of angular momentum, ClebschGordan coefficients</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Approximation Methods
Time independent and Time dependent Perturbation Theory Stationary Perturbation, first and second order</td><td>15</td></tr>
</table>

<table>
<tr><td></td><td>corrections, WKB approximation methods, connection formula and boundary conditions, Bohr Sommerfield quantization rule, Penetration of potential barrier, Time independent perturbation theory and its applications. Applications of time-dependent perturbation theory for constant perturbation, Fermi Golden rule, Coulomb excitation, Sudden and adiabatic approximation.</td><td></td></tr>
<tr><td colspan="2">Suggested Readings
B. S. Rajput: Advanced Quantum Mechanics
Schiff: Quantum Mechanics
Thankppan: Quantum Mechanics
Loknathan and Ghatak Quantum Mechanics</td><td></td></tr>
<tr><td colspan="2">Can be opted by
Bachelor in Science with Physics as major subject</td><td></td></tr>
<tr><td colspan="2">Suggested Continuous Evaluation Methods:</td><td></td></tr>
<tr><td colspan="2">Course Prerequisite: As per the university ordinance.</td><td></td></tr>
<tr><td colspan="2">Suggested Equivalent Online Courses:
1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8</td><td></td></tr>
</table>

<table>
<tr><th colspan="3">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td>Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VII/PAPER IV</td></tr>
<tr><td colspan="3">Subject: Physics</td></tr>
<tr><td>Course code……</td><td colspan="2">Course Title: Communication Electronics</td></tr>
<tr><td colspan="3">Course Outcomes

This course helps the student to gain basic ideas of the fundamentals of communication systems. The course includes Modulation AM and FM (Transmission and reception), SSB transmission, AM detection, AGC, Radio receiver characteristics, FM transmitter, Propagation of Radio Waves ,Antenna , Fundamentals of image transmission,TV transmitter,Transmission Lines etc.The course may provide the opportunity to work in any organization related to communication.</td></tr>
<tr><td colspan="2">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="2">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="3">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
</table>

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Modulation AM and FM (Transmission and reception): Modulation, AM generation, Power consideration, Balanced modulator, SSB transmission, AM detection, AGC, Radio receiver characteristics, signal to noise ratio, FM analysis, noise considerations, generation, direct method and reactance tube method, FM transmitter, AFC, FM Propagation, phase discriminator	15
UNIT II	Propagation of Radio Waves Ground wave, sky wave and space wave propagation. Ionosphere (Ecclr- larmer theory, magneto ionic theory.	15
UNIT III	Antenna and TV Antenna, HF antenna, Yagi antenna, loop antenna, Satellite communication, parabolic reflector, dish antenna, Fundamentals of image transmission, vestigial transmission, TV camera tubes, image orthicon, vidicon, TV transmitter, TV receiver and picture tubes.	15
UNIT IV	Transmission Lines Voltage and current relations on transmission line, propagation constant, characteristic impedance, impedance matching, quarter wave T/L as impedance transformer, attenuation along coaxial cable, cables of low attenuation, propagation of radio waves between two parallel lines, wave guide modes, TE10 mode and cut off wavelength, cavity resonator, light propagation in cylindrical wave guide, step index and graded index fibers, attenuation and dispersion in fibers	15

Suggested Readings: George Kennedy & Davis: Electronics Communication Systems Millar & Beasley: Modern Electronics Communication R.R Gulani: Monochrome and colour television (Wiley Eastern Limited) Taub and Schilling: Principle of Communication Systems (TMH) Simon Gaykuti: Communication Systems (John Wiley & Sons Inc. 1994	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VII/PAPER V</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: PRACTICAL</td></tr>
<tr><td colspan="4">Course Outcomes:

Student would gain practical knowledge by performing various experiments of Electronics and Optics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">List of Experiments</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="2">Study of RC circuit with an AC source using phase diagrams.

Absorption Spectrum of KMnO4 using Hilger-Nutting Photometer.

Young's modulus by Interference method.

NPN and PNP Transistor Characteristics with (a) Common base (b)
Common emitter configurations/ h – parameter.

Study of RC- coupled/ Transformer Coupled Amplifier.

Study of B-H curve.

Study of Amplitude Modulation /Demodulation.

Verification of the Hartmann's Formula.

Frank-Hertz experiment.

e/m by Zeeman effect.

Determination of susceptibility.

Study of CRO.

Velocity of Ultrasonic waves.

Linear Air track.

Leacher Wire</td><td>60</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
</table>

Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74 2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities		

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII/PAPER I</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code……</td><td colspan="3">Course Title: Atomic and Molecular Spectra</td></tr>
<tr><td colspan="4">Course Outcomes
The course structure includes atomic and molecular spectroscopy. As per the course structure, the students learn basics concepts of spectroscopic principles and rules. Students would learn technique in spectroscopy and know about their applications. The course is helpful for the students to explore R & D opportunities in various areas of science and technology such as biomedical, industrial and environmental fields.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Fine structure of hydrogen spectrum, L-S and J-J coupling, Spectroscopic terms, Hund’s rule and time reversal, Pauli’s exclusion principle.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Alkali spectra, spin-orbit interaction and fine structure in alkali Spectra, Equivalent and non-equivalent electrons, Normal and anomalous Zeeman effect, Paschen Back effect, Stark effect, Hyperfine structure (qualitative).</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Molecular spectra of diatomic molecules, Born Oppenheimer approximation, elementary idea of quantization of rotational and vibrational energy, rotational spectra for rigid and non rigid rotations, vibrational spectra (harmonic and an-harmonic), intensity and selection rules and molecular constants.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Atomic Polarizability, Raman spectra, Quantum theory of Raman spectra, Determination of molecular structure, Electronic spectra, band system, Progression and sequences, band head formation, Condon parabola, Franck Condon Principle dissociation energy and its determination</td><td>15</td></tr>
<tr><td colspan="3">Suggested Readings:
C. B. Banwell: Fundamentals of Molecular Spectroscopy

Walker and Stranghen: Spectroscopy Vol. I, II, & III G.M.

Barrow: Introduction to Molecular Spectroscopy Herzberg: Spectra of diatomic molecules</td><td></td></tr>
</table>

Jeanne L Mchale: Molecular Spectroscopy J. M. Brown: Molecular Spectroscopy P. F. Bemath: Spectra of atoms and molecules J. M. Holias: Modern Spectroscopy K. Thyagrajan and A.K. Ghatak: Lasers: Theory and applications A Yariv: Quantum Electronics M. D. Levenson: Intoduction to non-linear laser spectroscopy B. B. Laud: Laser and non-linear optics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII/PAPER II</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code……</td><td colspan="3">Course Title: Electrodynamics</td></tr>
<tr><td colspan="4">Course Outcomes:
The study of electrodynamics provides basic foundation for the student to understand advance courses of physics. The course includes Basic equations of Electromagnetism, Electrostatics; Magnetostatics; Maxwell’s equation, Four Vector Formalism of Maxwell’s Equations Four vector potential, electromagnetic field tensor and Quantization of electromagnetic energy</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Electromagnetism
Basic equations; Electrostatics; Magnetostatics; Different Systems of Units, Preliminary notations, four- vectors, Lorentz transformations, time, space and light like separations, Lorentz invariants, Energy and Momentum.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Maxwell’s Equations
Maxwell’s equation, Displacement current, electromagnetic waves in conducting and nonconducting medium, Poynting theorem, boundary condition at the interface of conducting and non conducting media, propagation between parallel conducting plates. Electromagnetic wave equations</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Four Vector Formalism of Maxwell’s Equations
Four vector potential, electromagnetic field tensor, Lorentz invariance, Lorentz force, covariant form of Maxwell’s equations, four vector current, continuity equation, Gauge invariance of Maxwell equation, electromagnetic energy-momentum tensor, Motion of charge particle in electromagnetic field, Lorentz force</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Electromagnetic Radiation
Lienard-Witchert potential, conventional potential, Quantization of electromagnetic energy (virtual photon), Radiation from an Accelerated Charge, Fields of an accelerated charge; angular and frequency distributions of the emitted radiation, special cases of acceleration parallel and perpendicular (circular orbit) to velocity; Larmor’s</td><td>15</td></tr>
</table>

	formula and its relativistic Generalization; Bremstrahlung, Cerenkov radiation	
Suggested Readings Jackson: Classical electrodynamics; Wiley Eastern, New Delhi Landau and Lifshitz: Classical theory of fields; Pergameon Press Thide : Electromagnetic field Theory Panofsky and Phillips: Classical Electricity and Magnetism Landau &Lifshitz : Electrodynamics of Continuous Media		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

<table>
<tr><td colspan="4">BACHELOR (RESEARCH IN PHYSICS)</td></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII/PAPER III</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Elementary Particle Physics</td></tr>
<tr><td colspan="4">Course Outcomes
The course is important for the students to learn about the most fundamental building blocks of matter and radiation, interaction among elementary particles and hence to understand their behaviour. The course provides a platform for the students seeking research opportunities in high energy physics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Elementary Particles and Conservation Laws:

History of elementary particles, prediction of neutrinos, the meson riddle, classification schemes of elementary particles, Fundamental interactions among elementary particles: special emphasis to Strong and weak interactions, Strange particles, Resonances, , Symmetries and conservation laws, Lepton and Baryon number and their conservation, Isospin , Conservation of isospin and its component I_3, Strangeness and its conservation, Hypercharge, Gell - Mann Nishijima relation, Parity, Time reversal and charge conjugation, Parity violation, CP violation in mesons, CPT invariance.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Particle Models:

Fermi Yang model, Sakata model, shortcomings of these models ,eight fold way scheme of hadrons and baryons and mesons multiplets , positive and negative aspects of eight fold way scheme, Necessity of Quark model, Gell - Mann Zweig Quark model and Quark structure of Hadrons, Positive facets of quark model, Elementary idea of charm, bottom and top quarks, Quantum number of quarks, Experimental evidence for the existence of quarks.</td><td>15</td></tr>
</table>

UNIT III	**Unitary Symmetries and Young Tableaux:** Symmetry ,symmetry transformation and groups, basics of unitary groups, Special Unitary Groups, fundamental representation of SU(2) and SU(3), diagonal generators and weights, generators of SU(2) , U(2) ,SU(3) and U(3), weight diagram of fundamental representation of SU(2) and its physical interpretation, Weights of SU(3) and their physical interpretation, Weight diagrams of the fundamental and Conjugate fundamental representations of SU(3), I, U, V spins, Young Tableaux and unitary symmetry, standard arrangements of young tableaux, integer- notation of the tableaux representing different Special Unitary Groups, Dimensionality of the representations of SU(N), Simple product representation using Young Tableaux technique	15
UNIT IV	Nuclear and Particle Detectors Basic principle of particle detectors, Ionization chamber, Proportional counter, Geiger-Muller Counter, Scintillation counters and-ray spectrometer, semiconductor detector, Nuclear emulsion technique, Cloud chamber, Bubble chamber	15

Suggested Readings: D. H. Perkins: Introduction to High Energy Physics, Cambridge University Press, 2000 S. N. Ghoshal: Atomic and Nuclear Physics, S. Chand and Company Ltd, 1994 D. Griffiths : Introduction of Elementary Particles DB Lichtenberg: Unitary Symmetry and Elementary Particles, Academic Press, 1978 Hughes: Elementary Particles Blatt and Weiskopff : Theoretical Nuclear Physics FE Close: Quarks and Patrons P.P.Cheng and G.LF Li : Gauge Field Theory: W. E. Burcham : Nuclear Physics R. M. Singru: Introduction to experimental nuclear physics E. Segre: Experimental nuclear physics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">BACHELOR (RESEARCH IN PHYSICS)</th></tr>
<tr><td colspan="2">Programme: BACHELOR (RESEARCH IN PHYSICS)</td><td>YEAR IV</td><td>SEMESTER VIII- PAPER IV</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Nuclear Physics</td></tr>
<tr><td colspan="4">Course Outcomes:
In this course students would know about the general properties of nuclei, nuclear forces and detectors, radioactive decay and nuclear reactions. The course builds a foundation for the students to carry out research in the field of nuclear physics, high energy physics, nuclear astrophysics, nuclear reactions and applied nuclear physics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Nuclear Properties and Nuclear Models Concepts of Atomic Nuclear-Size, Shape, charge distribution, spin & parity, magnetic moment; electric quadrupole moment; binding energy; semi-empirical mass formula, mirror nuclei, Liquid drop model, Experimental evidence for shell effects, Shell model, Magic numbers, Spin orbit coupling, Single particle shell model-its validity and limitations; collective model.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Nuclear Forces and Nuclear Interactions Theory of Deuteron and nuclear level properties, nucleon - nucleon interactions, low & high energy nucleon-nucleon scattering, Yukawa’s Meson theory of nuclear forces, Spin dependence and charge independence of nuclear forces.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Nuclear Reactions Kinds of nuclear reactions; Conservation laws; Nuclear reaction Kinematics; charge particle reaction spectroscopy; neutron spectroscopy; nuclear cross-section; compound nucleus; Nuclear transmutations, continuum theory of nuclear reaction, Nuclear fission, Chain reactions, Nuclear fusion, Thermonuclear reactions.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Nuclear Decays Basic understanding of α and β decay, Fermi theory of beta decay, selection rules in γ decay, Neutrino hypothesis, Parity violation in beta decay, K capture and internal conversion.</td><td>15</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
</table>

Suggested Readings: E. Burcham: Nuclear Physics Ervin Kapalan: Nuclear Physics Roy & Nigam: Nuclear Physics S. N. Ghoshal: Atomic and Nuclear Physics A.Enge: Nuclear Physics .D. Evans: Nuclear Physics E. Segre: Nuclei and Particles H.M. Agrawal: Nuclear Physics, PHI Learning	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

BACHELOR (RESEARCH IN PHYSICS)		
Programme: BACHELOR (RESEARCH IN PHYSICS)	YEAR IV	SEMESTER VIII/PAPER V

Subject: Physics

Course code	Course Title: PRACTICAL

Course Outcomes:

The student will have adequate knowledge to perform the experiments of different fields of physics with clear understanding of the theory behind the experiment.
Student will know about various electronic components and learn to design some basic electronic circuits and study their applications.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**

Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4

UNIT	List of Experiments	No. of Lectures
	1. Study of the Phase measurement by superposition of voltages with LCR Circuits. 2. Study of different oscillators (Hartely, colpit, Weinbridge oscillators etc.). 3. Study of an electronically regulated power supply. 4. Study of negative Feed- back Amplifier. 5. Determination of wavelength (λ) and wavelength difference (Δλ) by Michelson Interferometer. 6. Study of different type of Resistances and Diodes. 7. Study of Photo Voltaic Cell. 8. Stefan's Constant 9. FET characteristics 10. Fresnel's Law 11. Cauchy Formula 12. Lattice Dynamic Kit 13. Study of Logic gates 14. Detection Efficiency of Diode 15. Fabry – Perot Interferometer 16. Four Probe method	60

Can be opted by
Bachelor in Science with Physics as major subject

Suggested Continuous Evaluation Methods:

Course Prerequisite: As per the university ordinance.

Suggested Equivalent Online Courses:

1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities

Minor/Elective (04 Credit)

Exclusively for Other faculty students (any one from the list only if applicable)

1.Renewable Sources of Energy

2.Radiation Physics

3. Physics of Weather and Climate

MINOR ELECTIVE – RENEWABLE SOURCES OF ENERGY		
Programme: **Minor Elective**	**Year: IV**	**Semester: VII/VIII**
Subject: **Physics**		
Course Code:	Course Title: **Renewable Sources of Energy**	
Course Outcomes:		
Credits: 04	Minor/Elective	
Max. Marks: 100 External Exam: 75 Internal Assessment: 25	Min. Passing Marks: 36	
Total No. of Lectures-Tutorials		

Unit	Topic	No. of Lectures
Unit I	Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in wind Energy.	15
Unit II	Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.	
Unit III	Solar energy and its importance, storage of solar energy, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems.	` 15
Unit IV	Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Tide characteristics and Statistics: Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass	15

Suggested Reading

Reference books

1. Non-conventional energy sources, B.H. Khan, McGraw Hill
2. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
3. RenewableEnergy,Powerforasustainablefuture,GodfreyBoyle,3rd Edn., 2012.
4. Renewable Energy Sources and Emerging Technologies, Kothari et.al., 2ndEdition, PHI Learning.
5. Solar Energy: Resource Assesment Handbook, P Jayakumar, 2009

MINOR ELECTIVE: RADIATION PHYSICS		
Programme: **Minor Elective**	**Year: IV**	**Semester: VII/VIII**
Subject: **Physics**		
Course Code:	Course Title: **Radiation Physics**	
Course Outcomes:		
Credits: 04	Minor/Elective	
Max. Marks: 100 External Exam: 75 Internal Assessment: 25	Min. Passing Marks: 36	
Total No. of Lectures-Tutorials		

Unit	Topic	No. of Lectures
Unit I	Interactions of electrons with matter - Specific energy loss, radiative mode of energy loss, electron range and transmission curves. Interaction of gamma rays with matter - Elastic scattering, photoelectric effect, Compton scattering.	15
Unit II	Klein-Nishina formula (qualitative) and pair production processes, cross section, gamma ray attenuation, linear and mass absorption coefficients. Radiation quantities and units - radiation exposure, absorbed dose, equivalent dose and effective dose.	15
Unit III	Sources of ionising radiations in the environment – terrestrial radiation sources and radionuclides, cosmic radiations and cosmogenic radionuclides. Technologically enhanced radiation sources. Artificial radiation sources artificial radionuclides. Production of radioisotopes using reactors. Application of radioisotopes in medicine, agriculture and industry.	` 15
Unit IV	Fission chain reaction. Slowing down of neutrons - moderators. Conditions for controlled chain reactions in bare homogeneous thermal reactor, Effect of reflectors. Brief introduction of nuclear fuel cycle.	15

Suggested Reading:

Patel S B, „Nuclear Physics - An Introduction‟ (Wiley Eastern, 1991)
2. Krane K S, „Introductory Nuclear Physics‟ (John Wiley, 1988)
3. Roy R K and Nigam P P, „Nuclear Physics - Theory and Experiment‟ (Wiley Eastern Ltd., 1993)
4. Singru R M, „Experimental Nuclear Physics‟ (Wiley Eastern, 1972)
5. Zweifel P F, „Reactor Physics‟, International Student Edn. (McGraw Hill, 1973)
6. Kapoor S S and Ramamurthy V S, „Radiation Detectors‟ (Wiley Eastern, 1986)
7. Henry Semat& John R AlBright, „Introduction to Atomic and Nuclear Physics‟ V Edn. (Chapman & Hall, 1972)
8. Burcham W E, „Nuclear Physics‟, II Edn. (Longman, 1963)
9. Mann W B, Ayres R L and Garfinkel, „Radioactivity and its Measurements‟ (Pergamon Oxford, 1980) 10. Little field T A and Thorley N „Atomic and Nuclear Physics‟, II Edn. (Nostrand Co., 1988.

<table>
<tr><td colspan="4">MINOR ELECTIVE : PHYSICS OF WEATHER AND CLIMATE</td></tr>
<tr><td colspan="2">Programme:Minor Elective</td><td>Year: IV</td><td>Semester: VII/VIII</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course Code:</td><td colspan="3">Course Title: Physics of Weather and Climate</td></tr>
<tr><td colspan="4">Course Outcomes:</td></tr>
<tr><td colspan="2">Credits: 04</td><td colspan="2">Minor/Elective</td></tr>
<tr><td colspan="2">Max. Marks: 100
External Exam: 75
Internal Assessment: 25</td><td colspan="2">Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials</td></tr>
<tr><td>Unit</td><td colspan="2">Topic</td><td>No. of Lectures</td></tr>
<tr><td>Unit I</td><td colspan="2">Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature, requirements to measure air temperature; temperature sensors: types;</td><td>15</td></tr>
<tr><td>Unit II</td><td colspan="2">atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall</td><td>15</td></tr>
<tr><td>Unit III</td><td colspan="2">radiation: absorption, emission and scattering in atmosphere; radiation laws.Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.</td><td>15</td></tr>
<tr><td>Unit IV</td><td colspan="2">Climate and its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.</td><td>`
15</td></tr>
</table>

Reference books:

1.Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books

2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.

3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.

4. Text Book of Agro meteorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur .

5. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER I</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Advanced Quantum Mechanics</td></tr>
<tr><td colspan="4">Course Outcomes:
The course includes the study of scattering theory, identical particles, relativistic wave equations and quantization of wave fields. The course would describe the nature and behaviour of matter and energy at subatomic level. In particular, theory of scattering gives an understanding collision between a quantum mechanical particle and target. The study of relativistic quantum mechanics enables the students to understand the behaviour of objects moving with speeds comparable to that of light. The knowledge of this field forms the foundation for pursuing research in Quantum Field Theory and High Energy physics.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Free particle Dirac equation
Discrepancies faced by Schrödinger equations, Klein-Gordon equation and its drawbacks, Dirac's equation for a free particle, Dirac matrices, covariant form of Dirac equation, Probability and current densities, Free particle solutions of Dirac equation, Non conservation of Orbital Angular momentum and idea of spin, Interpretation of negative energy and hole theory</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Dirac particle in Electromagnetic Fields
Dirac equation in electromagnetic fields, Magnetic moment of charged particle, Gauge invariance of Dirac equation in electromagnetic fields, Non- relativistic correspondence of Dirac equation; Pauli equation, Adjoint spinors, Symmetries of Dirac Equation: Parity, Time reversal and Charge Conjugation; Lorentz covariance of Dirac Equation.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Identical Particles and Quantum Field Theory
Identical particles, exchange degeneracy, symmetric and anti symmetric functions for many particle system Classical Fields, Schwinger's action principle, Lagrangian and Hamiltonian densities, Field equation, quantum structure of free fields and the particle concept,</td><td>15</td></tr>
</table>

	Quantization relations, Quantization of non relativistic Schrödinger matter field, System of identical bosons and fermions, Commutation and anti-commutation relations, Occupation number representation, creation and annihilation operators.	
UNIT IV	**Quantum Theory of Scattering** Scattering Theory, Scattering cross section, method of partial wave analysis, phase shift, Optical theorem, scattering length, effective range theory; low energy scattering, scattering from a square potential well and a rigid sphere, Born approximation, Validity of Born approximation, Born approximation through time dependent perturbation, its application to square well potential.	15
Suggested Readings: Davydov : Quantum Theory Messiah : Quantum Mechanics Vols. I & II Rajput B. S. : Advanced Quantum Mechanics Ropman P. : Advanced Quantum Mechanics Trigg : Quantum Mechanics ThankappanV.K. : Quantum Mechanics Sakurai J.J. : Quantum Mechanics		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER IX PAPER II
Subject: Physics		
Course code	Course Title: **Plasma Physics**	
Course Outcomes: The course includes Magneto Hydrodynamics , Plasma Propagation and other topics related to plasma. Plasma physicists study plasmas, which are considered a distinct state of matter and occur naturally in stars and interplanetary space .The knowledge acquired by the student can be used in various field of Physics and thus career prospects are bright in the field of research.		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Introduction to Plasma** Elementary concept of plasma: Debye Shielding, Plasma parameters, Drift of guiding center, Gradient drift, Curvature drift, Magnetic mirror, Plasma confinement	15
UNIT II	**Magneto-Hydrodynamics and Fluid Plasma** Plasma Oscillation, Fluid equations for a plasma, Continuity equation, Wave Propogation in unmagnetized plasma, Magneto Hydrodynamics , Hydrodynamical description of Plasma: fundamental equation, Concept of convective derivative, hydromagnetic waves, magneto-sonic and Alfven waves.	15
UNIT III	**Magneto Plasma** Wave phenomena in Magneto plasma: Polarization, Phase velocity, group velocity, cutoff, resonance for electromagnetic wave propagating parallel and perpendicular to the magnetic field Helicon, Faraday rotation,.	15
UNIT IV	**Electromagnetic Wave Propagation in Plasma** Propagation at finite angle and CMA diagram, Propagation through ionosphere and magnetosphere Derivation of moment Equation from Boltzmann Equation, Momentum balance equation, Equations of state, Two-fluid equations, Plasma resistivity	15
Suggested Readings: Jackson: Classical Electrodynamics; Wiley Estern, New Delhi		

Bittencourt: Plasma Physics Chen: Plasma Physics Robert J Goldston and Paul H. Rutherford: Introduction to Plasma Physics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER III a
(Specialization paper)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Advanced Electronics- I</td></tr>
<tr><td colspan="4">Course Outcomes:
This course helps the students to gain basic ideas of the construction and working of electronic devices and circuits. The course includes the study of IC technology, Operational amplifier as linear Analog systems and non-linear analog systems. The course is of much practical purpose for the students to learn basics of integrated circuit technology which has wide applications in computing, process control, signal processing, communication systems, digital instruments etc.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
</table>

UNIT	TOPIC	No. of Lectures
UNIT I	**Integrated Circuit Technology** Advantages & limitations of integrated circuits. Classification of IC's, Fabrication of IC's & components, Basic monolithic integrated circuit technology, processes used in monolithic technology, fabrication of monolithic diodes, integrated resistors, integrated capacitors, metal semiconductor contact, The Schottky transistor, thick & thin film IC's, hybrid IC's.	15
UNIT II	**Operational Amplifier(OP-AMP)** Basic OP-AMP, Ideal OP-AMP, Inverting & Non inverting OP – AMP, OP-AMP internal circuit, Differential amplifier, The emmiter coupled differential amplifier, Common Mode Rejection Ratio (CMRR), Operational Amplifier characteristics, DC characteristics- Offset error voltages and currents, Temperature drift of input offset voltage and current. AC characteristics-Frequency response and stability, Frequency compensation, slew rate , Measurement of OP-AMP parameters.	15
UNIT III	**Operational Amplifier Applications** Circuit type of OP – AMP 741, Scale changer, Summing Amplifier-Inverting summing amplifier, non-inverting summing amplifier, subtractor, adder subtractor, voltage follower, current to voltage converter, voltage to current converter, OP-AMP circuits using diodes-Half wave rectifier, Full wave rectifier, Peak value detector, Clipper and Clamper, Sample and hold circuits, Logarithmic Amplifier, Antilogarithmic Amplifier, Integrator, Differentiator.	15

UNIT IV	**Comparator and Waveform Generators** Comparators, Applications of comparator- Zero crossing detector. Regenerative comparator (Schmitt trigger), Square and triangular, waveform generators, Discriminators, OP-AMP as astable and monostable multivibrator, IC 555 timer-Functional diagram, Monostable operation, Astable operation. Applications in monostable and astable mode- Missing pulse detector, Liner ramp generator, Frequency divider, FSK generator, Pulse-Position modulator, Schmitt Trigger.	15
	Suggested Readings: Coughlin: Operational Amplifiers and Linear Integrated Circuits. Schilling and Belove: Electronic circuits Discrete and Integrated,	

Mcgraw Hill Millman and Halkias: Electronic Fundamentals & Applications, Tata Mcgraw Hill Millman and Halkias: Integrated Electronics K.R. Botkar: Integrated Circuits, Khanna Publishers G.K. Mithal and Ravi Mittal: Electronic Devices & Circuits, Khanna Publishers Roychaudhary and Jain: Operational Amplifier & Linear Integrated Circuits V.K. Mehta: Electronics for Scientists & Engineers Robert J Goldston and Paul H. Rutherford: Introduction to Plasma Physics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER III b
(specialization Paper)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Astrophysics –I</td></tr>
<tr><td colspan="4">Course Outcomes:

The course would be important to understand the spherical astronomy, distance measurement in astrophysics, and physics of solar system and extra solar planets. The course provides an opportunity to understand the optics of the different astronomical instruments such as: telescopes, CCD camera etc. It has wide spared in use of R& D sector.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Spherical Astronomy Celestial sphere, Celestial coordinate system (equatorial and alt-azimuth): altitude and azimuth, right ascension and declination, hour angle, sidereal time, mean solar time, summer and winter solstice, seasons. Distance measurements: AU, parsec, standard candles, distance measurement by geometric means (parallax, distances to open clusters).</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Solar System Idea of solar system, Study of planets and their satellites, Earth-Moon system, tidal forces, asteroids, meteors, comets and their origin, composition and dynamical evolution, extra solar planets and their detection.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Telescopes: Basic Optics, Types of telescopes. Telescope mounting systems. Optical telescopes, Infrared, Ultraviolet, X-ray and Gamma-ray telescopes. Schmidt telescopes. Solar telescopes. Design and construction of a simple optical telescopes. Active and adoptive optics in astronomical study.
Sky charts and their importance.</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Classification of detectors, characteristics of detectors. Detectors for optical and infrared wavelength regions. Working of Charge Coupled Device (CCD). sensitivity, noise, quantum efficiency, spectral response, Johnson noise, signal to noise ratio, Application of CCD for stellar imaging, photometry and spectroscopy. Importance of space based astronomy. Observational techniques of astronomical sources from space in</td><td>15</td></tr>
</table>

	infrared, EUV, X-ray and Gamma-ray regions of the electromagnetic spectrum.	
Suggested Readings: Abhyankar K.D. : Astrophysics, Galaxies and Stars VaidyanthBasu : An Introduction to Astrophysics Motz : Astrophysics K S Krishnaswamy : Astrophysics: A Modern Perspective W. M Smart: Spherical Astronomy Mark A. Garlick: The Story of the Solar System		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

MASTER IN PHYSICS			
Programme: **MASTER IN PHYSICS**		YEAR V	SEMESTER IX PAPER III c (Specialization paper)
Subject: Physics			
Course code	Course Title: **High Energy Physics- I**		
Course Outcomes: Students would be able understand the complex properties and behaviour of high energy particles at the microscopic level. This course would encourage students to peruse higher study and research in particle and high energy Physics.			
Credits: 4			Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**			**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0			

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Quantization of Scalar Fields** Elements of field theory, Relativistic fields, Covariant formulation of field theory, Scalar field quantization, Lagrangian Formulation, Evaluation of conjugate momenta, Field Hamiltonian and field momentum densities, Neutral and Charged scalar fields and their quantization, Momentum representation and frequency splitting, Identification of various particle operators, Charge operator, various commutation relations and their properties.	15
UNIT II	**Quantization of Spinor Field** Spinor field and associated field equations, Lagrangian formulation for Spinor field, Evaluation of conjugate momenta, Field Hamiltonian and field momentum densities, Quantization of Spinor Field, Momentum representation and frequency splitting, inclusion of spin wavefunction and description of associated properties, use of projection operators, Identification of various particle operators, Charge density for Spinor field, choice of operator algebra and calculation of field Hamiltonian, field momentum and charge operator, various commutation relations and their properties.	15
UNIT III	**Quantization of Electromagnetic Field** EM fifeld as a vector field an dEM fifeld equations, Classical electromagnetic field theory and its gauge formulation, Covariant Lagrangian formulation for EM field, Quantization of EM field, Evaluation of conjugate momenta, Field Hamiltonian and field momentum densities, Momentum representation and frequency splitting, , Identification of various particle operators concept of longitudinal, temporal and transverse photons and complete quantized expression of EM field in terms of its various polarization states. Choice of the operator algebra with non-vanishing polarization states of quantized EM field.	15
UNIT IV	**Covariant Field Algebra for scalar, spinor and vector fields** Commutation/Anticommutation relations for scalar, spinor and EM field operators, Covariant form of these Field algebras and their properties, Invariant Delta functions and their use in covariant fifeld algebra, Covariant commutation relations for EM field operators and	15

	problems with temporal photons, Lorentz condition and consistency with EM field algebra, Resolution through Gupta- Bleular formulation and evaluation of the field momentum and Hamiltonian.	
Suggested Readings: L. Ryder : Quantum Field Theory B.K. Agarwal : Quantum Mechanics and Field Theory		
F Mandel and Shaw: Quantum Field Theory P. Roman: Quantum Field Theory A. Das: Quantum Field theory M. E. Peskin, D.V. Schroeder : An Introduction to Quantum Field Theory B.S.Rajput : Advanced Quantum mechanics		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

MASTER IN PHYSICS			
Programme: **MASTER IN PHYSICS**		YEAR V	SEMESTER IX PAPER III d (Specialization paper)
Subject: Physics			
Course code	Course Title: **Spectroscopy-I**		
Course Outcomes: Topics covered here deals with the observation and interpretation of radiation absorbed or emitted by molecules. This information can lead into the knowledge of structure and properties of the molecules. The course will enable the student to get an understanding on the Molecular spectra (rotational, vibrational and electronic spectra), NMR and ESR spectroscopy, and their applications. Knowledge acquired by the course will be of much use for various industries and R&D sector.			
Credits: 4			Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**			**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0			

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Rotational spectra:** rotational energy level populations, linear, symmetric, spherical and asymmetric top molecules, rotational selection rules for linear molecules, Stark effect in molecular rotation spectra, Molecular rotation-nuclear spin coupling, Positive and negative character of the wave functions of linear molecules, Symmetric-antisymmetric character and statistical weight of homo-nuclear linear molecule.	15
UNIT II	**Vibrational Spectra:** Vibration spectra of polyatomic molecule, coupling of rotation and vibration, perpendicular and parallel bands, Normal modes of vibration and their analysis in Cartesian coordinates, normal coordinates and their internal coordinates, calculation of vibrational frequencies and force field of H2O and CO2 molecules, anharmonicity, degenerate and non-degenerate vibrations, inversion doubling, Quantized Vibrational motion of polyatomic molecules.	15
UNIT III	**Electronic Spectra:** Spectroscopy of Diatomic and Polyatomic Molecules: Coupling of Electronic and Rotational motion in Diatomic Molecules and Rotational structure of 1π - 1Σ and 1Σ - 1Σ transitions, Vibronic interaction and Herzberg Teller theory for absorption spectrum of benzene vapour, Single vibronic level spectroscopy and lifetime of vibronic levels in benzene, Photoelectron spectroscopy, Quantum yield and the concept of nonradiative transitions in molecules, Electronic transitions, Basics of Absorption, Fluorescence and Phosphorescence.	15
UNIT IV	**NMR and ESR Spectroscopy (Resonance Spectroscopy):** NMR spectroscopy, Bloch Equation, Principle and working of NMR Spectrometer, Basic Principle & Theory of ESR spectroscopy, Resonance conditions, ESR spectrometer, Applications of resonance spectroscopy.	15

Suggested Readings: C.N. Banwell: Fundamentals of Molecular Spectroscopy Walker and Stranghen: Spectroscopy Vol. I, II, & III Herzberg: Spectra of diatomic molecules Jeanne L. Mchale: Molecular Spectroscopy P.F. Bemath: Spectra of atoms and molecules J.M Holias: Modern Spectroscopy K. Thyagrajan and A.K. Ghatak: Lasers: Theory and applications A Yariv: Quantum Electronics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER IX PAPER IV a (Specialization paper)

Subject: Physics	
Course code	Course Title: **Advanced Electronics- II**

Course Outcomes:

This course helps the students to gain basic ideas of the digital communication, optical communication, memory and optoelectronic devices. The course is of much practical purpose for the students to learn advanced concepts of digital communication systems.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Digital Communication:** Digital signal processing, Image processing (Basic ideas only), Pulse Modulation systems, Pulse Amplitude Modulation, Pulse Width Modulation, Pulse position modulation, Pulse code modulation, Delta modulation, Frequency division multiplexing (FDM), Basic idea of digital telemetry.	15
UNIT II	**Optical communication:** Principle of optical communication, Light propagation through cylindrical wave guide, Ray paths of planar optical waveguide, Different modes of propagation of E. M. Wave through optical fiber, TE and TM modes, Power associated with a mode, Radiation modes, Excitation of guided modes, Advantages of multimode fibers and cladding, Optical Fiber connectors, Advantages of optical communication.	15
UNIT III	**Optical Communication Transmitters, Repeaters and Receivers:** Optical Fiber communication transmitters; Semiconductor lasers, Laser diodes and LEDs, Optical gain in a semiconductor, Receivers; Principle of optical detection, PIN photodetector and Avalanche photodiodes, Optical Fiber amplifiers; Optical amplification, Energy levels of erbium ions, Gaussian envelope approximation, Noise in EDFA, EDFAs for WDM transmission.	15
UNIT IV	**Memory and Optoelectronic devices:** Bulk and thin films, Photoconductive devices (LDR), charge coupled devices (CCDs), LCDS, Memory devices, static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, nonvolatile- NMOS, magnetic, optical and ferromagnetic memories.	15

Suggested Readings: Coughlin: Operational Amplifiers and Linear Integrated Circuits. Mchilling and Belove: Electronic circuits Discrete and Integrated, Mcgraw Hill Millman and Halkias: Electronic Fundamentals & Applications, Tata Mcgraw Millman and Halkias: Integrated Electronics K.R. Botkar: Integrated Circuits, Khanna Publishers G.K. Mithal and Ravi Mittal: Electronic Devices & Circuits, Khanna Publishers Malmstadt and Enke: Electronics for scientists Taub and Schilling: Principal of communication systems Simon Gayukti: Communication Systems Martin S. Roden: Analog & Digital Communication Systems V. K. Sarkar and D. C. Sarkar: Optoelectronics and Fibre Optic Communication.	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER IX PAPER IV b (Specialization paper)

Subject: Physics	
Course code	Course Title: **Astrophysics –II**

Course Outcomes:

The Course will provide the deeper understanding of the radiative transfer and the interaction of radiation with matter. It would be important to understand the physics of the death of stars. This study is crucial for the deeper knowledge of the neutron stars, white dwarfs and black holes. Their study provides the insight for the gravitational waves.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Radiation transfer: Definitions of specific intensity, mean intensity, flux and energy density; Equation of radiation transfer; solutions in some specific cases, optical depth; Thermal emission; Blackbody spectrum and its characteristics; Kirchoff's law; Einstein coefficients.	15
UNIT II	Interior Properties of Stars Hydrostatic equilibrium, Virial theorem, Polytrophic indices, Lane – Emden equation LTE, Radiative equilibrium, stability condition of convective and radiative equilibrium, Continuous spectra of stars, Stellar opacity, limb darkening, line blanketing, theory of Fraunhofer lines, curve of growth and line broadening.	15
UNIT III	Elementary theory of white dwarfs, Chandrashekhar's limit for white dwarf stars, neutron stars their birth and properties, Pulsars, black holes, low medium mass star and high mass stars, death of high mass stars, supernova remnants..	15
UNIT IV	AGNs and Quasi-stellar Objects Theory of AGNs, Syferts, quasars and their energy generation and redshift anomaly. Different AGN models, radio lobes and jets, Gamma ray bursts.	15

Suggested Readings:

Abhyankar K.D.: Astrophysics, Galaxies and Stars

Vaidyanth Basu: An Introduction to Astrophysics

motz: Astrophysics A. R. Choudhuri : Astrophysics for Physicists

B. D. Abhyankar : An Introduction to Astrophysics T. Padmanabhan : Astrophysical Processes	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER IX PAPER IV c (Specialization paper)
Subject: Physics		
Course code	Course Title: **High Energy Physics-II**	
Course Outcomes: The course would provide the knowledge of basic building blocks of matter and its complex properties.The students will also be able to know the complicated theory of Higgs mechanism which led to the detection of God particle in LHC experiment in the year 2012.It would open doors for the students who want to work in the field of HEP.		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Lie Groups and Lie Algebra**: Symmetries, Groups and conservation laws, Definition of Lie groups ,U(N), SU(N) groups as Lie Groups , , generators of the groups, Lie Algebra, Different dimensions and parameter groups-their generators and algebra, Simple and semi-simple Lie groups, Standard form of Lie Algebras, Root diagrams for groups of different ranks.	15
UNIT II	**Special Unitary Groups and hadrons** : SU(3) shift operators, I,U,V spin subgroups of SU(2) in SU(3) multiplets, commutation relations of shift operators, irreducible representations of SU(3) ,application of shift operators for fundamental triplet of SU(3) and for baryon octet , decuplet etc, application of Young tableaux for finding out weight diagram for the (1 0), (0 1), (3, 0), (1 1) and (2 1) representations of SU(3) ,physical interpretation of these weight diagrams and identification of the particles of the weight diagram , SU(4) group and its generators, physical meaning of the weights of SU(4) ,reduction of the kronecker product of two representations of special symmetry groups by Young tableaux, kronecker product of three particle state vectors.	15
UNIT III	**Gauge Symmetry:** Concept of gauge fields and Gauge connections: coupling of physical space with internal symmetry space, principle of Gauge invariance, Global and local gauge invariance, Global U(1)Gauge Invarience, U(1) Local gauge symmetry of QED , Non – Abelian Gauge theory, Global SU(2) gauge symmetry, conserved isospin current for isospin group SU(2), Noether's Theorem, SU(2) Local Gauge symmetry, Yang Mill's Field and its properties	15
UNIT IV	**Spotaneous Symmetry Breaking** (SSB): Concept of Spontaneous Symmetry Breaking, Mass generation through SSB, SSB of Global Gauge Symmetry, Goldstone Bosons, SSB of Abelian local Gauge Symmetry and mass generation of Gauge fields,	15

	elimination of Goldstone Bosons Higgs Mechanism with physical examples and mass generation for gauge fields, Higgs bosons.	
Suggested Readings: .E. Close : Quarks and Patrons D.C. Cheng and O Neil : Elementary Particle Physics P.Cheng and G.LF Li : Gauge Field Theory I.J. Aitchison and A.J. Hey : Gauge theories in Particle Physics H. Georgi : Lie Algebras in particle Physics		
D. B. Lichtenberg : Unitary Symmetry and Elementary Particles, Academic Press, 1978		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER IX
PAPER IV d
(Specialization paper)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Spectroscopy -II</td></tr>
<tr><td colspan="4">Course Outcomes:
Laser, the light extraordinary, has so many applications in various field even having further potential and hence it has vital need to familiarize lasers & their technical advances to the students so that students be ready to apply coherent light to solve various problems in areas such as scientific, industrial, healthcare etc. Through this course students will learn about light matter interaction, basic principles of stimulated emission, fundamentals of lasers, types of laser, and applications of lasers in various fields including scientific research to common use. Also, it provides a good understanding of the critical laser parameters important for their use in various real-world applications such as: quantum optics, quantum technologies, telecommunications, and industrial material processing, sensing, bio-medicine, imaging, ranging and automobile industry.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td>UNIT I</td><td colspan="2">Radiation and Matter: Interaction of radiation with matter, Einstein quantum theory of radiation, Einstein's coefficients, Momentum Transfer, Lifetime, Theory of optical frequencies, Coherence Spatial and temporal and Monochromaticity, kinetics of optical absorption, line width, line broadening mechanisms.</td><td>15</td></tr>
<tr><td>UNIT II</td><td colspan="2">Basic Elements of Lasers: Laser fundamentals and fabrication – active medium, pumping source and the optical resonator, phenomenon of population Inversion, characteristic of laser light, Spontaneous emission, Stimulated emission, Possibility of amplification, laser pumping and population inversion in three and four level laser, rate equations, Threshold condition, Active resonators & laser modes, gain saturation, Saturable absorption.</td><td>15</td></tr>
<tr><td>UNIT III</td><td colspan="2">Type of Lasers: Different types of lasers, Principle and working of gas lasers, He-Ne laser, N2 & CO2 lasers, dye lasers, solid state lasers, Nd-YAG, semiconductor lasers, Excimer laser, Tunability of lasers</td><td>15</td></tr>
<tr><td>UNIT IV</td><td colspan="2">Applications of Lasers: Basic application of laser spectroscopy, laser cooling and trapping of atoms, Isotope separation, Plasma, Laser Induced Breakdown Spectroscopy (LIBS), Lasers in material processing, laser barcode scanner, Pattern formation by laser etching, LIDAR, lasers in Holography, Interferometry and Microscopy, Communication by Laser, Lasers in Astronomy, Biology, Chemistry, Medicines, Atmospheric optics, optical tweezers</td><td>15</td></tr>
</table>

Suggested Readings: K. Thyagarajan and A.K. Ghatak: Lasers: Theory and applications B.B. Laud: Lasers and Non-linear optics Orazio Svelto: Principles of Lasers Wolfgang Demtröder: Laser Spectroscopy M Hollas: Modern Spectroscopy	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><td colspan="4">MASTER IN PHYSICS</td></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR IV</td><td>SEMESTER IX/PAPER V</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: PRACTICAL</td></tr>
<tr><td colspan="4">Course Outcomes:
The student will have adequate knowledge to perform the experiments of different fields of physics with clear understanding of the theory behind the experiment.
Student will know about various electronics experiments and some advanced experiments in Physics</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">List of Experiments</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="2">1. Verification of Richardson’s law.
2. Study of ESR spectra of a given sample.
3. Hall Effect
4. RCS Spectrometer
5. gamma ray spectrometer
6. Radio Receiver
7. e by Millikan’s oil drop method.
8. Temperature dependence of diode characteristics.
9. Elastic constants of a cubic crystal by ultrasonic waves.
10. Study of Multivibrators .
11. Study of transistor amplifier cum feedback amplifiers.
12. Study of absorption of KMnO4 by Spectrophotometer
13. Study of different FETs and MOSFETs.
14. Study of Thermo luminance .
15. Study of VTVM.</td><td>60</td></tr>
<tr><td colspan="3">Can be opted by

Bachelor in Science with Physics as major subject</td><td></td></tr>
<tr><td colspan="3">Suggested Continuous Evaluation Methods:</td><td></td></tr>
<tr><td colspan="3">Course Prerequisite: As per the university ordinance.</td><td></td></tr>
<tr><td colspan="3">Suggested Equivalent Online Courses:
1. Virtual Labs at Amrita Vishwa Vidyapeetham,</td><td></td></tr>
</table>

https://vlab.amrita.edu/?sub=1&brch=74 2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER X PAPER I

Subject: Physics

Course code	Course Title: **Condensed Matter Physics**

Course Outcomes:

The students will be able to develop an understanding of the lattice, different types of crystal structures, symmetries. The student would gain insight about the interior of the substances using X-ray diffraction in crystals. This course also includes elastic waves, phonons, and lattice vibrational properties and also superconductivity. The course forms a theoretical basis of experimental material science and technology.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 3 6**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

UNIT	TOPIC	No. of Lectures
UNIT I	**Crystal Structure** Crystalline and non-crystalline solids. Lattice, basis, unit cell, co-ordination number, lattice planes and Miller indices. Interplanner spacing, seven crystal system. Interaction of radiation with matter (for elastic and inelastic scatterings of x- ray). X ray diffraction, Bragg's law. Diffraction conditions, Fourier analysis. Concept of reciprocal lattice point, calculation of reciprocal lattice point of SC, BCC. and FCC lattices, Application of reciprocal lattice point in diffraction technique. Neutron scattering and its applications.	15
UNIT II	**Bonding in Solids** Different types of bonding in solids, covalent, metallic, Vander Waal, hydrogen bonding & ionic bonding, Calculation of Madelung constant of ionic crystals, Determination of cohesive energy. Born-Haber cycle of NaCl molecule. Properties of covalent compounds and hybridization. Dispersion and dipole bonds. Thermal expansion and thermal conductivity, anharmonicity interaction of electrons and phonons with photons (direct and indirect transitions).	15
UNIT III	**Lattice Vibrations** Vibrations of crystals with monoatomic and diatomic basis. Concept of dispersion relation, optical and acoustical branches. Quantization of lattice vibrations (Phonons), normal modes & normal coordinates, longitudinal and transverse modes of vibration, modes of vibration of monatomic and diatomic lattices. Density of states, Phonon momentum, Inelastic scattering by phonons. Theory of specific heat of solids : classical theory , Einstein theory and Debye theory .Theory of metals : Classical theory , free electron theory and F-D distribution function , Hall effect and its applications.	15
UNIT IV	**Crystal Defects** Lattice vacancies, Fick's law, color centers and its production method in crystal, Point defects (Schottky & Frankel Defects) Imperfections, Line defects (Edge& Screw	15

	dislocations), slip, Burger vector & Burger Circuit, Role of dislocation in plastic deformation and crystal growth. Strength of alloys. Elementary idea of superconductivity, Meissner effect, Type-I and type-II superconductors, BCS theory. Theory of ferrimagnetism, ferromagnetism and antiferromagnetism.	

Suggested Readings

A. J. Dekker: Solid State Physics

S.O. Pillai : Solid State Physics

C. Kittle : Introduction to Solid State Physics

Verma &Srivastava : Crystallography for Solid State Physics

Can be opted by

MASTER IN PHYSICS

Suggested Continuous Evaluation Methods:

Course Prerequisite: As per the university ordinance.

Suggested Equivalent Online Courses:

1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/
2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd
3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	**YEAR V**	**SEMESTER X PAPER II**
Subject: **Physics**		
Course Code:	Course Title: **Statistical Physics**	
Course Outcomes: This course helps the students to learn about foundation of statistical mechanics, statistical properties and different statistical models. Students will have the idea about the different types of ensembles and different statistics namely M-B, B-E and F-D statistics.		
Credits: 04	Core Compulsory	
Max. Marks: 100 External Exam: 75 Internal assessment: 25	Min. Passing Marks: 36	
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		

Unit	Topic	No. of Lectures
Unit I	**Foundation of Statistical Mechanics** Microscopic and macroscopic states, density of states, micro-canonical, canonical and grand canonical ensembles, canonical ensemble and Gibb's distribution, Boltzmann–Planck method, partition function and statistical definition of thermodynamic quantities, computation of partition functions of some standard systems.	15
Unit II	**Statistical Properties** System of linear harmonic oscillators in the canonical ensemble; grand canonical ensemble and its partition function; chemical potential; Partition function and distribution for perfect gas; Gibb's paradox; Free energy, entropy, equation of state and specific heat determination of perfect gas.	15
Unit III	**Statistical Models** Theory of phase transitions, First order phase transition, Second order phase transitions and higher order phase transitions (elementary discussion), Ising model, one dimensional (with exact solution), Two dimensional (with exact solution) & three dimensional model (elementary idea), Landau theory of phase transition, Weiss theory of Ferro-magnetism, Heisenberg model. Virial equation of states.	15
Unit IV	**Quantum Statistics** Bose-Einstein and Fermi- Dirac distributions, degeneracy, gas degeneration, degenerate Bose gas, Bose Einstein condensation, highly degenerate B-E and F-D gases; examples of Molecular Hydrogen, liquid helium and electron gas in metals.	15

Suggested Readings:

A.S. Davidov: Quantum Mechanics
B.S. Rajput: Quantum Mechanics
Paul Roman: Quantum Mechanics
Glastohn Theoretical Chemistry
Landau and Lifshitz: Statistical Mechanics
Pathira: Statistical Mechanics
Huang: Statistical Mechanics

<table>
<tr><td colspan="4">MASTER IN PHYSICS</td></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER III A
(Specialization paper)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course Code:</td><td colspan="3">Course Title: Advanced Electronics- III</td></tr>
<tr><td colspan="4">Course Outcomes:
This course helps the students to gain advanced concepts of power supply regulation, microwave production and microwave generation which has wide applications in modern Industry and Research.</td></tr>
<tr><td colspan="3">Credits: 04</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min.
Passing
Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
</table>

Unit	Topic	No. of Lectures
Unit I	**Power Supply regulation with Series Regulators** Servomechanism, regulation using Operational Amplifier, Zener reference source, The 723 regulator, current regulator, short circuit and over load protection, Current Foldback, Current Boosting, Precision rectifier, Three terminal voltage regulations, dual Polarity regulated power supplies using 78 XX and 79 XX series regulators (Basic ideas only).	15
Unit II	**Switching Regulators and Active Filters** Switched mode power supply (SMPS), Active filters; advantages and limitations of Active filters, RC Active filters, First order, second order and higher order Low pass and High pass active filters, Voltage transfer function, frequency response and Gain roll-off, Narrow and wide band pass Active filters, Notch and wide band reject Active filters, PLL; Lock-in range, Capture range, Pull-in time, Phase detectors, Error amplifier, Voltage controlled oscillator (VCO).	15
Unit III	**Microwave Production** Limitation of convectional electronics devices at UHF, Microwave frequencies, Principle of velocity modulation and current modulation, Multicavity Klystron, Reflex klystron, Theory and uses of cavity magnetron, Strapping, Phase focusing effect, frequency pulling and pushing, Travelling-Wave tube (TWT), Semiconductor microwave devices; PIN & GUNN Diode, Detection of microwave.	15
Unit IV	**Microwave Communication** Advantages and Disadvantages of Microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on prorogation , Fresnel zone problem, ground reflection, Fading, Antenna action, Antennas used in microwave communication system; Antennas with parabolic reflectors, Horn antennas, Lens antennas.	15

Suggested Readings: Coughlin: Operational Amplifiers and Linear Integrated Circuits. Schilling & Belove: Electronic circuits Discrete and Integrated, Mcgraw Hill Millman &Halkias: Electronic Fundamentals & Applications, Tata Mcgraw Hill Millman &Halkias: Integrated Electronics .R. Botkar: Integrated Circuits, Khanna Publishers V.K. Mithal& Ravi Mittal: Electronic Devices & Circuits, Khanna Publishers Malmstadt &Enke: Electronics for scientists Taub & Schilling: Principal of communication systems Simon Gayukti: Communication Systems Martin S. Roden: Analog & Digital Communication Systems Terman: Electronic & Radio Engineering	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><td colspan="4">MASTER IN PHYSICS</td></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER III B
(Specialization paper)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Astrophysics-III</td></tr>
<tr><td colspan="4">Course Outcomes:
This course provides the basic physical mechanisms about the solar activities, which will help to probe the Sun- Earth connection. This study provides the knowledge of Astroseismology, classification of stars and the distribution in Galaxies.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
</table>

UNIT	TOPIC	No. of Lectures
UNIT I	Sun as a star : Solar spectrum, effective temperature, luminosity, photospheric absorption lines, limb darkening; energy source: Kelvin time scale, nuclear fusion; energy transport in the sun, Thomson scattering, mean free path, photon diffusion inside the Sun; photosphere, chromosphere, transition region, corona.	15
UNIT II	Quiet and Active Sun, Sunspots, their formation and magnetic field, Solar flares, Solar filaments/prominences, Coronal mass ejections (CMEs), Solar wind, Different type of solar eruptions models, Coronal heating, Solar Cycle, General idea of Heliosesmology, Astroseismology, Description about p-mode and g-mode oscillations, Introduction to variable stars and their locations in H-R diagram.	15
UNIT III	The Milky way and Other Galaxies Distributions of stars in the Milky way, Morphology, Kinematics, Interstellar medium, Galactic center. External galaxies, Types of galaxies: spirals, ellipticals and irregulars, Hubble classification for galaxies, 21cm line, rotation cure, dark matter.	15
UNIT IV	Principle of equivalence and principle of general covariance, Principal of general gravitational field, Metric tensor and gravity, Geodesics, Christoffel symbols, Space- time curvature and curvature tensor, Riemann curvature tensor, Bianchi identity, Ricci tensor, Einstein's field equations , Centrally Symmetric Fields, Metric in spherically symmetric space-time (Schwarzchild metric).	15

Suggested Readings:

Stix: The Sun: An Introduction

K. D. Abhyankar : Astrophysics: Stars and Galaxies
T. Padmanabhan : Galaxies and Cosmology Motz : Astrophysics
I. Zhelyazkov and R. Chandra : Kelvin Helmholtz Instability In

Solar Atmosphere Jets, Word Scientific R. K. Pathria, The Theory of Relativity, Hindustan Publishing Corpn, (India)	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER X PAPER III C (Specialization paper)
Subject: Physics		
Course code	Course Title: **Hight Energy Physics-III**	

Course Outcomes:

The course would provide the knowledge of advanced concepts of HEP. The students will be able to know the complicated theory of Relativistic propagators, S matrix expansion and S matrix formulation of QED. It would open doors for the students who want to work in the field of HEP.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Relativistic Propagators Relativistic propagators using quantized formulation of free fields, Properties of quantized scalar fields(Real and complex cases), Algebra of field operators, covariant form of the field operators algebras, (Covariant commutation relations), Meson propagator and its characteristics, Properties of quantized spinor fields, Algebras of spinor field operator, Covariant form of anti-commutation relations, Fermion propagator and its characteristics, properties of quantized EM field, Covariant commutation relations of EM field operators, Photon propagator and its characteristics, EM interaction in terms of radiation field and instantaneous coulomb fields.	15
UNIT II	Operator Products, Feynman Propagators and S-matrix Expansion Various type of operator products (Normal, Dyson products and Chronological T-products), Wick's theorem, Feynman propagators and its physical interpretation, Interacting fields, S-Matrix formulation as a perturbative series solution of collision processes, Dyson expansion of S-matrix.	15
UNIT III	S-matrix Formulation of QED Interaction Hamiltonian in QED, Reduction of S-matrix for the case of QED, Representation and description of various first and second order processes in QED using S-matrix expansion.	15
UNIT IV	Compton scattering, Moller scattering, Bhabha scattering, Electron self energy, Photon self energy, vacuum configuration in QED, Feynman diagrams and Feynman Rules in QED.	15

Suggested Readings: Ryder : Quantum Field Theory B.K. Agarwal: Quantum Mechanics and Field Theory F Mandel and G. Shaw: Quantum Field Theory Roman: Quantum Field Theory A. Das: Quantum Field theory M. E. Peskin, D.V. Schroeder: An Introduction to Quantum Field Theory		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER X PAPER III D (Specialization paper)
Subject: Physics		
Course code	Course Title: **Spectroscopy-III**	

Course Outcomes:

.

Through this coursework students will get a deep knowledge about the molecular symmetries and group theory, mechanism behind the absorption and emission of photon and related phenomena. Also, after attending the course a student will be acquainted with fluorescence measurement techniques and recent advances in fluorescence spectroscopy.

Knowledge acquired by the course will be of much use for various industries and R&D sector

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**

Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Molecular Symmetries and Group Theory:** Symmetry Properties of molecule: symmetry element, symmetry operation and point group, character table, Group theory: representation of a group, reducible and irreducible representations, LCAO coefficient of a polyatomic molecule, Huckel approximation, overlap and resonance integrals.	15
UNIT II	**Mechanism of Absorption and Fluorescence:** Theory of absorption spectroscopy, differential absorption spectroscopy(circular Dichroism), Mechanism of fluorescence emission and decay, radiative & nonradiative processes, Jablonski diagram, Kasha rule, Mirror image rule, Oscillator strength, Stoke's shift, Fluorescence lifetime and quantum yield, Environmental effects on absorption and fluorescence spectra, Time scale of molecular processes in solution, Fluorescence sensing and quenching, Fluorescence polarisation and Anisotropy.	15
UNIT III	**Instrumentation for Absorption and Fluorescence Spectroscopy:** Absorption, Excitation and Emission spectra, UV – Vis spectrophotometer, Basic instrumentation of steady state and time resolved fluorometer, An ideal spectrofluorometer, Principle of Time Correlated Single Photon Counting (TCSPC), Light sources, Monochromator, Optical filters, Photomultiplier tubes, Distribution in Excitation & Emission spectra, Photon counting versus Analog detection of Fluorescence Corrected Fluorescence spectra, Circular Dichroism, Applications of steady state and time resolved	20

	measurements,.	
UNIT IV	**Advances in Fluorescence Spectroscopy:** Concept of fluorescence lifetime imaging, Theory and principle of Fluorescence Correlation Spectroscopy and Single molecule fluorescence spectroscopy, Applications of fluorescence spectroscopy.	10
Suggested Readings: Barrow G.M: Introduction to Molecular spectroscopy; McgrawHill Herzberg G: Infrared and Raman Spectra of Polyatomic Molecules; Von Nostrand Herzberg G: Spectra of Polyatomic Molecules; J. R. Lackowicz: Principle of Fluorescence Bernard Valeur and Mário Nuno Berberan-Santos: Molecular fluorescence (Principles and Applications) King G.W: Spectroscopy and Molecular Structure		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

MASTER IN PHYSICS			
Programme: **MASTER IN PHYSICS**		YEAR V	SEMESTER X PAPER IV A (Specialization paper)
Subject: Physics			
Course code	Course Title: **Advanced Electronics-IV**		

Course Outcomes:

This course helps the students to gain basic ideas of the construction and working of electronic devices and circuits. The course includes the study of combinational circuits, sequential circuits and analog computation. The course is of much practical purpose for the students to learn basics of digital electronics. The digital electronics has wide applications in computing, process control, signal processing, communication systems, digital instruments etc.

Credits: 4	Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**	**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0	

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Analog Computation** Solution of ordinary linear differential equations with constant coefficients, Operation modes of analog computers, repetitive operation of computers, Time scaling, amplitude scaling, Combined time and amplitude scaling, Generation of functions, Simulation of time varying systems.	15
UNIT II	**Logic Circuits and Logic Families** Canonical and standard forms of Boolean functions, Algebraic simplification of Boolean equations. Karnaugh maps, Construction of K-maps from truth tables, don't care conditions, NAND and NOR implementations. The Tabulation method, Determination and selection of prime implicants, Classification of Digital logic families. Digital to Analog and Analog to Digital converters.	15
UNIT III	**Combinational Circuits** Adders & Subtractors, Magnitude comparator, Code converters; Parallel adders, Encoders, Decoders, Multiplexers, Demultiplexers, Parity bit generator and checker, Read only memory (PROM, EPROM), ROM applications, Programmable Logical Array(PLA).	15
UNIT IV	**Sequential Circuits** Sequential logic- Memory element, RS, JK, JKMS, T type and Edge triggered Flip flop; Registers; Shift register; Counters—synchronous and Asynchronous; The memory unit; Semiconductor Random Access Memory; Inter-register transfer; Arithmetic; Logic and Shift Micro-operation; Fixed point and floating point data.	15

Suggested Readings:

Morris Mano: Digital Logic & Computer Design

Rajaraman: Introduction to Digital Computer design

Malvino& Leech Sloan: Computer Hardware & Organization

V. Rajaraman: Analog Computation & Simulation Integrated Circuits. Schilling & Belove: Electronic circuits Discrete and Integrated, Mcgraw Hill Millman &Halkias: Electronic Fundamentals & Applications, Tata Mcgraw Hill Millman &Halkias: Integrated Electronics K.R. Botkar: Integrated Circuits, Khanna Publisher G.K. Mithal& Ravi Mittal: Electronic Devices & Circuits, Khanna Publisher	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PAPER IV B
(Specialization paper)</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: Astrophysics-IV</td></tr>
<tr><td colspan="4">Course Outcomes:
This course will provide the basic properties of stars, birth and the evolution of stars. In addition of this, it provides the deep understanding about the star clusters and their properties, e.g. luminosity and mass function, mass-luminosity relations etc.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0</td></tr>
</table>

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	Basic Properties of Stars: Mass, radius, distance, luminosity, temperature, magnitude system, Wien-displacement colour indices, filters, H-R diagram, classification of stellar spectra, luminosity classification, stellar motion, stellar populations	15
UNIT II	Star Formation and Stellar Evolution: Birth of stars, protostar, Pre-main sequence evolution: Jeans instability, star formation, Hayashi track, Zero age main sequence (ZAMS), Post-main sequence evolution: Core He burning, shell burning, red giant phase, planetary nebulae, white dwarf physics, electron degeneracy pressure, energy generation in stars – gravitational contraction, pp chain, CNO cycle and triple alpha process, stellar life, cycles-Premain sequence, main sequence, giants.	15
UNIT III	Star Cluster and their Properties : Open clusters, globular clusters and the galaxy itself are examples of 'stellar systems'; crossing time; mean potential and total potential energy in a constant density sphere; equation of motion of N-body stellar system; total momentum, angular momentum and energy as constants of motion, stellar population, population I and II type objects, inter-stellar extension, reddening determination from color color diagram, age and distance determination of star clusters, luminosity function, mass function, mass segregation, mass-luminosity relation.	15
UNIT IV	Cosmological Models: Universe at large scales – Homogeneity and isotropy – distance ladder – Newtonian cosmology - expansion and redshift - Cosmological Principle - Hubble's law - Robertson-Walker metric - Observable quantities – luminosity and angular diameter distances - Horizon distance- Dynamics of Friedman- Robertson-Walker models: Friedmann equations,	15

	Weyl's postulate, Big-bang and steady state models of the universe.	
Suggested Readings: Abhyankar K.D. : Astrophysics, Galaxies and Stars Vaidyanth Basu : An Introduction to Astrophysics Motz : Astrophysics T. Padmanabhan : Stars and Stellar Systems L Kutner: Astronomy: A Physical Perspective		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		
Course Prerequisite: As per the university ordinance.		
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8		

MASTER IN PHYSICS		
Programme: **MASTER IN PHYSICS**	YEAR V	SEMESTER X PAPER IV C (Specialization paper)
Subject: Physics		
Course code	Course Title: **High Energy Physics-IV**	
Course Outcomes: The course would provide the knowledge of some more advanced concepts of HEP. The students will also be able to know the detailed theory of weak interactions, electromagnetic interactions and strong interaction.		
Credits: 4		Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**		**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0		
UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Quarks and Gluons:** Quark-Lepton Symmetry, Theoretical and experimental need of charm quark, J/ψ and Charm ,Three generations of quark and leptons: from bottom to Top quark, Positive facets of quark model , Paradoxes of the Naive Quark Model, Need of color quantum number for Quarks, Gluons, Standard Model and Fundamental Particles ,Symmetry and Quark model, Color octet and singlet of Gluons, diquark and exotic hadrons, Color SU(3) ,SU(3) color ladder operators, concept of colorless hadrons .	15
UNIT II	**Strong Interaction:** basic difference between QED and QCD, QCD Lagrangian, SU(3) global color gauge invariance and concept of 8 conserved currents, SU(3) local color gauge symmetry and QCD ,basic idea of Asymptotic freedom and Perturbative QCD, Experimental indication for quarks and gluons, String model of hadrons and concept of confinement of Quarks, Classification of Hadrons and Regge Trajectories.	15
UNIT III	**Weak Interaction:** Classification of weak interaction in terms of Leptonic, Semi-leptonic and Non- Leptonic weak Decays, Fermi Non relativistic theory of beta decay, Fermi &Gammow Teller transitions, Paritry violation in weak interaction, Helicity of particle, Helicity operator, Two component theory of Neutrinos, Fermi’s relativistic theory of beta decay, concept of weak hadron current and lepton current, Current-Current Interaction and V-A theory.	15
UNIT IV	**Weak Gauge Bosons & Weak currents:** Universality of weak interactions, Intermediate Vector Boson (IVB) concept , Cabibbo theory, Cabibbo angle, Consequences of Cabibbo theory, Quark lepton Universality, Weak Isospin and weak hypercharge, W and Z bosons as weak gauge bosons, Charged and neutral weak currents, Conservation of Vector Current (CVC) Hypothesis, Elementary Idea of Unification of Fundamental Interactions	15

	with reference to standard model of electro weak unification	
Suggested Readings: E Close : Quarks and Patrons I.J. Aitchison and A.J. Hey : Gauge theories in Particle Physics F. Haltzin& A.D. Martin : Quarks and Leptons D.H. Perkins : Introduction of High Energy Physics, Cambridge University Press 2000		

P.Cheng and G.LF Li : Gauge Field Theory ED Commins : Weak Interactions D.C. Cheng and O Neil : Elementary Particle Physics	
Can be opted by **Bachelor in Science with Physics as major subject**	
Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

MASTER IN PHYSICS			
Programme: **MASTER IN PHYSICS**		YEAR V	SEMESTER X PAPER IV D (Specialization paper)
Subject: Physics			
Course code	Course Title: **Spectroscopy-IV**		
Course Outcomes: The course content covers the propagation of electromagnetic waves in nonlinear media. The course provides students with knowledge of laser physics and introduces them to nonlinear optics and spectroscopy applications. Students will be learning different nonlinear processes as an outcome under light matter interaction in nonlinear media. In addition, they will also have knowledge about holography, multiphoton processes, Raman scattering, Raman spectroscopy etc. Knowledge acquired by the course will be of much use for various industries and R&D sector.			
Credits: 4			Core Compulsory
Max. Marks: 100 **External Exam: 75** **Internal assessment: 25**			**Min. Passing Marks: 36**
Total No. of Lectures-Tutorials-Practical (in hours per week): 4-0-0			

UNIT	**TOPIC**	**No. of Lectures**
UNIT I	**Ultrashort Pulses and Dynamics of Laser Processes**: Production of giant pulse, Q-switching by different types of shutters, giant pulse dynamics, laser amplifiers, mode locking, mode pulling, ultra shot pulses, hole burning, Principle and theory of Holography, Characteristics of Holograms, Applications and advances in Holography.	15
UNIT II	**Non-Linear Optics:** Harmonic generation, phase matching, second harmonic generation, third harmonic generation, optical mixing, parametric generation of light, Self focusing of light.	15
UNIT III	**Multi Photon Processes:** Multi quantum photoelectric effect, two photon processes, experiments in two photon processes, parametric light oscillator, frequency up-conversion, phase conjugate optics, Femtosecond laser.	15
UNIT IV	Rayleigh and Raman scattering, Stimulated Raman effect, coherent stokes & anti-stokes, Raman scattering, Resonance Raman spectroscopy, surface enhanced Raman Spectroscopy, Hyper Raman effect, Photo acoustic Raman Spectroscopy, Spin – flip laser, Free electron laser, Laser stark spectroscopy	15
Suggested Readings: • Marc D. Levenson: Introduction to non-linear laser spectroscopy • B.B. Laud: Lasers and Non-linear optics • Orazio Svelto: Principles of Lasers • Wolfgang Demtröder: Laser Spectroscopy		
Can be opted by **Bachelor in Science with Physics as major subject**		
Suggested Continuous Evaluation Methods:		

Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. MIT Open Learning - Massachusetts Institute of Technology,	
https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. SwayamPrabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	

<table>
<tr><th colspan="4">MASTER IN PHYSICS</th></tr>
<tr><td colspan="2">Programme: MASTER IN PHYSICS</td><td>YEAR V</td><td>SEMESTER X
PRACTICAL</td></tr>
<tr><td colspan="4">Subject: Physics</td></tr>
<tr><td>Course code</td><td colspan="3">Course Title: PRACTICAL</td></tr>
<tr><td colspan="4">Course Outcomes:
The student will have adequate knowledge to perform the experiments of different fields ofphysics with clear understanding of the theory behind the experiment.
Student will know about advanced experiments based on their specialization paper.</td></tr>
<tr><td colspan="3">Credits: 4</td><td>Core Compulsory</td></tr>
<tr><td colspan="3">Max. Marks: 100
External Exam: 75
Internal assessment: 25</td><td>Min. Passing Marks: 36</td></tr>
<tr><td colspan="4">Total No. of Lectures-Tutorials-Practical (in hours per week): 0-0-4</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>UNIT</td><td colspan="2">TOPIC</td><td>No. of Lectures</td></tr>
<tr><td></td><td colspan="2">List of Experiments: (a) Advanced Electronics
1. Study of regulated power supply (723).
2. Study of operational amplifier (741).
3. Study of Timer (555). 4. A to D and D to A converter
5. 1 of 16 Decoder/Encoder
6. Study of Multiplexer/Demultiplexer
7. Study of Logic gates (Different types)
8. Study of Comparator and Decoder
9. Study of amplitude and frequency modulations anddemodulations.
10. Study of different flip- flop circuits (RS, JK, Dk type, T-type, Master slave).
11. Study of Digital combinational and sequential circuits
12. Study of Microprocessor (8085) 13. Study of SCR, DIAC,TRIAC
14. Study of IC- Based Power supply
15. Microwave experiment.
16. Shift Registers
17. Fiber Optics communication</td><td>60</td></tr>
<tr><td></td><td colspan="2">List of Experiments: (b) Astrophysics

1. Study of Hubble’s law and age of Universe (from given data)
2. Study of constant density neutron star
3. Study of the static parameters of a Neutron Star model withinverse square density distribution
4. Study of star cluster from a given data
5. Study of Extinction coefficients</td><td>60</td></tr>
</table>

	6. Study of variability of stars 7. Study of solar limb Darkening 8. Study of solar differential rotation. 9. Measuring extension of the atmosphere in B, V and R bands 10. Measuring the colour of star using differential photometer data 11. Determination of age star cluster 12. Determination of reddening in a star cluster.	
	List of Experiments: (c) High Energy Physics 1. Characteristic curve of a GM Detector and verification of inverse square law . 2. Characteristic curve of a GM Detector and Absorption coefficient of a using aluminum GM Detector. 3. Energy spectrum of gamma rays using gamma ray spectrometer. 4. Absorption coefficient of aluminum using gama-ray spectrometer. 5. Characteristics of Scintillation Detector. 6. Study of gama-gama unperturbed angular correlations. 7. Study of particle tracks using a Nuclear Emulsion Detector. 8. Classification of tracks in interaction with Nuclear Emulsion and determination of excitation energy.	60
	List of Experiments: (b) Spectroscopy 1. Study of the vibrational levels of Iodine. 2. Measurement of the fluorescence spectra of Uranyl Nitrate Hexahydrate. 3. Determination of the intrinsic life time for a dye molecule. 4. Determination of change in dipole moment in excited state using Solvatochromic shift method. 5. Measurement of non radiative decay rate for a known sample. 6. Determination of the quantum yield of known samples using steady state spectroscopy.	60
Can be opted by **Bachelor in Science with Physics as major subject**		

Suggested Continuous Evaluation Methods:	
Course Prerequisite: As per the university ordinance.	
Suggested Equivalent Online Courses: 1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74 2. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities	

Note- The Candidate shall have to undertake a Industrial Training /Survey /Resarch project in seventh, eight , ninth and tenth semester (fourth and fifth year) of four credits each as per the details given in annexure I.