Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon

SYLLABUS

for

Master of Science (M. Sc.)
[Physics]

Choice Based Credit System
(Outcome Based Curriculum)

2021 - 2022

Summary of Distribution of Credits under CBCS Scheme
for
M.Sc. (Physics)

Sr. No	Type of course	Sem I	Sem II	Sem III	Sem IV	Total
01	Core	**16**	**16**	**08**	**08**	**48**
02	Skill based	**04**	**04**	**04**	**04**	**16**
03	Elective	**-**	**-**	**04**	**04**	**08**
04	Project	**-**	**-**	**04**	**04**	**08**
05	Audit	**02**	**02**	**02**	**02**	**08**
06	Total Credits	**22**	**22**	**22**	**22**	**88**

Subject Type	Core	Skill based	Elective	Project	Audit	Total
Credits	**48**	**16**	**08**	**08**	**08**	**88**

Total Credits = 88

Kavayitri Bahinabai Chaudhari North Maharashtra University Jalgaon

M. Sc. Physics

Choice Based Credit System (Outcome Based Curriculum) with effect from 2021 -2022

Course credit scheme

Semester	(A) Core Courses			(B) Skill Based / Elective Course			(C) Audit Course (No weightage in CGPA)			Total Credits (A+B+C)
	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (T+P)	Total Credits	No. of Courses	Credits (Practical)	Total Credits	
I	4	16 + 0	**16**	1	0 + 4	**4**	1	2	2	**22**
II	4	16 + 0	**16**	1	0 + 4	**4**	1	2	2	**22**
III	2	08 + 0	**08**	3	4 + 8	**12**	1	2	2	**22**
IV	2	08 + 0	**08**	3	4 + 8	**12**	1	2	2	**22**
Total Credits	**48**			**32**			**8**			**88**

(T, Theory; P, Practical)

Structure of Curriculum

		First Year				Second Year				Total Credit Value
		Semester I		Semester II		Semester III		Semester IV		
		Credit	Course	Credit	Course	Credit	Course	Credit	Course	
(A)	**Prerequisite and Core Courses**									
	Theory	16	4	16	4	8	2	8	2	48
	Practical					8	2	8	2	16
(B)	**Skill Based / Subject Elective Courses**									
1	Theory /Practical	4	1	4	1	4	1	4	1	16
(C)	**Audit Course (No weightage in CGPA calculations)**									
1	Practicing Cleanliness	2	1							2
2	Personality and Cultural Development Related Course			2	1					2
3	Technology Related + Value Added Course					2	1			2
4	Professional and Social + Value Added Course							2	1	2
	Total Credit Value	22	6	22	6	22	6	22	6	88

***List of Audit Courses** (Select any ONE course of Choice from Semester II; Semester III and Semester IV)*							
Semester I (Compulsory)		**Semester II** (Choose One)		**Semester III** (Choose One)		**Semester IV**(Choose One)	
		Personality and Cultural Development		**Technology + Value Added Course**		**Professional and Social + Value Added Course**	
Course Code	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**	**Course Code**	**Course Title**
AC-101	Practicing Cleanliness	AC-201A	Soft Skills	AC-301A	Computer Skills	AC-401A	Human Rights
		AC-201B	Sport Activities	AC-301B	Cyber Security	AC-401B	Current Affairs
		AC-201C	Yoga	AC-301C	Seminar + Review Writing	AC-401C	Seminar + Review Writing
		AC-201D	Music	AC-301D	Biostatistics	AC-401D	Intellectual Property Rights (IPR)

Semester-wise Course Structure of M.Sc. Subject name

Semester I

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
PHY-101	Core	Mathematical Methods for Physics	4	--	4	40	--	60	--	4
PHY -102	Core	Classical Mechanics	4	--	4	40	--	60	--	4
PHY -103	Core	Solid State Physics	4	-	4	40	-	60	-	4
PHY -104 A/B/C	Skill Based (Select any one)	**A)**:Physics of Semiconductor Devices **B)**: Electronic Instrumentation **C)**Bio- Physics	4	-	4	40	-	60	-	4
PHY -105	Core	Basic Physics Laboratory – I	-	4+4	8	-	40	-	60	4
AC-101	Audit Course	Practicing Cleanliness	-	2	2	--	100	--	--	2
Total Credit for Semester I: 22 (T = Theory: 16; P = Practical:4; Skill Based:4; Audit Course:2)										

Semester II

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
PHY-201	Core	Statistical Mechanics	4	--	4	40	--	60	--	4
PHY -202	Core	Classical Electrodynamics	4	--	4	40	--	60	--	4
PHY -203	Core	Quantum Mechanics	4	--	4	40	--	60	--	4
PHY-204	Skill Based	Material Science	4	-	4	40	-	60	-	4
PHY-205	Core	Basic Physics Laboratory – II	-	4+4	8	-	40	-	60	4
AC-201 A/B/C/D	Audit Course(Select any one)	AC-201A -Soft Skills/ AC-201B- Sport Activities/ AC-201C- Yoga/ AC-201D Music) from Personality and Cultural Development	--	2	2	--	100	--	--	2
Total Credit for Semester II: 22 (T = Theory: 12; P = Practical:4; Skill Based:4; Audit course:2)										

Semester III

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
PHY-301	Core	Atomic and Molecular Physics	4	--	4	40	--	60	--	4
PHY-302 A/B/C	Elective (Select any one)	A)Materials Synthesis and Preliminary Analysis B) Computational Method sand Programming Using 'C' Language C) Acoustics and Entertainment Physics	4	-	4	40		60	-	4
PHY-303 A/B/C	Skill Based(Select any one)	A)Systematic Materials Analysis B) Microprocessor and its Applications C) Communication Electronics	4		4	40		60		4
PHY-304	Core	Special Laboratory-I	-	4+4	8	-	40	-	60	4
PHY-305	Project Based	Project Work-II (Literature Survey, Definition of Problem, Experimental work, Oral etc.)	--	4+4	8	--	40	--	60	4
AC-301 A/B/C/D	Audit Course(Select any one)	**Choose one out of Four (AC-301A-** Computer Skills / **AC-301B -** Cyber Security/ **AC-301C-** Seminar + Review Writing / **AC-301D-** Biostatistics**) from Technology + Value Added Courses**		2	2		100	--	--	2
Total Credit for Semester III: 22 (T = Theory: 8; P = Practical:8; Skill Based:4; Audit Course:2)										

Semester IV

Course	Course Type	Course Title	Teaching Hours/ Week			Marks (Total 100)				Credits
			T	P	Total	Internal		External		
						T	P	T	P	
PHY-401	Core	Nuclear Physics	4	--	4	40	--	60	--	4
PHY -402 A/B/C	Skill Based	A) Nanomaterials: Synthesis, Properties and Applications B) LASER and it's Applications C) Astrophysics	4	-	4	40	-	60	-	4
PHY-403 A/B/C	Elective (Select any one)	A) Renewable Energy Sources B) Microwave: Applications C)Environmental Physics	4	--	4	40	--	60	--	4
PHY -404	Core	Special Laboratory-II	--	4+4	8	--	40	--	60	4
PHY -405	Project	Project Work-II (Characterization, Analysis of Result, Conclusions, Project	--	4+4	8	--	40	--	60	4

	Based	Report, Oral etc.)								
AC-401 A/B/C/D	Audit Course(Select any one)	**Choose one out of Four (AC-401A-** Human Rights / **AC-401B –Current Affairs / AC-401C-** Seminar + Review Writing / **AC-401D -** Intellectual Property Rights (IPR**)**) **from Professional and Social + Value Added Courses**		2	2		100	--	--	2
Total Credit for Semester IV: 22 (T = Theory: 8; P = Practical:8; Skill Based:4; Audit Course:2)										

M. Sc. Programme

Number of teaching days/ year	180
Number of teaching days/ term	90
Number of contact hours for theory course or practical course/ week	04
Number of teaching hours for theory course/ term	52
Number of contact hours/ term for test, seminar and tutorial	08
Total number of contact hours/ term for course	52+08=60

Program at a Glance

Name of the program (Degree)	: M. Sc. (Physics)
Faculty	: Science and Technology
Duration of the Program	: Two years (four semesters)
Medium of Instruction and Examination	: English
Exam Pattern	: 60: 40 (60 marks University exam. And 40 marks continuous internal Assessment)
Passing standards	: 40% in each exam separately (Separate head of passing)
Evaluation mode	: CBCS
Total Credits of the program	: 88 (64 core credits including 4 credits of project/dissertation, 08 skill enhancement credits, 08 subject elective credits and 08 audit credits)

Program Objectives for M.Sc. Program:

The objectives of this Programme are to develop:

1. The students through high quality of education/study which enables them to succeed in career in which can understanding of physics is relevant.

2. The ability to think logically, to analyze problems and phenomena and to devise explanations or solutions.

3. An appreciation of the role of mathematical modeling of physical phenomena to produce predictions which can be tested against experimental observations.

4. An awareness of the importance of accurate experimentation in the understanding of natural phenomena.

5. The practical and technical skills required for physics experimentation.

6. An awareness of the value and the power of computer based techniques for experimentation, analysis and presentation and a familiarity in their exploitation.

7. An ability to communicate the concepts and discoveries of physics both orally and in writing.

8. An ability to organize time and meet deadlines.

9. An additional skills resulting from the experience of more extensive project work.

10. An ability to integrate 'Information Communication Technology' with basic concepts of physics to promote relevant education and training.

11. The qualities of adoptability, innovation and dynamism.

Important Instructions:

1. B. Sc. (Physics) students are eligible to offer this program.

2. Two written tests, one oral test and one seminar (per semester) should be conducted for each course in addition to regular teaching schedule.

3. Faculty members are advised to use 'compact disks' and computers as teaching aids so as to ingrain the basic ideas of Physics.

4. Students are advised to borrow scientific information (published worldwide) from scientific websites on Internet**.**

5. A well-equipped computer laboratory with at least 5 computers is necessary to conduct related experiments and Project

6. Student should start the Project work soon after the commencement of third semester. Literature survey, Definition of the problem, Pre-oral before finalization of the topic, Preliminary experimental work, Oral to assign the internal marks etc should be covered in the third semester**.**

7. Student should carry out the experimental work, keep record of the observations and results and should draw the conclusions of the project. Systematic project report should be prepared. Teacher should arrange oral examination to assign internal marks.

Program Outcomes (PO) for M.Sc. Program:

Upon successful completion of the M.Sc. program, student will be able to:

PO No.	PO	
PO1	M.Sc. Physics students can find jobs in public and private sectors. There are many opportunities available for M. Sc. Physics students in technical as well as scientific fields. They can work as Scientist, Assistant Scientist, Quality Control Manager, Laboratory Technician, School Science Technician or Research Analyst in any government or private organization. Besides these, they can also go for teaching in government or private institutions.	**General**

PO2	There are many opportunities available in IT field for M. Sc. Physics graduates. Many IT companies such as Infosys, Wipro and TCS are recruiting M. Sc. Physics graduates for software jobs. They can also get jobs in Energy Plants. Another job available for these graduates is Technician in Electronic Industry. They can apply for jobs in many companies in automobile industry. Some of those companies are Maruti Udyog, TATA Motors and Tech Mahindra.	Private Sector
PO3	: There are vast opportunities available for M.Sc. graduates in Government sector. They can apply for jobs in Scientific Research and Development Organizations such as The Defense Research and Development Organization (DRDO), CSIR, Physical Research Laboratory (PRL) Ahmedabad, Saha Institute of Nuclear Physics Kolkata and Nuclear Science Centre New Delhi. They can also apply for various jobs in popular government organizations such as: • Bhabha Atomic Research Centre (BARC) • Atomic Energy Regulatory Board (AERB) • Oil and Natural Gas Corporation (ONGC) • Bharat Heavy Electricals Limited (BHEL) • National Thermal Power Corporation (NTPC) • Indian Space Research Organization (ISRO) • National Chemical Laboratory (NCL) • Indian Institute of Tropical Meteorology (IITM) They can also apply for the various competitive exams conducted by Union Public Service Commission such as IFS, IPS and IAS. Several other government exams conducted for recruiting M.Sc. Physics graduates are given below: • Tax Assistant Exam, Statistical Investigator Exam, Combined Graduate Level Exam. After qualifying NET or SET exam they can apply for teaching jobs in government colleges or schools. Another option available for M.Sc. Physics graduate is to apply for jobs in public sector banking. Several banks are conducting exam every year for recruiting graduates to the post of Probationary Officers. They can also find many jobs in Railway sector. They should qualify the exams conducted by Railway Recruitment Board to get a job in Railway sector. These graduates can also apply for Combined Defense Services Exams conducted for recruiting candidates to various posts in Defense Department.	Government Sector
PO4	There are wide opportunities available for M. Sc. Physics graduates in foreign countries. They can work in several health care, manufacturing and electronics companies in foreign countries. Students having high percentage during their post-graduation can apply for jobs in National Aeronautics and Space Administration (NASA), one of most famous space research organization in the world.	Foreign countries
PO5	: Those who have completed M. Sc. degree in Physics can find a long term career in the research field. Even though they are joining the research organization as assistant /research fellow (JRF, SRF), can earn lot of experience and/or Ph.D. Degree. After these achievements, they will have chances to get promoted to higher posts.	Long term Career in Research

Program Specific Outcomes (PSOs) for M.Sc. Physics program:

Students who graduate with a Master of Science in **Physics** will:

The Master of Science in Physics program provides the candidate with knowledge, general competence, and analytical skills on an advanced level, needed in industry, consultancy, education, and research.

PSO No.	PSO	Cognitive level
PSO1	Apply the knowledge and skill in the design and development of Electronics circuits to fulfill the needs of Electronic Industry	
PSO2	Become professionally trained in the area of electronics, optical communication nonlinear circuits, materials characterization and lasers.	
PSO3	Pursue researches related to Physics and Materials characterization	
PSO4	Demonstrate highest standards of Actuarial ethical conduct and Professional Actuarial behavior, critical, interpersonal and communication skills as well as a commitment to life-long learning	
PSO5	Prepare students to become Physics professionals with comprehensive knowledge and Practical skills for emerging requirement	
PSO6	Prepare students who will achieve peer-recognition; as an individual or in a team; through demonstration of good analytical, design and implementation skills.	
PSO7	To prepare them to take up higher studies of interdisciplinary nature.	
PSO8	To give exposure to a vibrant academic ambience and To create a sense of academic and social ethics among the students	

Distribution of Course papers for M. Sc. Part I (Physics)

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part I					
Semester I : Theory Courses					
PHY-101	Mathematical Methods for Physics	Core course	04	100	03
PHY -102	Classical Mechanics	Core course	04	100	03
PHY-103	Solid State Physics	Core course	**04**	**100**	**03**
PHY104	**A)**:Physics of Semiconductor Devices Or **B)**: Electronic Instrumentation Or **C)**Bio- Physics	Skill based	**04**	**100**	**03**
Semester I : Practical Courses					
PHY-105	Basic Physics Laboratory – I	Core course	**04+04**	100	06
AC-101	Practicing Cleanliness AC-201A -Soft Skills/ AC-201B- Sport Activities/ AC-201C- Yoga/ AC-201D Music) from Personality and Cultural Development	Audit Course	**02**	**100**	
Semester II : Theory Courses					
PHY-201	Statistical Mechanics	Core course	**04**	**100**	**03**
PHY-202	Classical Electrodynamics	Core course	**04**	**100**	**03**
PHY-203	Quantum Mechanics	Core course	**04**	**100**	**03**
PHY-204	Material Science	Skill based	**04**	**100**	**03**
Semester II : Practical Courses					
PHY-205	Basic Physics Laboratory – II	Core course	**04+04**	**100**	**06**
AC-201A/B/C/D	Choose one out of Four (AC-201A/ AC-201B/ AC-201C/ AC-201D) from Personality and Cultural Development (Audit Course)	Audit Course	**02**	**100**	

M.Sc. Part I Semester I Physics: Core Courses

	PHY - 101: Mathematical Methods for Physics	Lecture
	Course description: This course is aimed at introducing the concepts of Mathematical physics to the students. **Course objectives**: 1. To impart knowledge of basic concepts in Mathematical physics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Vector Space**: Revision of vector space, Sub spaces, Linear combinations of vectors, Linear span, Linear dependence and independence, Basis and dimensions, Linear transformations, Linear operator, Matrix representation of linear operator. Inner product space - Definition of inner product space, Properties (Conjugate symmetry, linearity, non-negativity), Norm of a vector, Schwarz's inequality, Triangle in equality, Cauchy's inequality, Law of Parallelogram, Orthogonally, Orthonormal set, Orthonormal basis, Gram-Schmidt Orthogonalization Process. **(H-6, M-8)**	**08 L**
Unit 2	**Matrix Algebra**: Types of matrices (Symmetric, Skew symmetric, Hermitian, Skew Hermitian, Adjugate, Unitary and Orthogonal), Eigen values and Eigen vectors of a matrix, Diagonalization of matrix, Caley-Hamilton theorem. **(H-5, M-6)**	**05 L**
Unit 3	**Fourier Series:** Definition, Determination of Fourier coefficient, Dirichlet theorem, Extension of interval, Half range Fourier sine and cosine series, Complex form of Fourier series, Parseval'sidentity, Fourier integrals. **(H-10, M-8)**	**10L**
Unit 4	**Integral Transforms:** Definition of Laplace Transform, Properties (Linearity,	**14 L**

	Shifting, Change of Scale), Laplace Transform of derivative, Laplace transform of integrals, Derivative of Laplace transform, initial and final values theorems, Multiplication by power of t, division by t, Inverse Laplace transform- Definition, Proofs of Linearity, Ist & IInd shifting theorem, Convolution theorem(Statement only), Applications to solution of differential equations. Definition of Fourier transformation, Fourier cosine transforms. **(H-14, M-18)**	
Unit 5	**Special Functions**: Legendre, Hermit, & Laguerre Functions (Generating functions, Recurrence relations, Orthogonally, Rodrigue's Formula), Associated Legendre equation, Associated Legendre function, Properties of Associated Legendre function, Recurrence formulae for Associated Legendre function, Laguerre polynomials, Associated Laguerre Polynomials, Orthogonally of associated Laguerre polynomials, Recurrence formulae for Associated Lageurre polynomials. Generating function for Jn(x), Integral representation for Jn(x), Reccurence relation for Jn(x), Bessel's Function of half odd order (J+1/2(x), J-1/2(x), J+3/2(x), J-3/2(x)), Integral formula of Laguerre polynomials Orthogonally of Bessel's equations. **(H-12, M-15)**	**12 L**
Unit 6	**Complex Analysis:** Complex number, Conjugate complex numbers, Function of Complex variable, Analytic function, Cauchy- Riemann condition, Cauchy's theorem, Cauchy's integral formula, Derivative of analytic function, Taylors theorem, Lorentz's theorem, Cauchy's residue theorem, Evaluation of definite integrals(integration round the unit circle). **(H-5, M-5)**	**05 L**

Suggested readings / References:-

1. Linear algebra By Seymour Lipschutz, Schaum outline series.
2. Theory & Problems of Matrices by Frank Ayres.
3. Mathematical Method For Physics by Arfken.
4. Mathematical Method in Physics by B. D. Gupta.
5. MMP by H.K.Das (S. Chand Publication).
6 .Mathematical Physics by B. S. Rajput.
7. Fourier Series by Seymour Lipschutz ,Schaum outline series.
8. Laplace Transforms by Seymour Lipschutz ,Schaum outline series.
9. Complex Variables & Applications by J. W. Brown.
10. Mathematics for physical science by Mary Boas.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C101.1	Course outcome: Learner will be able to …. Apply the concept and knowledge of Mathematical physics to understand and solve real life problems.	
C101.2	Knowledge about Vector calculus, Bessel Functions, Legendre Differential equations, complex variable, Laplace transforms, Fourier Series etc and their physical significance is learnt by students. These mathematical concepts are widely used in various physics derivations.	
C101.3	Understanding of the Basic Mathematical physics will create scientific temperament.	

	PHY-102: Classical Mechanics	
	Course description: This course is aimed at introducing the fundamentals of Classical Mechanics to Post Graduate students. ***Course Objectives***:: 1. To impart knowledge of basic concepts in Classical Mechanics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Mechanics of System of particles:** Conservation of linear and angular momentum of system of particles, Relation between about any point and about Centre of mass, Discuss similar relations for kinetic energy also. Scattering of Particles: Elastic and inelastic collision, Lab. and C.M. system of coordinates, Differential and total cross section, Impact parameter, Rutherford's scattering, Relation of cross-section between C.M. and Lab Frame. **(H-10, M-14)**	**10 L**
Unit 2	**Lagrangian Formulation:** Types of constraints, degrees of freedom, Generalized coordinates, Concept of virtual displacement and virtual work, D'Alemberts principle, Lagrange's equation from D'Alemberts principle, Properties of Lagrange's equation, Applications of Lagrange's equation (simple pendulum, linear simple harmonic oscillator, compound pendulum and Atwood's machine). **(H-10, M-10)**	**10 L**
Unit 3	**Hamilton's equation of motion**: Introduction, Legendre's dual transformation, Hamilton's function and Hamilton's equations of Motion, Properties of the Hamiltonian and of Hamilton's equations of motion, Routhian, Configuration space, Phase space and State space, Lagrangian and Hamiltonian of relativistic particles and light rays. **(H-10, M-12)**	**10 L**
Unit 4	**Principle of Least Action and Hamilton's principle:** Introduction, Principle of least action, Hamilton's principle, Comparison between Fermat's principle of least action in optics & Maupertuis' principle of least action in mechanics, Derivation of Euler-Lagrange equations of motion from Hamilton's principle, Derivation of Hamilton's equations of motion for holonomic systems from Hamilton's principle, Invariance of Hamilton's principle under generalized coordinate transformation. **(H-12, M-14)**	**12 L**
Unit 5	**Canonical transformations and Hamilton-Jacobi theory**: Gauge transformation, Canonical transformation, Condition for transformation to be canonical, Poisson brackets, Canonical equations in terms of Poisson bracket notation, Infinitesimal transformation, Relation between infinitesimal transformations and Poisson brackets, The Hamilton - Jacobi equations, Solution of harmonic oscillator. **(H-10, M-10)**	**10 L**

Suggested readings:/Reference Books:

1. Introduction to Classical Mechanics: R. G. Takwale and P. S. Puranik.
2. Classical Mechanics: N. C. Rana and P. S. Joag, Tata McGraw -Hill Publishing Co. Ltd.
3. Classical Mechanics: P. V. Panat, Narosa Publishing House.2008
4. Classical Mechanics: Gupta, Kumar and Sharma, Pragati Publication
5. Classical Mechanics: Herbert Goldstein, Narosa Publishing House.
6. Classical Mechanics: J. C. Upadhyaya, Himalaya Publishing House.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C102.1	Outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Classical Mechanics to real life problems.	
C102.2	2. Understanding of the Classical Mechanics will create scientific temperament.	
C102.3	This paper enables the students to understand : • The Lagrangian and Hamiltonian approaches in classical mechanics. • The classical background of Quantum mechanics and get familiarized with Poisson brackets and Hamilton -Jacobi equation.	

	PHY - 103: Solid State Physics	
	Course description: This course is aimed at introducing the fundamentals of Solid state Physics to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Solid state Physics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Band theory of Solids**: Nearly free electron model, Bloch theorem (with proof), Kronig Penny model, Motion of electrons in 1-D according to band theory, Distinction between metals, insulators and intrinsic semiconductor, origin of energy gap, Effective mass of an electron. (Ref: 2, 6 & 8) **(H-8, M-8)**	**08 L**
Unit 2	**Defects in solids:** Defect (Imperfection), Classification of defects, Point defect: Schottky defect, Frenkel defect and Interstitial defect, Determination of number of concentration of defects in interstitial defect, Schottky defect and Frenkel defects, Elementary idea about dislocation. (Ref:1,4&9) **(H-5, M-8)**	**05 L**
Unit 3	**Lattice vibrations and phonons:** Concept of lattice vibration, Elastic waves in an infinite and finite one dimensional array of identical atoms, Lattice vibrations of diatomic lattice, Optical and Acoustic modes of vibrations, Quantization of lattice vibrations: Phonons. (Ref: 5 & 6) **(H-7, M-8)**	**07 L**
Unit 4	**Theory of Dielectrics, Piezoelectricity and Ferroelectrics:** Polarization of dielectric, Dielectric constant, Local electric field, Polarizability, Clausius Mosotti relation, Dipolar polarizability, Calculation of Ionic & Electronic polarizability, Total polarizability, Piezoelectricity, Ferro electricity, Theories of Ferro electricity: Dielectric behavior above T_c, Spontaneous polarization below T_c and Ferroelectric Hysteresis, Applications of ferroelectrics. (Ref: 1, 3, 6, 8& 9) **(H-9, M-10)**	**09 L**
Unit 5	**Magnetism**: Origin of magnetic moments, Classification of magnetic materials, Langevin's classical theory of diamagnetism, Langevin's classical theory of Para magnetism, Weiss theory of Para magnetism, Paramagnetic susceptibility of conduction electron, Ferromagnetic domains, ferromagnetic Hysteresis, Exchange energy, Anisotropy energy, Bloch wall, Weiss theory of ferromagnetism, Two sub-lattice model of Anti ferromagnetism, Neel's model of ferrimagnetism. (Ref: 1, 4,8 &9) **(H-13, M-14)**	**13 L**
Unit-6	**Superconductivity**: Basic concept, Occurrence, Meissner effect, Critical field, Type-I and type-II superconductors, Heat capacity, Energy gap, Microwave and IR properties, Critical currents, Thermodynamics of super conducting transitions, London equation, Coherence length, London penetration depth, BCS theory of superconductivity, High T_c super conducting materials, Qualitative discussion of Josephson superconductor tunneling (a.c. &d.c.). (Ref: 1, 3, 6, 7,8& 9) **(H-10, M-12)**	**10 L**

Suggested readings:/Reference Books:

1. Fundamentals of Solid State Physics: B.S.Saxena , R.C.Gupta & P.N.Saxena, PragatiPrakashan, Meerut 11thEd.
2. Solid State Physics : R. L. Katiyar, Campus Books International, New Delhi . 2009.
3. Solid State Physics : R. L. Singhal, Kedarnath Ramnath Prakashan, Meerut.
4. Solid State Physics : S.L. Gupta & V. Kumar, K. Nath & Co. Meerut.
5. Solid State Physics: A.J. Dekkar, McMillan students Ed.
6. Introduction to Solid State Physics: C. Kittle, Wiley Eastern Ltd; 7th Ed.
7. Solid State Physics: C. M. Kachhava, Tata McGraw Hill Eds.
8. Solid State Physics: R. K. Puri and V. K. Babbar.
9. Elementary Solid State Physics: M. Ali Omar.

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C103.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Solid state Physics understand and solve the real life problems.	
C103.2	2. Understanding of the course will create scientific temperament..	
C103.3	After successful completion of this paper, the student will be well • Introducing the behavior of ferroelectric and ferromagnetic material in terms of their properties and applications. • Superconductivity and lattice defects. • Introducing basic concepts via diffraction methods, lattice vibrations and free electrons, Hall effect. • Understanding the basic transport properties of metals and semiconductors. • Their introduction to the band structures for studying different materials.	

M.Sc. Part I Semester I(Physics): (Skill Based Course)

	PHY - 104: (A) Physics of Semiconductor Devices	
	Course description: This course is aimed at introducing the fundamentals of Physics of Semiconductor Devices to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Physics of Semiconductor Devices. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Charge Carriers and Fermi Level in Semiconductors in Equilibrium:** Equilibrium distribution of electrons and holes, Intrinsic carrier concentration and Fermi level position, Doping of semiconductors with impurities, Extrinsic semiconductors: Equilibrium distribution of electrons and holes, Degenerate and non-degenerate semiconductors, Impurity carrier concentration, Charge neutrality equation, Equilibrium electron and hole concentration and its temperature dependence, Position of Fermi level and its variation with temperature and concentration. **(H-9, M-10)**	**09 L**
Unit 2	**Current Transport Phenomena and Continuity Equation: Drift of carriers:** Drift current, mobility and its temperature dependence. Diffusion current, diffusion constant, Total current density, Non-uniform impurity distribution and induced internal field. Einstein's relation, Non-equilibrium excess carriers and Continuity equation. Excess carrier generation, recombination and injection and its mathematical analysis using continuity equation, Life-time and diffusion length of carriers, Concept of quasi Fermi levels. **(H-9, M-10)**	**09 L**
Unit 3	**Characterization of semiconductor solids:** Hall effect, Measurement of resistivity, mobility, carrier concentration, diffusivity, Hall coefficient and carrier types for majority carriers, Hall effect in intrinsic semiconductors. Haynes-Shockley experiment, Mobility, diffusivity and life time of minority carriers. **(H-5, M-7)**	**05 L**
Unit 4	**P-N Junctions-Characteristics and Devices:** Junction in equilibrium, Continuity of Fermi level across the junction, Junction under forward and reverse bias, Zero bias, Built-in-potential, Electric field in depletion region, Space Charge width, Biased junction, Space charge width under electric field, Junction Capacitance, Diffusion capacitance, One sided junction, Non-uniformly doped junctions, Linearly graded, Hyper abrupt etc.,	**13 L**

	Break down in P-N junction, Avalanche and Zener Breakdown. a) PN Junction diode: Carrier distribution profile, Ideal P-N junction current, small signal equivalent, Current voltage characteristics of junction diode. b) Zener diode: Reverse bias breakdown, principle of operation, device design for particular breakdown voltage. c) Photovoltaic Cell: Principle of operation, forward and reverse bias characteristics, equivalent circuit, applications. **(H-13, M-15)**	
Unit 5	**Metal-semiconductor Junction Diode:** Structure, metal semiconductor contacts, energy band diagram for different cases, barrier formation, Schottky barrier diode, Non ideal effects on barrier heights, Current voltage characteristics, Comparison of barrier diode and PN-junction diode, Metal Semiconductor Ohmic contact, Ideal non-rectifying barriers, Heterojunction. **(H-7, M-8)**	**07 L**
Unit 6	**Bipolar Junction Transistor:** Structure, The basic principle of operation, Modes of operation, Carrier concentration profile in various regions in forward active mode, current gain and current gain factors, Equivalent circuit models: Ebers-Moll model, the dependence of Ebers-Moll parameters on the structure and operating point, Maximum transition current, Voltage and power rating. **(H-9, M-10)**	**09 L**

Suggested readings:/Reference Books:

1. Semiconductor and electronic Devices, Adir Bar-lev (1987), Prentice Hall of India.
2. Advanced Theory of Semiconductor Devices, Hess, K.(1988)Englewood Cliffs, N. J. , PH India
3. Physics of Semiconductor Devices, Roy.D.K. (1992), University Press, India.
4. Physics of Semiconductor Devices, Shur,M.(1990) Englewood Cliffs, N. J. Prentice Hall of India.
5. Solid State Electronic Devices, Streetman, B.G. (1990),3rded; Englewood Cliffs, N. J. PH India.
6. Semiconductor Devices; Physics and Technology, Sze, S.M. (1981) Wiley Eastern Ltd.
7. Physics of Semiconductor Devices, Sze, S. M. (1985) Wiley Eastern Ltd.
8. Fundamentals of Semiconductor Theory and Device Physics, Wang, S.(1989) Englewood Cliffs. N.J., PHIndia
9. Semiconductor Devices - Basic Principles, Jasprit Singh, John Wiley & Sons, Inc.(2002).
10. Semiconductor Devices, Zambuto, M .(1989), McGraw Hill.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C104.A,1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Physics of Semiconductor Devices to understand and solve the real life problems.	
C104.A.2	2. Understanding of the course will create scientific temperament.	
C104.A.3	On completion of this course the student will learn about : • Operational amplifiers, comparator and applications, Voltage regulators and features of Timer 555. • Modulation and communications. • Comparator and applications	

	PHY - 104: (B) : Electronic Instrumentation	
	Course description: This course is aimed at introducing the fundamentals of Physics of Electronic Instrumentation to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Physics of Electronic Instrumentation. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Signal representation & generation:** Periodic signals, periodic signals, modulated signals (A.M., F.M., P.M.), sampled data pulse Modulation (PWM, PAM, PPM), definition and their graphical representation. Generation of sine, Square, triangular, linear ramp & saw tooth waveforms. **(H-8, M-10)**	**08 L**
Unit 2	**Measurement of electrical signals**: Meters: comparison of analog & digital meters, moving coil, moving iron, electrodynamics, Induction meter, clamp on meter. CRO: Detail study of CRT, Block diagram of general purpose CRO, Dual beam and dual trace oscilloscope, measurement of voltage, current, resistance, frequency, phase, capacitance & inductance using CRO. **(H-14, M-14)**	**14 L**
Unit 3	**Bio-electric Signals and Electrodes:** Basic Physics of membrane potential, resting membrane potential of nerves, nerve action potential, origin of bio-electric signals, recording electrodes, polarization, skin contact impedance, electrodes for ECG, electrodes for EEG, electrical conductivity of electrodes jellies and creams, microelectrodes. **(H-8, M-10)**	**08 L**
Unit 4	**Telemetry System:** Multiplexer: Analog & digital multiplexer, Sample and hold Circuit. Data transmission system. Telemetry system Block diagram, Characteristics, Land line Telemetry, Radio telemetry, Processing system. **(H-8, M-10)**	**08 L**
Unit 5	**Applications of electronic system:** Frequency selective wave analyzer, Spectrum analyzer, Lock-in amplifier, Fiber optic sensors. Measurement of Humidity, Hygrometers, Measurement of pH, Measurement of thermal Conductivity (gas analyzer), Nuclear instrumentation-types of radiation, Geiger Muller tube, ionization chamber. Flow meters: Classification, working principle, electromagnetic flow meter, Ultrasonic flow meter. **(H-14, M-16)**	**14 L**

Suggested readings:/Reference Books:

1. Transducers& Instrumentation: D.V.S.Murthy.
2. Instrumentation-Devices &system: C.S.Rangan, G.R.Sharma, V.S.V.Mani.
3. Principles of measurement and Instrumentation : Alan S.Morris.
4. Electronic Instrumentation: Kalsi
5. Electrical & electronic measurement Instrumentation: A.K. Sawhney.
6. Modern electronic instrumentation & measurement Technique: Helfrick Cooper.
7. Handbook of Bio-medical Instrumentation – R.S. Khandpur, TMH, New Delhi
8. Introduction to Bio-medical equipment Technology- J.J Carr, Pearson Pvt.Ltd.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C104.B.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Physics of Electronic Instrumentation to understand and solve the real life problems.	
C104.B.2	2. Understanding of the course will create scientific temperament.	
C104.B.3	On completion of this course the student will learn about : • Fabrication of integrated devices. • Applications of electronic system. • Bio-electric Signals and Electrodes	

	PHY - 104: (C) Bio-Physics	
	Course description: This course is aimed at introducing the fundamentals of Bio-Physics to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Bio-Physics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Cellular Basis of Life:** Cell components-structure and function, plant and animal cells, Biomolecules- General idea about structure and functions- H_2O, Proteins, carbohydrates, fats and nucleic acids, Introduction to Biological energy, Energy consumption, Respiration, Energy production, photosynthesis, ATP synthesis. **(H-12, M-8)**	**12 L**
Unit 2	**Protein structure:** 4 levels, Ramachandran plot, Interpretations, classifications (by structure and function), Nucleic acids, Types of DNA, properties, RNA, Base pairing, Transcription and Translation. **(H-6, M-8)**	**06 L**
Unit 3	**Confirmation Analysis:** Asymmetric carbon, Fisher conventions, L-D type systems, Torsion angle, Newmann projection, Cis-trans peptide. **(H-6, M-6)**	**06 L**
Unit 4	Membrane Biophysics & Transport: A) Structure and function of membrane, membrane proteins. B) Transport across membrane, processes, chemical potential, flux equation, Nernst equation, Using–Teorell unidirectional flux ratio, Osmotic pressure, Osmotic phenomenon in leaky membrane, The Donnan equilibrium – Goldmann equation. **(H-10, M-11)**	**10 L**
Unit 5	**Bioenergetics:** Entropy in biological systems, Information processing, Photosynthesis pathways, Redox potentials, Glow curves, Orders of kinetics, Thermodynamics in photosynthesis, Thermo luminescence, Mitochondrial bioenergetics. **(H-8, M-11)**	**08 L**
Unit 6	**Enzyme Kinetics:** Classification of enzymes, Activation energy barrier, substrate concentration, Vmax, Km competitive inhibition, Allosteric enzymes. **(H-5, M-8)**	**05 L**
Unit 7	**Neuro biophysics:** Structure and function of neuron, types of synapses, testing potential, local depolarization, action potential: Generation and propagation, equivalent circuit of cell, voltage clamp, Na-K pump, equivalent circuit. **(H-5, M-8)**	**05 L**

Suggested readings:/Reference Books:

1 Biophysics: A introduction by Rodney M.S., Colteril. John Willey and Sons Ltd.
2. Biophysics: Vasantha Pattabhi, M. Gantham, Narosa Publishing House.
3. Biophysical Plant Physiology and ecology, P.S. Nobel (University of California, Los Angeles and W.H. Freeman & Co., San franscisco, 1983).
4. Biophysics & Physiology of excuitable membranes, Adleman, (Van-Nostrand eehihod.Co.1971).
5. Problems of Biological Physics. L.A. Bluemonfeld (Springer-Verlag-Berlin 1979).
6. The structure and function of proteins. L Dickerson & J.Geis (Harpes&Reod 1975.)
7. Biology, a human approach, I.W.Sherman and V.G.Sherman (Oxford Uni. Press 1979).
8. Essentials of Biophysics, P. Narayanan, New Age Publications, 2000.
9. Principles of Biochemistry: Lahninger.
10. Neuron to brain, S.W. Kuffler and J.G. Nichols (SinacuerAsso. Inc. 1995).

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C104.C.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Bio-Physics to understand and solve the real life problems.	
C104.C2	2. Understanding of the course will create scientific temperament.	
C104.C.3	On completion of this course the student will learn about : • Cell components-structure and function.	

	• Membrane Biophysics & Transport. • Bioenergetics. • Neuro biophysics: Structure and function of neuron, types of synapses, testing potential.	

M.Sc. Part I Semester I Semester I : Practical Courses I (Core course)

PHY-105: Basic Physics Laboratory – I	
	Course description: This course is aimed at introducing the fundamentals of Basic Laboratory Physicsto Under the students. **Course objectives:** 1. To impart knowledge of basic concepts in Laboratory Physics and Mechanics. 2. To provide the knowledge and methodology necessary for Practical in Physics. 3. The course involves the related experiments based on the Practicals.
	Group A **Note: At least 4 experiments from each group and minimum, 10 experiments should be performed**
1	λ by Michelson Interferometer.
2	Febry -Perot Interferometer. Determination of wavelength of monochromatic source.
3	To determine ultrasonic velocity and to obtain compressibility of a given liquid.
4	Magnetic susceptibility of paramagnetic material by Quincke's method.
5	"e/m" by Millikan oil drop method
6	Diffraction at single and double slits using laser source.
7	Surface tension by ripples method.
8	Determination of elastic constants by Cornu's method.
9	Determination of thickness of thin transparent sheet like mica using Michelson interferometer.
10	Determination of Rydberg constant using Hydrogen discharge tube.
11	To find the values of Cauchy's constants for the material of the given prism using Hg.
Group B	
1	Design and build ERPS using IC 723 and study its line and load regulation.
2	Design, build and test the phase shift oscillator using IC-741.
3	Design, build and test Schmitt trigger circuit using 741.
4	To study the characteristics of LDR, Photodiode and Phototransistor.
5	Design, build and test first order & second order low pass filter using IC 741.
6	Design, build and test first order & second order high pass filter using IC 741.
7	Design, build and test precision rectifier using IC 741.
8	Design, build and test Astable /monostablemultivibrator using IC 741/IC 555.
9	Design, build and test voltage to frequency converter.
10	Design, build and test the temperature to frequency converter. 11.Design, build and test transformer less class-B push pull amplifier.
	NOTE: This list is flexible; one can add any suitable experiment (of appropriate standard) from Physics with prior permission of BOS in Physics, NMU, Jalgaon.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C105.1	Course outcome: Learner will be able to ….	

	1. Apply the concept and use of knowledge of the Basic Physics Laboratory course to real life problems.	
C105.2	2. Understanding of the Basic Physics Laboratory course which will create scientific temperament.	
C105.3	Students will have hand on experience of : • Amplifiers, diodes, various logic gates, flip-flops and multivibrator. • Solar cell, Michelson interferometer, photovoltaic cell, lasers and various optoelectronic devices. • Hall coefficient, Curie temperature, B-H curve. • Digital electronics experiments. • Understands in depth about thin film preparation and production controlling techniques and the application of thin films in the field of science & Technology.	

M.Sc. Part I Semester I Physics : Audit Courses

AC-101: Practicing Cleanliness
(Compulsory; Campus-level Audit Course; Practical; 2 Credits)

Course Objectives (CObs):

- To make students aware of Clean India Mission and inculcate cleanliness practices among them.

	• Awareness program on
	  o Swachh Bharat Abhiyan (Clean India Mission)
	  o Clean Campus Mission
	  o Role of youth in Clean India Mission
	• Cleaning activities inside and surroundings of Department buildings.
	• Tree plantation and further care of planted trees
	• Waste (Liquid/Solid/e-waste) Management, Japanese 5-S practices
	• Planning and execution of collection of Garbage from different sections of University campus
	• Role of youth in power saving, pollution control, control of global warming, preservation of ground water and many more issues of national importance.
	• Cleanest School/Department and Cleanest Hostel contests
	• Painting and Essay writing competitions	

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC101.1	Identify need at of cleanliness at home/office and other public places.	**2**
AC101.2	Plan and observe cleanliness programs at home and other places.	**4**
AC101.3	Practice Japanese 5-S practices in regular life.	**3**

M.Sc. Part I Semester II (Physics): Core Courses

PHY – 201: Statistical Mechanics		
	Course description: This course is aimed at introducing the fundamentals of Statistical Mechanics to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Statistical Mechanics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Phase Space and Ensembles:** Phase space, Types of Ensembles, Partition function, Liouville's theorem, Principles of conservation of density and extension in phase space, Grand canonical ensemble, Physical interpretation of α, Chemical potential in the equilibrium state, Fluctuations in number of particles of a system in grand canonical ensemble, Partition function of Classical ideal gas and calculation of thermodynamic quantities, Entropy of mixing and Gibb's paradox, Sackur-Tetrode equation. **(H-14, M-14)**	**14 L**
Unit 2	**Classical and Quantum Statistical Mechanics:** Brief outline of classical and Quantum statistics, Symmetry of wave functions, The quantum distribution functions, Maxwell Boltzmann statistics, Bose Einstein. Statistics, Photon statistics, Fermi Dirac statistics, The Boltzmann limit of Boson and Fermions gases, Evaluation of partition function for quantum monatomic gas, Partition function for diatomic molecules, Equation of state for an ideal gas. **(H-12, M-12)**	**12 L**
Unit 3	**Ideal Bose Systems:** Photon gas: Black body radiation, radiation properties such as pressure, density, emissivity and equilibrium number of photons in a cavity. Einstein's derivation of Planck's law, Bose Einstein condensation, Specific heat from lattice vibrations, Debye's model of solids: Phonon gas. **(H-10, M-12)**	**10 L**
Unit 4	**Ideal Fermi Systems:** Fermi energy, Mean energy of fermions at absolute zero temperature, Fermi energy as a function of temperature, Electronic specific heat, White Dwarfs, Compressibility of Fermi gas, Pauli paramagnetism, Relativistic degenerate gas. **(H-8, M-12)**	**08 L**
Unit 5	Phase transition and Critical Phenomena: Phase transitions, Conditions for phase equilibrium, Order parameter, Ist order phase transition, IInd order Phase transition, Critical indices, van der Waals theory of liquid gas transition, Mayer theory of condensation, Curie Weiss theory of magnetic transition, Ising model. **(H-8, M-10)**	**08 L**
Suggested Readings:/ Reference Books: 1. Fundamentals of Statistical Mechanics: B.B. Laud, New Age Int.l Publishers (2003) 2. Introduction to Statistical Mechanics: S. K. Sinha, Narosa Publication, New Delhi (2007). 3. Fundamentals of Statistical & Thermal Physics: F. Reif, Mcgraw Hill Company, (1965). 4. Statistical Mechanics: R. K. Patharia, Butterworth-Heinemann (Elsevier) (2/e Reprint 2004). 5. Statistical Physics: Harvey Gould and Jan Tobochnik..		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C201.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Statistical Mechanics to understand and solve the real life problems.	
C201.2	2. Understanding of the course will create scientific temperament..	

C201.3	The students should be able to : • Explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics. • Apply the principles of statistical mechanics to selected problems. • Grasp the basis of ensemble approach in statistical mechanics to a range of situations. • To learn the fundamental differences between classical and quantum statistics and learn about quantum statistical distribution laws. • Study important examples of ideal Bose systems and Fermi systems.	

	PHY - 202: Classical Electrodynamics	
	Course description: This course is aimed at introducing the fundamentals of Classical Electrodynamics to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Classical Electrodynamics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Electrostatics and Multipole Fields:** Electrostatics energy and energy density and free space and in dielectrics ,Thermo dynamic interpretation of Electrostatics energy, Electric dipole, Multipole expansion of potential, The dipole potential, The quadrupole potential and quadupole moment, further remarks concerning electric multipoles. **(H-10, M-10)**	**10 L**
Unit 2	**Electromagnetic Waves:** Plane waves in non conducting media, Polarization, Energy Flux in a plane wave, Radiation Pressure and Momentum, Plane waves in a conducting medium, the Skin effect, Current distribution in conductors –The Skin depth. **(H-10, M-10)**	**10 L**
Unit 3	**Reflection, Refraction and Dispersion:** Boundary conditions for the electromagnetic field vectors B, E, D and H at interface between two media, Reflection and Refraction at the boundary of two non-conducting media, General treatment of reflection and refraction, Fresnel's equations-Incident wave polarized with its vectors E normal and parallel to the plane of incidence, The coefficients of reflection and transmission at the interface between two dielectrics, Brewster angle and degree of polarization, Rectangular wave guide, Dispersion (Normal and Anomalous), Dispersion in liquid and solid. **(H-12, M-15)**	**12 L**
Unit 4	**Electromagnetic Fields and Radiating systems:** Lienard-Wiechart Potentials, Electric and magnetic fields of charge in uniform rectilinear motion, Electric and magnetic fields produced by arbitrary moving charge, Radiation due to non relativistic charges and relativistic charges, Radiating systems, Radiation due to an oscillating electric dipole, Radiation due to a small current element, Linear half wave antenna. **(H-12, M-15)**	**12 L**
Unit 5	**Relativistic Electrodynamics:** Galilean transformations, Lorentz transformations, Velocity momentum and energy in relativity, four vectors in electrodynamics. Covariant form of electric and magnetic field- Electromagnetic field tensor. **(H-8, M-10**)	**08 L**
Suggested readings / Reference books:- 1) Electrodynamics by Gupta, Kumar and Singh 2) Classical Electromagnetic Radiation by Jerry B. Marion 3) Electromagnetic by B. B. Laud. 4) Classical Electrodynamics by J. D. Jackson 5) Introduction to Electrodynamics by A. Z. Capri & P. V. Panat		

6) Classical Electricity & Magnetism by Panofsky Phillips
7) Foundations of Electromagnetic theory by Reitz & Milford
8) Electromagnetic theory & Electrodynamics by Satyaprakash, Kedarnath.
9) Introduction to Electrodynamics by David Griffith.

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C202.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Classical Electrodynamics to understand and solve the real life problems.	
C202.2	2. Understanding of the course will create scientific temperament.	
C202.3	3 After successful completion of the course, the student is expected to : • Have gained elaborated knowledge about the electrostatics and laws governing the charge distribution. • Have gained ability to apply Laplace equation for calculating potentials. • Study in depth about Polarization, bound charges and boundary conditions. • Realize the importance of application of Biot Savarts Law and Amperes law. • Understand the relevance of different magnetization and the boundary condition of magnetic field.	

	PHY - 203: Quantum Mechanics	
	Course Objectives: 1. To Course description: This course is aimed at introducing the fundamentals of Quantum Mechanics to the students. Course objectives: 1. To impart knowledge of basic concepts in Quantum Mechanics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Operator methods in quantum mechanics:** Linear vector space and its properties, examples, Linear independence of vectors , dimensions, bases and expansion theorem, Inner product & unitary spaces, Orthonormal sets, completeness, Hilbert spaces. Operators: Linear operators, Identity operator, Null operator, Inverse operator, Eigen values & eigen functions, Hermitian operators and their properties, Expansion of eigen functions, Continuous spectrum, Parity operator & its properties, Projection operator, Equation of motion. **(H-10, M-12)**	**10 L**
Unit 2	**Matrix formulation of Quantum Mechanics**: Dirac's Bra and Ket notations for vectors and their properties, Ket vector as a column matrix and bra vector as a row matrix, Operators as matrices, Matrix form of wave function, Unitary transformation, Eigen value problem, Quantum Dynamics: Schrodinger, Heisenberg and Interaction representations, Defining equations for the operators a and a+, Computation of values of a a+, a+a, [a, a+], [a, H], [a+, H], Eigen values & Eigen functions of 1-D harmonic oscillator using ladder operators a and a+, Matrices for the operators: a, a+, x, p, H, Derivation of Schrodinger's equation from a and a+. **(H-14, M-16)**	**14 L**
Unit 3	**Angular Momentum**: Total angular momentum operator J. Commutation relation of components J_x, J_y and J_z. Ladder Operators J_+ and J_- , Commutation relations of J_2 and J_z with J_+ and J_- , Commutation between J_+ and J_-, Eigen values and Eigen functions of J_2 and J_z, Angular momentum Matrices, Electronic states in a central field, Addition of angular momenta, Computation of Clebesch- Gordan coefficients for (j_1 = ½ & j_2 = ½)	**14 L**

	and for ($j_1 = 1$ & $j_2 = ½$). **(H-14, M-16)**	
Unit 4	**Approximation Methods**: a) Time independent Perturbation Theory: Non degenerate case – Evaluation of first order energy and first order wave function, Evaluation of second order energy and second order wave function, Application to: Perturbed Harmonic Oscillator, b) Variation Method: Basic principles, Applications to: one dimensional harmonic oscillator, Ground state energy of hydrogen atom. c) The WKB approximation: The principle of the method, the WKB wave function, Application to: transmission through a barrier. **(H-14, M-16)**	**14 L**

Suggested readings:/Reference Books:

1. Advanced Quantum Mechanics: SatyaPrakash, Kedarnath Ramnath, Meerut.
2. Quantum Mechanics: G. R. Chatwal & S. K. Anand, Himalaya Publishing House.
3. A text book of Quantum Mechanics: P.M.Mathews & K.Venkatesan, Tata McGraw Hill Pvt. Ltd.
4. Quantum Mechanics: John L Powell & Bernd rasemann., Narosa Publishing House.
5. Quantum Mechanics: A.K.Ghatak&S.Loknathan, The Macmillan company of India Ltd..
6. Quantum Mechanics: L. I. Schiff. McGraw Hill.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C203.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Quantum Mechanics to real life problems.	
C203.2	2. Understanding of the course will create scientific temperament.	
C203.3	After successful completion of this paper, the student will be well • Linear vector spaces, versed in Hilbert space, concepts of basis and operators and bra and ket notation. • Both Schrödinger and Heisenberg formulations and their applications. • Theory of angular momentum and spin matrices, orbital angular momentum and Clebsh Gordan Coefficients. • Space -time symmetries and conservation laws, theory of identical particles, Oscillators • Time Dependent and independent Perturbation Theory, Variational Method, WKB Method, Collision Theory and Relativistic Quantum Mechanics.	

M.Sc. Part I Semester II (Physics): Skill Based Course

	PHY - 204: Material Science	
	Course description: This course is aimed at introducing the fundamentals of Material Science to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Material Science. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Phase diagram**: Solid solutions, types of solid solutions, Hume-Rothery rules, intermediate phase/ compounds Phase equilibrium, Gibbs Phase rule, Lever rule,	**11 L**

	Equilibrium Phase Diagrams, Unary diagrams, Binary diagrams, typical isomorphous Phase diagram, Cooling curves for isomorphous binary system Al2O3-Cr2O3, properties of eutectic, peritectic, monotectic and eutectoid-systems. Phase diagram for isomorphous system-. Eutectic phase diagram for Pb-Sn system. **(H-11, M-12)**	
Unit 2	**Phases in alloys and Phase transformations:** Iron-Carbon phase diagram and different phases of the system. Phase transformations in steel during heating and transformation of austenite during cooling. Transformation rate effects and TTT diagrams, Microstructure and Property Changes in Fe-C Alloys. **(H-13, M-14)**	**13 L**
Unit 3	**Applications and Processing of Metals and Alloys:** Types of metals and alloys: Ferrous materials -A Steels: Low carbon steels, Medium carbon steels, High carbon steels, Stainless steels. Cast irons: Gray cast iron, White cast iron, Nodular (or ductile) cast iron, Malleable cast iron. Non-ferrous materials: Aluminium alloys, Copper alloys, Magnesium alloys, Titanium alloys, Refractory metals Noble metals, free cutting steel, structural steel, high speed steel, ball, bearing steel. Cu-alloys: Brasses and Bronzes-Properties and applications, Cu-Ni – alloys. Thermal processing of metals and alloys: Annealing processes: Process annealing, Stress relief, Full annealing, Normalizing. Quenching and Tempering processes. Case Hardening: Induction hardening, Flame hardening, Laser hardening, Carburizing, Cyaniding. **(H-14, M-16)**	**14 L**
Unit 4	**Applications and Processing of Ceramics:** Ceramics: Structure, types and properties. Glasses, Clay products, Refractories, Abrasive ceramics, Cements, Advanced ceramics, typical ceramics and respective applications. Fabrication and processing of ceramics. Glasses- structure, Glass transition, properties of glasses. Metallic glasses-introduction, preparation of metallic glasses, mechanical and magnetic properties, principal uses of metallic glasses. **(H-8, M-12)**	**08 L**
Unit 5	**Solar Energy materials:** Solar energy spectrum, photovoltaic conversion materials: Si, GaAs, CdS, $CuInSe_2$, fabrication of CdS/Cu_2S cell, introduction to organic solar cells. **(H-6, M-6)**	**06 L**

Suggested readings:/Reference Books:

1. Introduction to engineering materials: B. K. Agrawal, Tata McGraw-Hill Pub.
2. Material Science and Engineering, A first course : V. Raghavan, Prentice Hall Of India.
3. Introduction to Materials Science: H. B. Lal, Dominant Publishers, New Delhi.
4. Composite Material Science and Engineering, Springer, 2001. By Krishnan K. Chawla.
5. Material Science and Engineering: R. K. Rajput , S. K. Kataria & Sons, New Delhi,2002.
6. Solid State Physics-Structure and Properties of Materials: M. A. Wahab, Narosa Publishing.
7. Material Science and Engineering- An introduction W. D. Callister Jr sixth edition.
8. Foundations of Material Science and Engineering- William F. Smith.
9. Mechanical Metallurgy, Third Edition, G. E. Dieter McGraw-Hill, New York, 1986.
10. Introduction of Dislocations, D. Hull, Third Edition, Butterworth-Heinemann, Woburn, U.K.
11. Introduction to Ceramics, Second Edition W. D. Kingery, H. K. Bowen, and D. R. Uhlmann.
12.Physical Ceramics for Engineers L. H. Van Vlack, Addison-Wesley Longman.
13. Heat treating, Vol. 4, ASM Handbook, , ASM International, Materials Park, OH, 1991.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C204.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Physics of material Science to understand and solve the real life problems.	
C204.2	2. Understanding of the course will create scientific temperament.	
C204.3	3 The student will get familiar with • Crystal imperfections. • Diffusion in solids and mechanical properties. • Phase transformations and heat treatment	

M.Sc. Part I Semester II Semester II : Practical Courses II (Core course)

PHY- 205: Basic Physics Laboratory – II	
Course description: This course is aimed at introducing the fundamentals of Basic Physics Laboratory to Under the students. **Course objectives:** 1. To impart knowledge of basic concepts inBasic Physics and Mechanics etc. 2. To provide the knowledge and methodology necessary for Practical problems in Physics. 3. The course involves the related experiments based on the Practicas.	
Important note: At least 4 experiments from each group and minimum, 10 experiments should be performed.	
Group A	
1	Determination of Brewster's angle & estimation of refractive index of a given transparent material by using spectrometer and sodium lamp.
2	Study of normal Zeeman effect using LG plate.
3	Construction & study of Pb-Sn binary phase diagram from direct cooling curve of a particular composition and the given transition temperature data.
4	Determination of ionic conductivity & activation energy of NaCl/KCl solid specimen.
5	Hall effect: Determination of Hall coefficient, mobility and type of charge carriers.
6	To investigate the characteristics of radiation emitted by bodies at elevated temperatures (Black body radiation) and determine various constants.
7	Study of magneto resistance in semiconductors.
8	Determination of dielectric constant at high frequency by Lecher wire.
9	To determine Young's modulus of a metallic rod by Searle's optical interference method (Newton's Rings).
10	.Audiometry of human using an audiometer.
11	.Magnetic susceptibility by Guoy method..
12	.Measurement of electrical conductivity of silicon/germanium material at different temperatures by Four Probe method
Group B	
1	.Design, build & test square, triangular and sine wave generator using IC -741.
2	Build & test dual power supply using three pin regulators: 78XX and 79XX series
3	Instrumentation amplifier with thermocouple transducer AD-590.
4	Capacitance measurement using IC 555 .
5	Design, Build and test Inductance simulation circuit using IC 741.
6	Design, build and test the DC to DC converter circuit.
7	Design, build & test Notch filter using IC-741
8	Study of voltage control oscillator using IC 566.
9	Study of optocoupler MCT 2E and their applications.
10	.Active filters for bio-signals: design & testing.
11	.Build and test temperature controller using Solid State Relay (SSR) and PT-100.
NOTE: **This list is flexible; one can add any suitable experiment (of appropriate standard) from Physics with prior permission of BOS in Physics, NMU, Jalgaon**.	

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C205.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Basic Physics Laboratory course to real life problems.	
C205.2	2. Understanding of the Basic Physics Laboratory course which will create scientific temperament.	
C205.3	Students will have hand on experience of : • Zeeman effect using LG plate. • Construction & study of Pb-Sn binary phase diagram Hall coefficient. • Dielectric constant at high frequency. • Magnetic susceptibility. • Design, build & test square, triangular and sine wave generator etc.	

M.Sc. Part I Semester II (Physics): Audit Courses

	AC-201(A): Soft Skills **(Personality and Cultural Development Related Audit course; Practical; 2 Credits) (Optional:)**	
	Course description: This course is aimed at introducing the fundamentals Soft Skills to Under the students. **Course objectives:** 1. To impart knowledge of basic concepts Soft Skills. 2. To provide the knowledge and methodology necessary for Soft Skills 3. The course involves the fundamentals and knowledge of Soft Skills based on the Practicals.	
Unit 1	**Introduction to soft skills:** Formal definition, Elements of soft skills, Soft vs. Hard skills, Emotional quotient, Goal setting, life skills, Need for soft skills, Communication skills, Etiquettes& Mannerism.	**2 H**
Unit 2	**Self-Assessment:** Goal setting, SWOT analysis, attitude, moral values, self-confidence, etiquettes, non-verbal skills, achievements, positive attitude, positive thinking and self-esteem. Activity: The teacher should prepare a questionnaire which evaluate students in all the above areas and make them aware about these aspects.	**4 H**
Unit 3	**Communication Skills:** Types of communication: Verbal, Non-verbal, body language, gestures, postures, gait, dressing sense, facial expressions, peculiarity of speaker (habits). Rhetoric speech: Prepared speech (topics are given in advance, students get 10 minutes to prepare the speech and 5 minutes to deliver, Extempore speech (students deliver speeches spontaneously for 5 minutes each on a given topic), Storytelling (Each student narrates a fictional or real-life story for 5 minutes each), Oral review (Each student orally presents a review on a story or a book read by them) Drafting skills: Letter, Report & Resume writing, business letters, reading & listening skills Activity: The teacher should teach the students how to write the letter, report and build resume. The teacher should give proper format and layouts. Each student will write one formal letter, one report and a resume.	**8 H**
Unit 4	**Formal Group Discussion, Personal Interview & Presentation skills:** Topic comprehension, Content organization, Group speaking etiquettes, driving the discussion & skills. Preparation for personal interview: dress code, greeting the panel, crisp self-introduction, neatness, etiquettes, language tone, handling embarrassing & tricky questions, graceful closing.	**4 H**

	Activity: Each batch is divided into two groups of 12 to 14 students each. Two rounds of a GD for each group should be conducted and teacher should give them feedback. Mock interview are to be conducted.	
Unit 5	**Aptitude and analytical skills** Quantitative aptitude, Numerical reasoning, verbal reasoning, diagrammatic test, situational tests, logical thinking. Analytical skills: Definition, Types, problem solving	**8 H**
Unit 6	**Life skills** Time management, critical thinking, sound and practical decision making by dealing with conflicts, stress management, leadership qualities Activity: The teacher can conduct a case study activity to train students for decision making skills. The teacher should conduct a session on stress management and guide students on how to manage stress. The teacher may conduct a stress relieving activity in the class. He/she may counsel students individually to know their problems and guide them on dealing with them effectively.	**4 H**

Suggested readings:

1. Basics of Communication In English: Francis Sounderaj, MacMillan India Ltd.
2. English for Business Communication: Simon Sweeney, Cambridge University Press
3. An Introduction to Professional English and Soft Skills: Das, Cambridge University Press
4. Quantitative Aptitude: R.S. Agrawal

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201A.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Soft Skillsto real life problems.	
AC201A.2	On completion of this course the student will learn about: • Self-Assessment. • Communication Skills. • Formal Group Discussion, Personal Interview & Presentation skills. • Aptitude and analytical skills. • Life skills, Time management etc.	

AC-201(B): Practicing Sports Activities

(Personality and Cultural Development Related Audit course; Practical; 2 Credits)
(Optional: Campus-level)

Course Objectives (CObs):

- To motivate students towards sports and provide them required training.

SR NO.	NAME OF THE SPORT/GAME (Select ONE of the Following)	SYLLABUS OF THE COURSE	TIMING (02 Hours in a Week)	SEMESTER
1	Volleyball	• General Fitness • Basic Fitness • Specific Fitness • History of the Game • Basic Skill of the Game • Major Skill of the Game • Technique & Tactics of the Game • Game Practice	Morning : 07 to 09 AM OR Evening : 05 to 07 PM	Total 30 Hours in Each Semester
2	Athletics			
3	Badminton			
4	Cricket			
5	Basketball			
6	Handball			
7	Kabaddi			
8	Kho-Kho			
9	Table-Tennis			
10	Swimming			

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201B.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Sports to real life problems	
AC201B.2	On completion of this course the student will learn about: Varies type of Games, • General Fitness • Basic Fitness • Specific Fitness • Basic Skill of the Game • Major Skill of the Game and Technique & Tactics of the Game	

AC-201(C): Practicing Yoga **(Personality and Cultural Development Related Audit course; Practical; 2 Credits)** **(Optional:)**	
	Course Objectives: • To motivate students towards yoga and provide them required training.
	• Yoga: Meaning, Definition & Introduction, Objectives • Primary Introduction of Ashtanga Yoga • Preparation of Yogabhyas • Omkar Sadhana, Prayer, Guru Vandana • Sukshma Vyayamas • Suryanamaskar (12 Postures) • Asanas : ▪ Sitting (Baithaksthiti) - Vajrasana, Padmasan, Vakrasan, Ardha-Pashchimotanasanan ▪ Supine (Shayansthiti) - Uttan Padaasan(Ekpad/Dwipad), Pavanmuktasana, Viparitakarani Aasan, Khandarasan, Shavasana ▪ Prone (Viparitshayansthiti) - Vakrahasta, Bhujangasana, Saralhasta Bhujangasana, Shalabhasana(Ekpad/Dwipad), Makarasana ▪ Standing (Dhandsthiti) - Tadasana , TiryakTadasana, Virasana, Ardh Chakrasana • Primary Study of Swasana: Dirghaswasana, Santhaswasana, JaladSwasana - 6 Types • Pranayama : Anuloma-viloma, Bhramari

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201C.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Yoga to real life problems	
AC201C.2	On completion of this course the student will learn about: • Primary Introduction of Ashtanga Yoga • Omkar Sadhana, Prayer, Guru Vandana • Sukshma Vyayamas • Suryanamaskar (12 Postures) and Asanas • Pranayama : Anuloma-viloma, Bhramari	

AC-201(D): Introduction to Indian Music **(Personality and Cultural Development Related Audit course; Practical; 2 Credits)** **(Optional: Campus-level)**	
	Course Objectives: • To motivate students towards Indian music and provide them minimum required training. .
	• Definition and brief about generation of Swar, Saptak, Thaat, Raag, Aavartan, Meend, Khatka, Murkee, Taal, Aalaap etc. • Taal and its uses - Treetaal, Daadraa, Zaptaal, Kervaa. • Information of Badaakhyaal, Chhotaakhyaal (one), Sargam, Lakshangeet (information) • Detailed information of Tambora • Detailed information of Harmonium and Tablaa. • Five filmy songs based on Indian Classical Music (Theory and Presentation) • Sound Management - Basic information of Sound Recording (including Practicals) • Composition of Music as per the Story • Preparing news write-ups of the Seminars, Library Musical Programmes held at the nearest Akashwani, by personal visits.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC201D.1	Identify different types of Indian music.	**3**
AC201D.2	Develop more interest to learn and practice Indian music.	**4**

Distribution of Course papers for M.Sc. Part II (Physics)

Subject Code	Title of the Paper		Duration (Hrs./Wk)	Max. Mark	Exam. Time (Hrs.)
M.Sc. Part II (Subject Name)					
Semester III : Theory Courses					
PHY -301	**Atomic and Molecular Physics**	**Core course**	**04**	**100**	**03**
PHY-302	**Any ONE of the following** **A) Materials Synthesis and Preliminary Analysis OR** **B)Computational Methods and Programming Using 'C' Language OR** **C) Acoustics and Entertainment Physics**	**Elective course**	**04**	**100**	**03**
PHY -303	**Any ONE of the following** **A) Systematic Materials Analysis OR** **B)Microprocessor and its Applications OR** **C) Communication Electronics**	**Skill Course**	**04**	**100**	**03**
Semester III : Practical Courses					
PHY -304	**Special Laboratory I**	**Core course**	**04+04**	**100**	**06**
PHY -305	**Project Work-I(Literature Survey, Definition of Problem, Experimental work, Oral etc.)**	**Skill course**	**04+04**	**100**	**06**
AC-301A/B/C/D	**Choose one out of Four (AC-301A-** Computer Skills / **AC-301B -** Cyber Security/ **AC-301C-** Seminar + Review Writing / **AC-301D-** Biostatistics**) from Technology + Value Added Courses**	**Audit course**	**02**	**100**	
Semester IV : Theory Courses					
PHY -401	**Nuclear Physics**	**Core course**	**04**	**100**	**03**
PHY -402	**Any ONE of the following** **A) Nanomaterials: Synthesis, Properties and Applications OR** **B) LASER and it's Applications OR** **C) Astrophysics**	**Core course**	**04**	**100**	**03**
PHY -403	**Any ONE of the following** **A) Renewable Energy Sources OR** **B) Microwave: Theory and Applications OR** **C) Environmental Physics**	**Elective course**	**04**	**100**	**03**
Semester IV : Practical Courses					
PHY -404	**Special Laboratory II**	**Core course**	**04+04**	**100**	**06**
PHY -405	**Project Work-II(Characterization, Analysis of Result, Conclusions, Project Report, Oral etc.)**	**Skill based**	**04+04**	**100**	**06**
AC-401A/B/C/D	**Choose one out of Four (AC-401A-**Human Rights / **AC-401B –Current Affairs / AC-401C-** Seminar + Review Writing / **AC-401D** - Intellectual Property Rights (IPR)**) from Professional and Social + Value Added Courses**	**Audit course**	**02**	**100**	

PHY– 301: Atomic and Molecular Physics		
	Course description: This course is aimed at introducing the fundamentals of Atomic and Molecular Physics to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Atomic and Molecular Physics. 2. To provide the knowledge and methodology necessary for solving problems in Physics. 3. The course also involves the related experiments based on the theory.	
Unit 1	**Atomic spectra:** Introduction, origin of hyperfine structure, hyperfine structure of two or more valence electrons, Zeeman Effect in hyperfine structure, Back Goudsmit effect in hyperfine structure. **(H-14, M-17)**	**14 L**
Unit 2	**Rotational Spectra:** Classification of molecular spectra (pure rotational spectra, Rotation-vibration spectra, visible and UV spectra),Types of molecules: Diatomic linear symmetric top, asymmetric top and spherical top molecules, Introduction to rotational spectra, relative intensities of spectral lines, rotational spectra of rigid and non-rigid molecules through microwave spectroscopy, Determination of moment of inertia and bond length from rotational spectra. **(H-10, M-12)**	**10 L**
Unit 3	**Vibrational spectra:** Anharmonic oscillator, deduction of molecular properties from vibrational spectra of diatomic molecules. **(H-4, M-5)**	**04 L**
Unit 4	**Rotation-Vibrational spectra:** Coupling of rotation and vibration, rotation-vibration spectra, selection rules and transitions for the vibrating rotator, intensities in rotation and irrotational spectra, parallel and perpendicular bands of linear molecules, isotope effect in vibrational rotational spectra. **(H-5, M-6)**	**05 L**
Unit 5	**Electronic spectra of Diatomic molecules**: Electronic energy curves, potential energy curves, stable and unstable molecular states, vibrational structure of electronic spectra, general formula, graphical representation, rotational structure of electronic spectra, P,Q,R branches of band, Band head formation, shading of bands: fortrat diagram, intensities in electronic – vibrational bands structure, Frank Condon principle. **(H-7, M-07)**	**07 L**
Unit 6	**RAMAN spectra:** Raman effect, quantum theory, Molecular polarizability, Pure rotational Raman spectra of diatomic molecules, vibration rotation Raman spectrum of diatomic molecule, intensity alternations in Raman spectra of diatomic molecules, applications of IR & Raman spectroscopy in the structure determination of simple molecules, polarization of Raman lines. **(H-7, M-7)**	**07 L**
Unit 7	**NMR spectroscopy:** Resonance Technique: NMR – nuclear spin magnetic moment, interaction of nuclear magnet with external field. Quantum description of N.M.R, NMR spectrometer, Chemical shift, spin – spin interaction, Application of NMR spectroscopy. **(H-5, M-6)**	**05 L**

Suggested Readings: / References:

1. Molecular Spectra & Molecular Structure: G. Herzberg, Vol. 1 & 2 (Von no strand Co. Inc 1965)
2. Fundamentals of Molecular Spectroscopy: C.B. Banwell.
3. Atomic and Molecular Spectra: Rajkumar
4. Fundamental of molecular spectroscopy: Raymond Chang, McGraw Hill-Kogakusha Ltd, London 1971.
5. Introduction to IR & Raman spectroscopy: Calthup, Daiy& Wimberley, Academic press1964.
6. Spectroscopy Vol I & II: Edited by B.P. Stranghan& S. Walker.
7. Spectroscopy and Molecular Structure: C. W. King Holt Reinhardt & Winston Inc. 1964.
8. Atomic Spectra – H. E. White
9. Physical Methods in Inorganic Chemistry – Drago
10. Physical Chemistry – Puri, Sharma, Patharia.

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C301.1	After successful completion of the course, the student is expected to : know about different atom model and will be able to differentiate different atomic systems, different coupling schemes and their interactions with magnetic and electric fields.	
C301.2	Have gained ability to apply the techniques of microwave and infrared spectroscopy to elucidate the structure of molecules.	
C301.3	• Be able to apply the principle of Raman spectroscopy and its applications in the different field of science & Technology. • To become familiar with different resonance spectroscopic techniques and its applications. • To find solutions to problems related different spectroscopic systems.	

M.Sc. Part II Semester III (Physics): Elective Course (Select only one)

PHY-302(A): Materials Synthesis and Preliminary Analysis		
Unit 1	**Nucleation , Growth of Thin Films and Single crystal:** Condensation, Langmuir-Frankel theory of condensation. Theories of nucleation: Capillarity model, Atomistic model, Various stages of growth. Types thin film deposition techniques (list only**).** **(H-5, M-7)** **Single crystals:** Importance of growing single crystals and their uses, Thermodynamic principles and crystal growth equilibrium. Theory of crystal growth, Nucleation, Growth of single crystal by water solution method, growth by Gel method, growth by Flux method, Hydrothermal growth. **(H-5, M-7)**	**10 L**
Unit 2	**Physical Vapour Deposition Techniques:** **Thermal evaporation:** General considerations, evaporation methods: Resistance heating, Flash evaporation, R.F. heating, Electron beam (e-beam) heating, Molecular Beam Epitaxy (MBE**).** **(H-6, M-7)** **Sputtering:** Cathodic sputtering- Sputtering process, glow discharge sputtering pressure, Deposit distribution, current and voltage dependence, cathode, contamination problem, Deposition control, Sputtering variants, Low pressure sputtering: Magnetic field, Assisted(triode)sputtering, R.F. sputtering, Ion-beam sputtering. Reactive sputtering. **(H-6, M-7)**	**12 L**
Unit 3	**Chemical vapour deposition Techniques:** Principle, chemical reactions used. Pyrolysis (Thermal decomposition), Hydrogen reduction, Halide disproportionation, Transfer reactions, polymerization**.** **(H-4, M-5)**	**04 L**
Unit 4	**Chemical Bath Deposition Technique:** **Electode less deposition:** Mechanisms of chemical bath deposition. Introduction, Nuclean, Adhesion and film growth processes in Ion-by-Ion mechanism, Hydroxide cluster mechanism, complex decomposition mechanism. **(H-5, M-5)** **Chemical Spray Method:** Nucleation and growth process in film deposition, General idea of air pressure spray pyrolysis, Ultrasonic spray pyrolysis to prepare nanostructured films. **(H-5, M-5)**	**10 L**
Unit 5	**Thick film deposition technique:** Fundamental aspect of the process, Design aids, Screens, Substrate materials, Screen printing, Firing process, Components and network: Passive components, active components, Assembly, packaging and testing:	**08 L**

	soldering methods for component attachment, wire bonding, packaging, testing. **(H-8, M-7)**	
Unit 6	**Thickness measurement and Electrical Properties of films:** **Thickness measurement:** Optical interference technique, Multiple beam interferometry, Quartz crystal microbalance, Stylus (Talyestep) method. **(H-4, M-5)** **Electrical Properties:** Electrical conductivity of bulk, thin and thick films, two probe, Van-der Pauw and Four probe methods, Hall measurements, TEP measurements. **(H-4, M-5)**	**08 L**
Suggested Readings: References: 1. Thin Film Phenomenon, K.L. Chopra, McGraw Hill, 1969. 2. Hand book of Thin Film Technology L.I. Maissel & R.Glang, McGraw Hill, 1970. 3. Thin Film Processes: J.L. Vossen and W. Kern, Academic Press, 1978. 4. Thin Film Fundamentals, A.Goswami, New Age International Publishers. 5. Chemical Solution Deposition of Semiconductors Films : Gary Hodes- Weizmann Institute of Science, Rehorot, Iszael. New York-Basar. 6. The materials science of Thin Films: M.Ohring Academic Press,1992. 7. Active and Passive Thin Film Devices: T.J.Coutts, Acadmeic Press 1978. 8. An Introduction to Physics and Technology of Thin Films : A Wegendristel and Y.Wang, World Scientific 1994. 9. Handbook of Sensor and Actuators- Thick Film Sensors- Edited by M.Prudenziati, Elsevier (1994), Vol. I, Series editor S. Middelhoek.		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C302.A.1	After successful completion of the course, the student is expected to : know about Films Thin Deposition Techniques	
C302.A.2	Have gained ability to apply the techniques of Chemical vapour deposition Techniques , Principle and chemical reactions	
C302.A.3	The students will know the Mechanical response of Materials under • Chemical Spray Method: Nucleation and growth process in film deposition. • Thickness measurements. • Thick film deposition technique. • Gel method, growth by Flux method, Hydrothermal growth. Electrical Growth of single crystal by water solution method	

PHY-302(B): Computational Methods and Programming Using 'C' Language

	Course description: This course is aimed at introducing the fundamentals of Computational Methods and Programming Using 'C' Language to the students. **Course objectives:** 1) To impart knowledge of basic concepts in Computational Methods and Programming Using 'C' Language and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The **graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.**	
Unit 1	**'C ' Language:** a) Review of C language for preparing and running 'C'programs. **(H-5, M-6)**	**05 L**

	b) Pointers: The concepts of pointers, The address operator, pointer arithmetic, pointers as function parameters, pointers and arrays, Dynamic storage allocation. **(H-4, M-4)**	**04 L**
	c) Structures and Unions: Declaration and period operator, structure initialization, structure and arrays, structure and functions, structure and pointers, structure within structure, Unions, Rules to use unions. **(H-4, M-4)**	**04 L**
	d) File handling: Opening and closing a data file, creating a data file, processing a data file. **(H-3, M-4)**	**03 L**
Unit 2	**Numerical methods:** In the following topics on numerical methods, students are expected to write programs using' C' language as well as perform numerical calculations using electronic calculators and mathematical tables. **a) Iterative methods to obtain roots of equations:** The method of successive bisection, false position method, Newton Raphson method. Derivation of formula and advantages as well as limitations of these methods solve each other. **(H-7, M-9)**	**07 L**
	b) Interpolation: Definition of Interpolation and extrapolation, finite differences, Interpolation with equally spaced and unevenly spaced points. Lagrange's interpolation, curve fitting, polynomial least squares and cubic spline fitting. **H-8, M-9)**	**08 L**
	c) Numerical Integration: Derivation and application of Trapezoidal, Simpson1/3 and Simpson' s 3/8 th rule. **(H-8, M-9)**	**08 L**
	d) Solution of simultaneous line are equations: Gauss elimination method, pivotal condensation, Gauss Seidal method. **(H-7, M-9)**	**07 L**
	e) Solution of first order differential equation: Euler's method, Runge-Kutta methods. **(H-6, M-6)**	**06 L**

Suggested Readings: References:

1. The 'C' Programming Language: Kernighan B.W. & Ritchie D.M.(Prentice Hall India Pvt. Ltd.).
2. Letus 'C': Yashwant Kanetkar (BPB Publications).
3. Schaum's outline of theory and problems of programming with 'C': Gottfried B.S. (Tata McGraw Hill Publishing Co. Ltd.).
4. Programming in ANSIC (IIndEdition)-E. Balagurusamy (Tata McGraw Hill Publishing Co. Ltd.)
5. The C language Trainer with C graphics and C++ -J.Jayasri (New Age International Pvt. Ltd. New Delhi.)
6. The spirt of 'C'–Mullish Cooper (Jaico Publishing Co. New Delhi).
7. Programming in ANSIC–Ramkumar (Tata McGraw Hill).
8. Introductory methods of Numerical Analysis-S.S. Sastry.
9. Numerical methods for engineers with programming and software applications-Steven C Chapra, Raymond P. Canale. (McGraw Hill).
10. Numerical Methods problems and solutions– M.K..Jain, S.R.K. Iyengar, R.K. Jain (Wiley Eastern Ltd).
11. Computer Oriented Numerical Methods – V. Rajaraman (Prentice Hall India Pvt Ltd.).

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C302.B.1	After successful completion of the course, the student is expected to : know about Computational Methods and Programming Using 'C' Language and Applications	
C302.B.2	Have gained ability to apply the techniques of Computational Methods and Programming Using 'C' Language	
C302.B.3	The students will know the: • Review of C language for preparing and running 'C' programs. • Structures and Unions: Declaration and period operator, structure initialization. • Numerical Integration: Derivation and application of Trapezoidal, Simpson 1/3 and Simpson' s 3/8 th rule.	

PHY-302(C): Acoustics and Entertainment Physics		
	Course description: This course is aimed at introducing the fundamentals of Acoustics and Entertainment Physicsto the students. **Course objectives:** 1) To impart knowledge of basic concepts in Acoustics and Entertainment Physics and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The **graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.**	
Unit 1	**Basic Principles:** Sound wave propagation ,Plane and Spherical waves, Plane wave equation(without derivation) ,Acoustic Intensity, Energy density, Acoustic impedance, **Decibel Scales :** Intensity level, Sound Pressure level, Sound power level, Loudness level, Equivalent continuous sound level, Laeqt, Perceived noise level LEPN, Noise pollution level, LNP. Human Speech and hearing mechanism, Threshold of audibility and feeling, Analogy among Electrical, Mechanical and Acoustical systems. **(H-10, M-10)**	**10 L**
Unit 2	Architectural Acoustics: Reverberation time, Decay of sound in a live room, Sabine Equation, Decay of sound in a dead room, Eyring's Journals, Optimum reverberation time, Coefficient of absorption and its measurement. Methods of measurement of reverberation time, Synthetic reverberation, Acoustical evaluation of Theatre/ auditoria/studios, Requirements for good acoustics of Theatre/Studios/auditoria. Sound reinforcement systems for auditoria. Amplifier power requirements, Audio delayers. **(H-10, M-12)**	**10 L**
Unit 3	**Loudspeakers:** Direct radiator dynamic loudspeakers, Horn loudspeakers, Directional characteristics, Equivalent circuits, Efficiency of loudspeakers, Special Purpose loudspeakers, Loudspeaker systems, woofer, midrange/squankes, tweeter, Crossover, networks, Loudspeaker Cabinets. **(H-6, M-6)**	**06 L**
Unit 4	**Microphones:** Carbon, Condenser, Moving coil dynamic and ribbon microphones, Microphone sensitivity, directional characteristics and applications, Calibration of microphones. **(H-6, M-6)**	**06 L**
Unit 5	**Sound Recording and Reproducing systems:** Basic requirements of a system for good quality recording and reproduction, Hi-Fi system, volume compressors. Viviters and expanders, Graphic equalizers. Monophonic and stereophonic sound reproducing systems. Magnetic tape sound recording and reproducing systems, Basic principles Analogue recording, Digital Audio tape, recording (DAT), Noise reduction in sound reproducing system-(I) Dolby A. B. System, Basic principles of compact Disc (CD), audio systems. **(H-10, M-12)**	**10 L**
Unit 6	**Musical Acoustics:** Characteristics of musical notes: Vibratio, tremolo, portamento, waveforms of typical musical tones, Basic principles of musical instruments, Electronic musical instruments, Computer music, MIDI and applications. **(H-5, M-7)**	**05 L**
Unit 7	**Ultrasonic and underwater acoustics:** Ultrasonic transducers-Principles and applications, Under water acoustics-Principles and applications of underwater transducers, underwater communication, SONAR. **(H-5, M-7**)	**05 L**

Suggested Readings: References:

1. Fundamentals of acoustics (2nd Ed.)-Kinsler and Frey.
2. Acoustics-W.W.Sets (Schwm series)
3. Music Physics and Engineering-HIF Olson
4. Acoustics Measurement-L.L.Bernek
5. Basic Acoustics-D.E.Hall

6. Technical Aspects of sound-(Vol. I) Richardson
7. Noise reduction-L.L.Bernk.
8. Audio Cyclopedia-H. Tremanic
9. Hand book of sound Engineers (New Audio cyclopedia)-G.M. Balloh(Ed.)
10. Acoustic techniques for the Home and Studio-F Alton Everest.
11. Design for good acoustics and noise control-J.E. Moore.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO
C302.C.1	After successful completion of the course, the student is expected to : know about Acoustics and Entertainment Physicsand Applications
C302.C.2	Have gained ability to apply the techniques of Acoustics and Entertainment Physics
C302.C.3	The students will know the : • Review of C language for preparing and running 'C' programs. • Structures and Unions: Declaration and period operator, structure initialization. • Numerical Integration: Derivation and application of Trapezoidal, Simpson 1/3 and Simpson' s 3/8 thrule.

M.Sc. Part II Semester III (Physics): Skill Course (Select only one)

PHY-303(A): Systematic Materials Analysis		
	Course description: This course is aimed at introducing the fundamentals of Systematic Materials Analysisto the students. **Course objectives:** 1) To impart knowledge of basic concepts in Systematic Materials Analysisand its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The **graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.**	
Unit 1	**Characterization Techniques:** Importance of materials characterization, Classification of characterization techniques, Destructive and non-destructive techniques, Electromagnetic spectrum, Properties of electromagnetic radiation. **(H-6, M-6)**	**06 L**
Unit 2	**Infrared Spectroscopy:** Range of IR absorption, Requirements for infrared radiation Absorption, Theory of IR absorption Spectroscopy, Linear molecules, Spherical top molecules, Symmetric top molecules, Asymmetric molecules, Spectrophotometers, Application of IR Spectroscopy, Limitation of IR Spectroscopy. **(H-7, M-10)**	**07 L**
Unit 3	**UltraViolet & Visible Spectroscopy:** Regions of UV-Visible radiation, Colour and light absorption, The chromophore concept, Theory of electronic spectroscopy– orbital involved in electronic transitions, Laws of light absorption-Beer's and Lambert's laws, Instrumentation. U.V. spectrometer, Sample and reference cells, Applications of UV visible spectroscopy. **(H-10, M-12)**	**10 L**

Unit 4	**X-Ray Diffraction:** Crystalline state, X-ray diffraction processes, Preliminary discussion of powder and single crystal pattern and their information content, Structure determination, Particle size determination, Crystallography by diffraction of radiation other than X-ray, Applications of X-ray diffraction measurements. **(H-10, M-10)**	**10 L**
Unit 5	**Electron Microscopy:** Demerits of optical microscope at nano level, Need of Electron Microscopy, Why electrons? Electron Specimen interaction (Emission of secondary electrons, back scattered electrons, characteristics x-rays, transmitted electrons), Specimen interaction volume, resolution, Scanning electron microscope (SEM) Schematic diagram, Short details of each component, Field Emission Gun, Field Emission Electron Scanning electron microscope(FESEM),Principle of Image Formation, Energy Dispersive Analysis of X-rays (EDAX), Transmission electron microscope(TEM), Merits of TEM over SEM/FESEM. **(H-14, M-16)**	**14 L**
Unit 6	**Scanning Tunneling Microscopy:** An Introduction to Quantum Mechanical Tunneling, Basic Principles of STM, Two Modes of Scanning, Interpreting STM Images, and Applications of STM. **(H-5, M-6)**	**05 L**
Suggested Readings: References: 1. Elements of X-ray diffraction, B.D.Cullity, Addision-Wesely Publishing Co., USA. 2. SEM micro characterization of semiconductors, D.B. Holt, and D.C. Joy, Academic Press, New Delhi. 3. Fundamentals of Molecular Spectroscopy, C.N. Banwell, Tata McGraw-Hill Publ. Delhi. 4. Instrumental methods of Analysis (Seventh Edition) H.H. Willard, L.L. Merritt, John A Dean, F.A. Settle CBS Publishers and Distributors, New Delhi-110002. 5. Introduction to Nanoscience and Nanotechnology, K.K. Chattopadhyay and A.N. Banerjee, PHI Pvt. Ltd., New Delhi- 110001. 5. Characterization of Materials, Volume1, & 2, Elton N. Kaufman, Wiley-Inter science. 6. Hand book of Microscopy for Nanotechnology, NanYao, Ahong LinWang, Kluwer Academic Publishers.		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C303.A.1	After successful completion of the course, the student is expected to : know about Systematic Materials Analysis and Applications	
C303.A.2	Have gained ability to apply the techniques of Introduction to Characterization Techniques: Importance of materials characterization	
C303.A.3	The students will know the Mechanical response of Materials under • Infrared Spectroscopy. • Ultra Violet & Visible Spectroscopy: Regions of UV-Visible radiation. • Scanning Tunneling Microscopy: An Introduction to Quantum Mechanical Tunneling. • Crystalline state, Xray diffraction processes.	

PHY-303(B): Microprocessor and its Applications

	Course description: This course is aimed at introducing the fundamentals of **Microprocessor and its Applications** to the students. **Course objectives:**	

	1) To impart knowledge of basic concepts in Microprocessor and its Applications. 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**The 8086 Microprocessor:** Register organization of 8086, 8086 Architecture, Pin configuration, Physical Memory organization, General bus operation, I/O address capability, Special purpose activities, minimum and maximum mode of 8086 systems with timings. **(H-15, M-20)**	**15 L**
Unit 2	**Instruction set of 8086 and programming:** Addressing modes of 8086, Instruction set of 8086, Assembler directives and operators. Simple programs like addition of two numbers, BCD addition, find the largest number, addition of two 3 x 3 matrices, move the string of data, find the number of positive numbers and negative numbers from, a given series of signed numbers etc. **(H-17, M-20)**	**17 L**
Unit 3	**Special Architectural features:** Stack structure of 8086, Interrupts and interrupt service routine, Interrupt programming, Macros. (Programming is not expected). **(H-6, M-10)**	**06 L**
Unit 4	**Programmable Peripheral Devices and their Interfacing:** i] Programmable peripheral interface 8255, ii] Programmable Communication interface 8251USART, iii] Programmable DMA interface 8257, iv] Programmable interrupt Controller 8259. **(H-10, M-5)**	**10 L**
Unit 5	**32 bit Processor:** Features of 80386, 80486, 80586 (Pentium), MMX (Multimedia Extension) **(H-4, M-5)**	**04 L**
Suggested Readings: References: 1. Advance Microprocessor and Peripherals: A.K.Ray, K.M.Bhurchandi., Tata McGraw Hill, New Delhi. 2. Microprocessor and Interfacing: DauglasV.Hall, McGraw Hill International Edition. 3. Architecture, Programming and Design: Yu Cheng Liu,G.A.Gibson, 2ndEdition. PHI Publications.		

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C303.B.1	After successful completion of the course, the student is expected to : know about Microprocessor and its Applications	
C303.B.2	Have gained ability to apply the techniques of Programmable Peripheral Devices and their Interfacing	
C303.B.3	The students will know the Mechanical response of Materials under- • The 8086 Microprocessor: Register organization of 8086, 8086 Architecture. • 32 bit Processor: Features of 80386, 80486, 80586 (Pentium). • Instruction set of 8086 and programming: Addressing modes of 8086	

PHY-303(C): Communication Electronics

	Course description: This course is aimed at introducing the fundamentals of Communication Electronics to the students. **Course objectives:** 1) To impart knowledge of basic concepts in Communication Electronics and its applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of	

	areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**Electronic Communication:** Importance of Communication, Introduction to Elements of communication systems and types of electronics communication (Simplex, Duplex, Analog, Digital, Base band and modulated signals) [kennedy]. **(H-3, M- 4)**	**03 L**
Unit 2	**Modulation Systems Amplitude Modulation:** (Spectrum of an Amplitude Modulated signal, Low level AM Modulator), Single Sideband (SSB) Modulation, Generation of SSB signal (Filter Method), Vestigial-Sideband (VSB) Modulation, Demodulation of AM Waves (Square-law Detectors, Linear Diode Detector) Frequency and Phase Modulation:- FM generation (Parameter Variation method), Frequency multiplication, FM Demodulation (Slope Detector) Pulse Modulation, Pulse Code Modulation (PCM), Pulse Amplitude Modulation (PAM), Time-Division Multiplexing (TDM), Pulse Time Modulation (PTM) [Roddy & Coolen]. **(H-11, M-12)**	**11 L**
Unit 3	**Radiation & Propagation of Waves Electromagnetic Radiation:** (Fundamentals of electromagnetic waves & effect of environment), Propagation of waves (Ground or surface waves, sky wave propagation- The ionosphere, space waves, Tropospheric scattering propagation, Extraterrestrial communications) [Kennedy]. **(H-7, M-8)**	**07 L**
Unit 4	**Antennas:** Antenna parameters- power gain, isotropic radiator, radiation resistance, directivity, directional gain, radiation parameter, polarization, effective apparatus, effective length, front to back ratio. Types of antenna- Half wave dipole (without mathematical derivation), Yagi & dish antenna. [Roddy & Coolen]. **(H-7, M-8)**	**07 L**
Unit 5	**Television Fundamental**: Introduction to TV, TV systems & standards, Black & White transmission & reception, Colour transmission & reception. [Kennedy] **(H-4, M-5)**	**04 L**
Unit 6	**Radar and Satellite Systems Fundamentals of RADAR system:** Block Diagram, Frequencies and Powers used in RADAR, RADAR performance Factors, Effects of Noise, Basic Pulse RADAR systems (Block Diagram and Description), Antenna and Scanning, Moving target Indication (Doppler Effect), Other RADAR systems (RADAR Beacons, Phased RADAR), RADAR applications. [Kennedy]; Orbital Satellites, Geostationary Satellites, Look Angles (angle of elevation, Azimuth angle), Satellite system Link Model (UP Link Model, Transponder, Down-Link Model) [Roddy] **(H-10, M-10)**	**10 L**
Unit 7	**An overview of Telecommunication:** History of Telecommunication, Telecommunication network, Internet, classification of data network, by spatial distance (WAN, MAN, LAN), by Cellular concept, Mobile Telephone communication [A. A. Gokhale] **(H-4, M-6)**	**04 L**
Unit 8	**Introduction To Fiber Optic Technology:** Introduction, Principle of light transmission in a fiber, losses in fiber, dispersion, light sources for fiber optics, photo detector, fiber optic communication system.[Roddy & Coolen] **(H-6, M-7)**	**06 L**

Suggested Readings: References:

1. Electronic communication System- Kennedy & Davis (Tata Mc-Graw Hill) 4th ed.
2. Electronic communication- Roddy & Coolen. (PHI) 3rd ed.
3. Satellite Communication- Dennis Roddy, (Mc-Graw Hill), 3rd ed. 9
4. Fiber Optic Communication- John Senior, (Prentice Hall International), 2nd ed.
5. Antenna & Wave Propagation- K. D. Prasad, (Satya Prakashan New Delhi)
6. Introduction to Telecommunication-Anu A Gokhale, (Cengage Learning) 2nded.
7. Electronic communication-Sanjeev Gupta (Khanna Publication, New Delhi).
8. Electronic communication: Fundamentals Through Advances-Wame Tomdsi (Prentice Hall Publications)

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C303.C.1	After successful completion of the course, the student is expected to :	

	know about Communication Electronics and Applications	
C303.C.2	Have gained ability to apply the techniques of Introduction to Elements of communication systems and types of electronics communication	
C303.C.3	The students will know the Mechanical response of Materials under • Modulation Systems Amplitude Modulation. • Radiation & Propagation of Waves of Electromagnetic Radiation. • Types of antenna- Half wave dipole. • Television Fundamental, Introduction to TV, TV systems. • Radar and Satellite Systems Fundamentals of RADAR system: Block Diagram, Frequencies and Powers	

M.Sc. Part II Semester III (Physics): Practical (Core course)

PHY -304: Special Laboratory I	
Course description: This course is aimed at introducing the fundamentals of Special Laboratory I to the students. **Course objectives:** 1. To impart knowledge of basic concepts in Special Physics II. 2. To provide the knowledge and methodology necessary for Practical problems in Physics. 3. The course involves the related experiments based on the Practical.	
Group A **Perform at least TEN experiments from the following**	
1	1. To measure the thermoelectric power of semiconductor. 2. Study of Haynes-Schokley experiment for determination of mobility and diffusion constant. 3. Measurement of thickness of thin film by Tolansky method. 4. Study of electron spin resonance spectrum for given sample and determination of Lande 'g' factor. 5. To record and analyze the spectral response of a given photo conducting sample. 6. Determination of resonance frequency of piezoelectric element. 7. Study of hysteresis of hard and soft ferrites. 8. Skin depth of electromagnetic radiation in Al. 9. Determination of Fermi energy in Cu. 10. Coherence & width of spectral lines using Michelson interferometer. 11. The Franck-Hertz experiment. 12. Absorption Spectrum Of Iodine Vapour. 13. Charge on an electron using spectrometer.
2	**Material Synthesis** 1. Deposition of metallic thin films by vacuum evaporation method and measurement of resistance/resistivity/ conductivity and TCR at different temperatures by the two probe/four probe method. 2. Deposition of thin films by spray pyrolysis method and thickness measurement by gravimetric method. 3. Measurement of reflectivity and transferability of thin films by using He-Ne laser. 4. Determination of refractive index of a transparent film by Abe's method. 5. Study of vacuum system to measure speed of rotary pump. 6. Pattern generation by Photolithography. 7. Electrical conductivity measurements in thick films. 8. Synthesis of CdS thin film by chemical bath deposition (CBD) method.

	9. Stress measurement of transparent conducting oxides (Newton's ring method) 10. Determination of band gap energy of a given sample using absorption/transmission spectra.
3	**Material Science:** 1. Study of phase transformation in a ferroelectric crystal. 2. Study of creep behaviour of Sn-Pb alloy. 3. Thermoluminescence of alkali halides. 4. Determination of diffusion coefficient of cobalt atoms in Gel medium. 5. Determination of crystal structure of given material by X-ray diffract meter. 6. Determination of grain size of a given sample by Scherer method. 7. Determination of direct and indirect band gap of a given materials by UV-visible spectroscopy. 8. Determination of inter atomic bond length in a diatomic molecule by studying rotational vibrational IR spectra. 9. Study of Beer Lamberts Law in absorption spectroscopy using IR spectroscopy. 10. Synthesis of conducting oxide films by pyrolysis method.
4	**Communication Electronics**: 1. Pulse amplitude modulation. 2. Pulse position modulation. 3. Pulse width modulation. 4. Study of delta modulation. 5. Characteristics of antenna. 6. Study of amplitude modulator and demodulator. 7. Study of frequency modulator. 8. Study of FSK modulator and demodulator. 9. Study of Digital multiplexer.
5	**Microprocessors:** 1. Square, Triangular and Ramp wave generator using microprocessor. 2. Interfacing an eight bit ADC with microprocessor. 3. Write a program for four digit hexadecimal counters. The counter should stop and resume counting by pressing a key. 4. Temperature measurement using ADC. 5. Read data through thumb wheel switches and display it on monitor and 7-segment display. 6. Write a program to control relay switches with a delay of 1 second. 7. Average the given set of data and display the result in decimal form. 8. Stepper motor speed control using microprocessor. 9. Read string through keyboard which is terminated by any specified character and reverse the string. 10. Read two digit hexadecimal number through key board and convert it into binary form. 11. Interrupt driven clock.(Ref. Ramesh S. Gaonkar Page No.376)
6	**Computational Methods & 'C' Language programming :** 1. Draw a flowchart and write a program to find the root of the equation f(x)=0 by Bisection method. 2. Draw a flowchart and write a program to find the root of the equation f(x)=0 by Newton Raphson method. 3. Draw a flowchart and write a program to find the root of the equation f(x)=0 by False position method. 4. Draw a flowchart and write a program to integrate the given function using Trapezoidal rule. 5. Draw a flowchart and write a program to integrate the given function using Simpson's 1/3 rule. 6. Draw a flowchart and write a program to integrate the given function using Simpson's 3/8 rule. 7. Draw a flowchart and write a program for fitting of a polynomial of degree n usingLagrange's Interpolation formula. 8. Draw a flowchart and write a program to solve given set of simultaneous equationsusing Gauss Elimination method.

	9. Draw a flowchart and write a program to solve given set of simultaneous equationsusing Gauss Seidal method. 10. Draw a flowchart and write a program to solve given differential equation usingEuler's simple method. 11. Draw a flowchart and write a program to solve given differential equation usingRungekutta method. 12. Draw a flowchart and write a program for finding the inverse of a givenmatrix./transpose of a matrix. 13. Implement strlen ( ), Stract ( ), Strcpy ( ), Strcmp ( ) using pointers. 14. Write a menu driven program to create, list, modify and calculate the student record details. Assume the file structure: Register No., Subject 1 mark, Subject 2 mark and Subject 3 mark.
7	**Biomedical Instrumentation** : 1. ECG preamplifier- instrumentation amplifiers design & testing. 2. Active filters for bio-signals-design & testing. 3. Wave shaping circuits for cardiac pacemaker. 4. Acoustic impedance measurement. 5. Recording of action potentials with extra cellular electrodes. 6. ECG signal recording with surface electrodes. 7. Blood pressure measurement with transducer/pressure differentiation circuits.
Course Outcomes (COts):	
On completion of this course, the student will be able to:	

CO No.	CO	Cognitive level
C304.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Special Physics II course to real life problems.	
C304.2	2. Understanding of the Special Physics II course which will create scientific temperament..	
C304.3	Students will have hand on experience of Practical Based on : • Measurement of thickness of thin film by Tolansky method. • Franck-Hertz experiment. Magnetic susceptibility. • Material Synthesis. • Material Science. • Communication Electronics. • Microprocessors. • Computational Methods & 'C' Language programming. • Biomedical Instrumentation	

PHY-305 M. Sc. Project – I(Skill Base)		
	Course Objectives: 1. To give exposure to the students to research culture and technology. 2. To introduce students how to select a research topic, plan, perform experiments, collect data and analyse the data. 3. To foster self-confidence and self-reliance in the students as he/she learns to work and think independently.	
	Activities: 1. To display the list of 'project titles' on notice board. 2. To organize a meeting of project supervisors' and students for discussion about	

	projects. 3. To finalize the project titles so as to match student's particular interest. 4. Survey of the Literature. 5. To set the experiment/to start Preliminary Experimental work. 6. Internal examination. The guide should regularly monitor the progress of the project work. **ASSESSMENT OF PROJECT TERM WORK (FIRST TERM)**: Student should submit a Progress Report on the work done by him/her during the First Phase of the project including following points; 1. Project Selection, 2. Literature Search Strategy, 3. Literature Review, 4. Project Planning. Student will have to give a seminar on the above topics. **Internal examination (40 marks): Components of internal assessment: Project Selection (05 Mark.) Literature Collection and Literature Revive(10 marks) planning and design (10 marks), Submission of progress report (10 marks), and regular attendance (5 marks) recorded: Research Supervisors** **External Examination system should be held on fourth semester with assessment of PHY-405.**	

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C305.1	Conceive a problem based on published research and carry out comprehensive survey of literature	**4**
C305.2	Plan and carry out task in given framework of dissertation and present the work in written and viva	**6**
C305.3	Use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.	**6**
C305.4	Learn handling of instruments, use of chemicals and how to conduct the experiments	**3**
C305.5	Learn how to present the project in power point and answer the queries to examiners as well as science of writing	**6**

M.Sc. Part II Semester III Physics: Audit Courses

AC-301(A): Computer Skills **(Technology + Value added Audit course; Practical; 2 Credits)** **(Optional: Campus + Program level)**		
Course Objectives (CObs): • To inculcate different daily useful computer skills among students.		
Unit 1	**Elements of Information Technology** 1.1 Information Types: Text, Audio, Video, and Image, storage formats. 1.2 Components: Operating System, Hardware and Software, firmware. 1.3 Devices: Computer, Mobile Phones, Tablet, Touch Screen, Scanner, Printer, Projector, smart boards. 1.4 Processor & Memory: Processor functions, speed, Memory types: RAM /ROM /HDD /DVD-ROM/Flash drives, memory measurement metrics.	**2 H**
Unit 2	**Office Automation-Text Processing** 2.1 Views: Normal View, Web Layout View, Print Layout View, Outline View,	**5 H**

	Reading Layout View. 2.2 Working with Files: Create New Documents, Open Existing Documents, Save Documents to different formats, Rename Documents, Close Documents. 2.3 Working with Text: Type and Insert Text, Highlight Text, Formatting Text, Delete Text, Spelling and Grammar, paragraphs, indentation, margins. 2.4 Lists: Bulleted and Numbered List. 2.5 Tables: Insert Tables, Draw Tables, Nested Tables, Insert Rows and Columns, Move and Resize Tables, Moving the order of the column and/or rows inside a table, Table Properties. 2.6 Page Margins, Gutter Margins, Indentations, Columns, Graphics, Print Documents. 2.7 Paragraph Formatting, Paragraph Attributes, Non-printing characters. 2.8 Types of document files: RTF, PDF, DOCX etc.	
Unit 3	**Office Automation-Worksheet Data Processing** 3.1 Spreadsheet Basics: Adding and Renaming Worksheets, Modifying Worksheets. 3.2 Moving Through Cells, Adding Rows, Columns, and Cells, Resizing Rows and Columns, Selecting Cells, Moving and Copying Cells. 3.3 Formulas and Functions: Formulas, Linking Worksheets, Basic Functions, AutoSum, Sorting and Filtering: Basic Sorts, Complex Sorts, Auto-fill, Deleting Rows, Columns, and Cells. 3.4 Charting: Chart Types, drawing charts, Ranges, formatting charts.	**5 H**
Unit 4	**Office Automation- Presentation Techniques and slide shows** 4.1 Create a new presentation, AutoContent Wizard, Design Template, Blank Presentation, Open an Existing Presentation, PowerPoint screen, Screen Layout. 4.2 Working with slides: Insert a new slide, Notes, Slide layout, Apply a design template, Reorder Slides, Hide Slides, Hide Slide text, Add content, resize a placeholder or textbox, Move a placeholder or text box, Delete a placeholder or text box, Placeholder or Text box properties, Bulleted and numbered lists, Adding notes. 4.3 Work with text: Add text and edit options, Format text, Copy text formatting, Replace fonts, Line spacing, Change case, Spelling check, Spelling options. 4.4 Working with tables: Adding a table, Entering text, Deleting a table, Changing row width, Adding a row/column, Deleting a row/column, Combining cells, Splitting a cell, Adding color to cells, To align text vertically in cells, To change table borders, Graphics, Add clip art, Add an image from a file, Save & Print, slide shows, slide animation/transitions.	**6 H**
Unit 5	**Internet & Applications:** 5.1 Computer Network Types: LAN, PAN, MAN, CAN, WAN, Defining and describing the Internet, Brief history, Browsing the Web, Hypertext and hyperlinks, browsers, Uniform resource locator 5.2 Internet Resources: Email, Parts of email, 5.3 Protecting the computer: Password protection, Viruses, Virus protection software, Updating the software, Scanning files, Net banking precautions. 5.4 Social Networking: Features, Social impact, emerging trends, issues, Social Networking sites: Facebook, Twitter, linkedin, orkut, online booking services 5.5 Online Resources: Wikipedia, Blog, Job portals, C.V. writing 5.6 e-learning: e-Books, e-Magazines, e-News papers, OCW(open course wares): Sakshat (NPTEL) portal, MIT courseware	**4 H**
Unit 6	**Cloud Computing Basics** 6.1 Introduction to cloud computing 6.2 Cloud computing models: SAS, AAS, PAS 6.3 Examples of SAS, AAS, PAS (Drop Box, Google Drive, Google Docs, Office 365 Prezi, etc.)	**3 H**

Suggested readings:

1. TCI, "Introduction to Computers and Application Software", Publisher: Jones & Bartlett Learning, 2010, ISBN: 1449609821, 9781449609825
2. Laura Story, Dawna Walls, "Microsoft Office 2010 Fundamentals", Publisher: Cengage Learning, 2010, ISBN: 0538472464, 9780538472463

3. June Jamrich Parsons, Dan Oja, "Computer Concepts Illustrated series", Edition 5, Publisher Course Technology, 2005, ISBN 0619273550, 9780619273552
4. Cloud computing online resources

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301A.1	Identify their lacunas about some computer skills and try to overcome the same.	**2**
AC301A.2	Practice the learned computer skills in real life and do their jobs more effectively.	**3**

AC-301(B): Cyber Security

(Technology + Value added Audit course; Practical; 2 Credits)

(Optional: Campus + Program level)

Course Objectives (CObs):

- To make students aware of different daily useful cyber security skills/rules.

Unit 1	**Networking Concepts Overview** Basics of Communication Systems, Transmission Media, ISO/OSI and TCP/IP models, Network types: Local Area Networks, Wide Area Networks, Internetworking, Packet Formats, Wireless Networks: Wireless concepts, Advantages of Wireless, Wireless network architecture, Reasons to use wireless, Internet.	**3 H**
Unit 2	**Security Concepts** Information Security Overview, Information Security Services, Types of Attacks, Goals for Security, E-commerce Security, Computer Forensics, Steganography. Importance of Physical Security, Biometric security & its types, Risk associated with improper physical access, Physical Security equipments. Passwords: Define passwords, Types of passwords, Passwords Storage – Windows & Linux.	**7 H**
Unit 3	**Security Threats and vulnerabilities** Overview of Security threats, Hacking Techniques, Password Cracking, Types of password attacks, Insecure Network connections, Wi-Fi attacks & countermeasures, Information Warfare and Surveillance. Cyber crime: e-mail related cyber crimes, Social network related cyber crimes, Desktop related cyber crimes, Social Engineering related cyber crimes, Network related cyber crimes, Cyber terrorism, Banking crimes.	**7 H**
Unit 4	**Cryptography** Understanding cryptography, Goals of cryptography, Types of cryptography, Applications of Cryptography, Use of Hash function in cryptography, Digital signature in cryptography, Public Key infrastructure.	**5 H**
Unit 5	**System & Network Security** System Security: Desktop Security, email security: PGP and SMIME, Web Security: web authentication, Security certificates, SSL and SET, Network Security: Overview of IDS, Intrusion Detection Systems and Intrusion Prevention Systems, Overview of Firewalls, Types of Firewalls, VPN Security, Security in Multimedia Networks, Fax Security.	**3 H**
Unit 6	**OS Security** OS Security Vulnerabilities updates and patches, OS integrity checks, Anti-virus software, Design of secure OS and OS hardening, configuring the OS for security, Trusted OS.	**2 H**
Unit 7	**Security Laws and Standards** Security laws genesis, International Scenario, Security Audit, IT Act 2000 and its	**3 H**

	amendments.	

Suggested readings:

1. Skills Factory, Certificate in Cyber Security, Text Book Special edition, Specially published for KBC NMU, Jalgaon.
2. BPB Publication, "Fundamentals of Cyber Security", Mayank Bhushan, Rajkumar Singh Rathore, Aatif Jamshed.
3. Create Space Independent Publishing Platform, "Cyber Security Basics", Don Franke, ISBN-13: 978-1522952190ISBN-10: 1522952195.
4. Online references.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301B.1	Practice learned cyber security skills/rules in real life.	**3**
AC301B.2	Provide guidance about cyber security skills/rules to their friends, parents and relatives.	**2**

AC-301(C): Seminar + Review Writing

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (CObs):

- To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant biological information.

Writing a Scientific Literature Review:

- Choosing a topic, Deciding the scope of topic, Significance and impact of scientific problem being addressed, Relevance to subject, current issues and social relevance, Strengths and limitations of the study, Enticing broad audience.
- Literature Survey and Information to consider in the review:
  - Literature search using authentic library resources (print and non-print, digital and virtual) for Almanacs, Encyclopaedia, Dissertations, Theses, Research papers, Review articles, Reference/ Textbooks, and Popular articles (INFLIBNET, Google Scholar, Pub Med, Highwire, Google patents, Indian patent database, etc.).
  - Analyzing the literature quality (indexing, peer review, citations, journal impact factor, etc.).
- Deciding a writing approach (theoretical, experimental, interpretive, clinical, etc.), prepare the highlights and drawing important conclusion from literature.
- Sections to include and tips for writing them: Abstract, Introduction, Body, Discussion, Conclusion, References.
- Reference styles (MLA, APA, etc.), Use of bibliography/ reference/ citation managers and generators (Reference Manager, EndNote, RefWorks, Mendeley, Zotero, Qiqqa, etc.).
- Ethics of publication: Approval and consent, Data ethics (accuracy, falsification, fabrication, and confidentiality), Plagiarism and self-plagiarism, collaborative authorship, conflict of interest, legal consequences.
- Content similarity detection, Use of anti-plagiarism services (Urkund, iThenticate, Turnitin, Copyscape, Grammarly, etc.).

Seminar Activity:

- Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journal to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities.
- Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation.

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301C.1	Retrieve, analyses, comprehend the scientific information on a given topic and derive logical inferences.	**4**
AC301C.2	Compile the scientific information on a topic, verify for similarity index or plagiarism.	**2**
AC301C.3	Deliver the interactive presentation of scientific data before audience and participate in open discussion with confidence.	**2**

AC-301(D): Biostatistics

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (CObs):

- To learn basic statistical concepts/methods and their applications in biological processes and experiments.

Unit 1	**Descriptive Statistics and Presentation of Data** • Types of Data: qualitative and quantitative data; nominal and ordinal data; discrete and continuous data; frequency and non-frequency data, Different types of scale - nominal, ordinal, ratio and interval. • Analysis of univariate Quantitative Data: Concepts of central tendency or location, dispersion, skewness and kurtosis, measures of dispersion: range, quartile deviation, variance, standard deviation. • Analysis of bivariate Data: measures of association, correlation. • Presentation of Data: construction of tables with one or more factors of classification, diagrammatic and graphical representation of non-frequency data, frequency distributions, histogram. • Graphical presentation of data through bar graph, line graph, pie chart, histogram, dot plot, box-plot, multiple line/bar graphs etc.	**8 H**
Unit 2	**Correlation and regression** • Bivariate data: scatter diagram, coefficient of determination, rank correlation: Spearman's rank correlation coefficient. • Meaning and concept of regression, fitting of simple linear regression and quadratic regression in single predictor variable. • Multivariate data: multiple regression, coefficient of determination, R-square and its interpretation, testing significance of predictor variables.	**8 H**
Unit 3	**Testing of hypothesis and basic statistical designs** • Introduction of methods of sampling. • Statistical hypothesis, problem of testing of hypothesis, simple and composite hypothesis, types of errors, p-value, conclusions in hypothesis testing. • Statistical tests: one sample t-test, paired t-test, test for proportions, chi-square test for testing independence/association of attributes. • Design of experiments: introduction to basic terms of design of experiments, standard designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), concept of ANOVA, F-test in ANOVA, interpretation of results from ANOVA.	**8 H**
Unit 4	**PRACTICALS (Emphasis on examples from Biological Sciences)** • Based on graphical Representation. • Based on measures of Central Tendency & Dispersion. • Based on Distributions Binomial Poisson Normal.	**6 H**

	• Based on t, f, z and Chi-square. • Based on basic statistical designs.	

Suggested readings:

1. Le CT (2003) Introductory Biostatistics. 1st edition, John Wiley
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.
5. Design and Analysis of Experiments by Montgomery D.C. (2001), John Wiley.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC301D.1	Describe and identify data generated from biological processes and experiments.	**1**
AC301D.2	Use summary statistics: measures of central tendency, measures of dispersion with their interpretations for explain the data more effectively through graphical tools.	**3**
AC301D.3	Apply knowledge of correlation, regression analysis and testing of hypothesis to real life data and understand their interpretation.	**3**

M.Sc. Part II Semester IV (Physics): Core Courses

PHY– 401: Nuclear Physics		
	Course description: This course is aimed at introducing the fundamentals of Nuclear Physics to the students. **Course objectives:** 1) To impart knowledge of basic concepts Nuclear Physics and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**General Properties of Nuclei:** Constituents of nucleus and their properties; packing fraction; mass defects; binding energy; average binding energy and its variation with mass number; concept of parity; magnetic dipole moment; electric quadruple moment; problems. **(H-5, M-6)**	**05 L**
Unit 2	**Nuclear Model:** Types of nuclear models (list only); Liquid drop model: assumptions, semi empirical mass formula, achievements, failure and limitations of liquid drop model; Shell model, basic assumptions, nuclear magic numbers, experimental evidences of nuclear magic number and its significance, achievements and limitations of shell model; rules for angular momenta and parity of nuclear ground state; prediction of angular momenta and parity of nuclear ground state; nuclear energy level and their applications; problems. **(H-7, M-8)**	**07 L**
Unit 3	**Nucleon – Nucleon Interaction:** The deuteron problem; radius of deuteron; magnetic dipole moment and electric quadruple moment of deuteron; Nature of interactions: electromagnetic, weak interactions and hadronic interactions; nucleon - nucleon scattering; scattering cross section; Low-energy neutron proton scattering and proton-proton scattering, High energy neutron-proton and proton -proton scattering. **(H-8, M-8)**	**08 L**
Unit 4	**Interaction of charged particle and EM radiations with matter:** Energy loss of charged particles (Bohr formula); stopping power; range and straggling; Cerenkov radiation; gamma (γ) ray interaction through matter; law of absorption of γ – rays; linear and mass absorption coefficient; the photoelectric process; Compton effect; pair production and annihilation of electron – positron pair; Dirac's theory of pair production; problems. **(H-14, M-18)**	**14 L**
Unit 5	**Particle accelerators and Radiation Detectors:** Classification of accelerators; Van-de-Graft generator; linear accelerator; synchrocyclotron; pellet on; microtone; types of detectors; scintillation detector and photomultiplier tube (PMT); semiconductor detector; bubble chamber; cloud chamber; spark chamber. **(H-10, M-12)**	**10 L**
Unit 6	**Elementary Particle Physics** Introduction; classification of elementary particles; particle interactions; elementary particle and their intrinsic quantum numbers (charge, Lepton number, Baryon number, iso-spin, strangeness etc.); conservation laws; Invariance under charge; Electrons and Positrons, Protons and antiprotons, Neutrons and antineutrons, Neutrinos and antineutrinos; Quark: assumption and properties; Quark model; colour of a Quark and its importance. **(H-8, M-8)**	**08 L**

Suggested Readings: Reference Books:

1. Concepts of Nuclear Physics: B.L. Choen, Tata McGraw Hill.
2. Subatomic Physics: Franenfelder and Hanley, Prentice Hal.l
3. Nuclei and Particles: E. Segre.
4. Atomic Nucleus: R. C. Evans.
5. Basic Nuclear Physics: B.N. Shrivastava.
6. Introduction to Nuclear Physics: David Halliday.
7. Introduction to Nuclear Physics: Herald Enge. 30.
8. Nuclear Physics: Irving Kaplan.
9. Elements of Nuclear Physics: M.L. Pandya and Yadav.
10. An Introduction to Nuclear Physics: Bhide & Joshi.
11. Nuclear Physics: D.C. Tayal.

12. Radiation Detectors By Ramamurthy and Kapoor.
13. Introduction to Nuclear Physics By S. B. Patel.
14. Radiation Detection Techniques By Price.
15. Introduction to Nuclear Techniques By Knoll.

Course Outcomes (Cots):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C401.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Nuclear Physics course to real life problems.	
C401.2	2. Understanding of the Nuclear Physics course which will create scientific temperament.	
C401.3	Students will have hand on experience of theory Based on : • General Properties of Nuclei Constituents of nucleus and their properties. • Interaction of charged particle and EM radiations with matter Energy loss of charged particles. • Particle accelerators and Radiation Detectors Classification of accelerators; Van-de-Graft generator etc. • Elementary Particle Physics Introduction; classification of elementary particles; particle interactions. • Nucleon – Nucleon Interaction The deuteron problem.	

M.Sc. Part II Semester IV (Physics): SkillCourse(Select only one)

	PHY- 402 (A): Nanomaterials: Synthesis, Properties and Applications	
	Course description: This course is aimed at introducing the fundamentals of Nanomaterials: Synthesis, Properties and Applications to the students. **Course objectives:** 1) To impart knowledge of basic concepts Nanomaterials: Synthesis, Properties and its applications 2) The graduates will have knowledge of fundamental concepts and principles in a variety of areas of Nanoscience and Nano Technology with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques related to Nanomaterials.	
Unit 1	**Introduction:** Definition of, Nanomaterials-Definition and Necessity, Properties of Nanoscale, Comparison of Nanomaterials with bulk material, What is nanotechnology? What should we expect from it? Introduction to low dimensional structures: Quantum wells, Quantum wires and Quantum dots, Nanoclusters and Nanocrystals. Quantum mechanics for low dimensional structures: Electron confinements, Schrodinger equation for particle in one dimensional box, Density of states, Density of states for a zero dimensional quantum dots, Density of states for 1-D Quantum wire, Density of states for two dimensional thin films, Density of states for a particle in three dimensional box. **(H-10, M-12)**	**10 L**
Unit 2	**Techniques for synthesis of nanomaterials**: I. Physical methods: High energy ball milling, Physical vapour deposition: Resistive heating, LASER ablation, sputter deposition.	**20 L**

	II Chemical methods: Colloid, Synthesis of colloids, Growth of nanoparticles, synthesis of metal nanoparticles by colloidal route, synthesis of semiconductor nanoparticles by colloidal route, Langmuir-Blodgett method, Sol-gel method, Synthesis of metal oxides by sol-gel technique. III Biological, methods: Introduction, Synthesis of nanoparticles using Microorganisms, Synthesis using plant extracts, Use of proteins and Temples like DNA. IV Hybrid techniques: Chemical vapor deposition, Ultrasonic automization, Electrochemical. V Nanolithography: Lithography using photons, using particle beams, Scanning probe lithography. **(H-20, M-24)**	
Unit 3	**Synthesis of some special Nanomaterials**: Synthesis of magnetic nanoparticles, Magnetic properties-Super paramagnetic materials, processes for their biocompatibility, applications of magnetic nanoparticles. Carbon nanotubes: Synthesis of SWNT and MWNT, Applications of SWNT and MWNT. **(H-6, M-08)**	**06 L**
Unit 4	**Nanophotonics**: Foundation for nanophotonics, Synthesis of metal chalcogenides (S, Se and Te) nanocomposites, photo conducting and photoluminescence properties of metal chalcogenides, photoconductivityofnanorods. **(H-6, M-08)**	**06 L**
Unit 5	**Characterization of Nanomaterials**: X-ray diffraction- structural studies, Interpretation of broadening of peaks, Electron microscopy (FESEM/TEM)- Micro structural properties (Topographical and morphological studies) Scanning Tunneling Microscopy-Determination of surface structures UV-VIS- optical properties related to Quantum confinement, Electrical and thermal transport properties, Plasmon resonance peaks and blue shiftatNanoscale. **(H-10, M-08)**	**10 L**

Suggested readings: Reference Books: /

1. Nanotechnology: Michel Kohler, Wolfgang Fritzsche.
2. Nanomaterials: Synthesis, Properties and Applications: A.S. Edelstein and R.C. 20 Cammarata, Institute of Physics Publishing Bristol and Philadelphia.
3. Nanoparticles: Buildingblocks for Nanotechnology, Vincent Rotello-Springer.
4. Introduction to Nanotechnology: Charles P. Poole Jr., Frank J.Owens
5. Nanoparticles Edited by GunterSchmid.
6. Nanoscale Science and Technology: Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan, John Wiley & Sons Ltd.
7. Nanoparticles &Nanostructure films: Preparation, Characterization & Applications: Wiley-VCH 8. Nanomaterials:AnIntroductiontoSynthesis,PropertiesandApplications:DieterVollath
9. NanostructuredMaterialsandNanotechnology:HariSinghNalwa,AcademicPress
10. Nanophotonics: Paras N Prasad, Wiley Interscience John Willey & Sons, Inc Publication
11. Handbook of Microscopy for Nanotechnology: Nan Yao, Zhong Lin Wang, Kluwer Academic Publishers.
12. Nanotechnology: Principles and Practice, S.K.Kulkarni, Capital Publishing Company.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C402.A.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Nanomaterials: Synthesis, Properties and Applications course to real life problems.	
C402A..2	2. Understanding of the Nanomaterials: Synthesis, Properties and Applications Physics course which will create scientific temperament..	
C402.A.3	Students will have hand on experience of Theory Based on : • Comparison of Nanomaterials with bulk material. • Different Techniques for synthesis of Nanomaterials of magnetic nanoparticles, Magnetic properties-Super paramagnetic materials. • Foundation for nanophotonics, Synthesis of metal chalcogenides (S, Se and Te) nanocomposites	

PHY-402(B):LASER and its Applications		
	Course description: This course is aimed at introducing the fundamentals of LASER and its Applications to the students. **Course objectives:** 1) To impart knowledge of basic concepts LASER and its Applications and Applications and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**Basics of Lasers**: Introduction, Brief history of LASER, Interaction of radiation with matter, Einstein's prediction about emission, Absorption, Spontaneous and Stimulated emission, Einstein's coefficients and relations between them, Condition for light amplification, Population inversion, Pumping and pumping methods, Active medium, Pumping schemes. **(H-8, M-8)**	**08 L**
Unit 2	**Principles of Lasers**: Introduction, Optical resonator, Basic components of laser, Principle of laser action, Difficulties in laser process and their removal, Threshold condition for laser oscillation, resonance frequencies, Laser operating frequencies, Cavity configurations, Modes; Longitudinal and Transverse modes, Single mode operation. **(H-8, M-10)**	**08 L**
Unit 3	**Laser Rate equations:** Two level system. Three and four level system, Rate equations for three and four level system, Threshold pumping power, Relative merits and demerits of three and four level systems. **(H-6, M-8)**	**06 L**
Unit 4	**Laser Systems and Types**: Classification of Lasers: CW and Pulsed lasers, Detail discussion about constructional features, energy level diagrams, Laser action and working, characteristics etc of the following laser systems: I) Solid State Lasers: The Ruby Laser, Nd-YAG Laser, Nd-Glass Laser etc. II) Dye (Liquid) Lasers, III) Gas Lasers: • Atomic Gas Lasers: He-Ne Laser. • Ion Gas Lasers: Argon ion and Krypton ion lasers, He-Cd metal vapour laser, • Molecular gas Lasers: CO2 Lasers, Eximer laser, N2 laser etc. IV)Semiconductor lasers, V). Chemical Lasers: HF laser. CO2 mixture lasers.**(H-14, M-18)**	**14 L**
Unit 5	**Laser beam characteristics**: Directionality, Intensity, Coherence, Monochromaticity, Polarization, Speckles', Measurements of Laser power, energy-wavelength, frequency, line width. etc. **(H-6, M-6)**	**06 L**
Unit 6	**Applications of Lasers**: Applications of lasers in Material Processing and Mechanical industries, Medicine and Surgery, Defense and Military applications, Laser Range finders. Optical communication, Holography, Electronic industries. Laser Spectroscopy. **(H-10, M-10)**	**10 L**

Suggested Readings: Reference Books:

1. Lasers – A.G.Sigman- Oxford University Press 1986.
2. Principles of Lasers- O.Suelto-Plenum, 1982.
3. An introduction to lasers and their applications. – D.C.O.Shea, W. Russell and W.T.Rhodes, Addison – Welslay Pub.Co. (1977)
4. Laser Systems and Applications- SatyaPrakash , PragatiPrkashan, IInd Ed, (2012)
5. An introduction to Lasers - Theory and Applications- M. N. Avadhanulu, S. Chand & C0. (2008)
6. Principles of laser and their Applications – by Callen, O'shea, Rhodes.
7. Lasers and non linear Optics – B.B. Laud (2nd edition).

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C402.B.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the LASER and its Applications course to real life problems.	
C402.B.2	2. Understanding of the LASER and its Applications of Physics course which will create scientific temperament.	
C402.B.3	Students will have hand on experience of Theory Based on : • Basics of Lasers: Introduction, Brief history of LASER, Interaction of radiation with matter, Einstein's prediction. • Laser Rate equations: Two level system. Three and four level system. • Laser beam characteristics: Directionality, Intensity, Coherence, Monochromaticity, Polarization, Speckles'. • Applications of lasers in Material Processing and Mechanical industries, Medicine and Surgery, Defence and Military applications.	

PHY-402(C): Astrophysics		
	Course description: This course is aimed at introducing the fundamentals of Astrophysics to the students. **Course objectives:** 1) To impart knowledge of basic concepts Astrophysics and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**Astronomical Instruments:** Optical telescopes-refracting and reflecting- (Newtonian & Cassegrain), Radio telescopes, Hubble's space telescope, spectroscopes, photometry, spectro-photometry, Detectors & image processing. **(H-8, M-8)**	**08 L**
Unit 2	**Message from starlight:** Electromagnetic spectrum, Radiation from heated object, Doppler effect, Stellar spectra, determination of abundance of elements from stellar spectra. **(H-6, M-8)**	**06L**
Unit 3	**The Hertzsprung- Russel diagram:** Brightness and luminosity, population of stars, H-R diagram, variable and binary stars. **(H-4, M-6)**	**04 L**
Unit4	**Stellar Evolution:** Nuclear Fusion, Fusion reactions in stars formation of Helium, Carbon Oxygen and other reactions, E equation of state for stellar interior, Mechanical and thermal equilibrium in stars, stellar evolution, white dwarfs red giants, pulsars, neutron stars, black holes. **(H-10, M-12)**	**10 L**
Unit 5	**Galaxies:** Types of galaxies, evolution of galaxies, radio galaxies, seyfert galaxies, quasars, milky way galaxy. **(H-8,M-8)**	**08 L**
Unit 6	**General theory of relativity:** Space time & gravitation, vectors & tensors-contravariant & covariant vectors, symmetric and antisymmetric tensors, contraction, space time curvature, Geodesics, Principle of equivalence. **(H-9, M-10)**	**09L**
Unit 7	**Cosmology:** Big bang theory, steady state universe, oscillating universe, Hubble's law, experimental evidences for big bang, open and close universes. **(H-7, M-8)**	**07L**
Suggested Readings: Reference Books: 1. Astronomy-Fundamentals and Frontiers-Robert Jastow and Malcolm H. Thompson (Pub. John Wiley & Sons). 2. An Introduction to Astrophysics-Baidyanath Basu(Pub. Prentice Hall India Pvt. Ltd.).		

3. Introduction to Cosmology– J. V. Naralikar (Pub: Cambridge University Press).
4. An Introduction to the study of stellar structure-S. Chandarashekhar (Pub: Dover).
5. Measure of the universe-T.D. North (Pub. Oxford University Press).

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C402.C.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the LASER and its Applications course to real life problems.	
C402.C.2	2. Understanding of the LASER and its Applications of Physics course which will create scientific temperament..	
C402.C.3	Students will have hand on experience of theory based on : • Basics of Lasers: Introduction, Brief history of LASER, Interaction of radiation with matter, Einstein's prediction. • Laser Rate equations: Two level system. Three and four level system. • Laser beam characteristics: Directionality, Intensity, Coherence, Monochromaticity, Polarization, Speckles. • Applications of lasers in Material Processing and Mechanical industries, Medicine and Surgery, Defence and Military applications.	

M.Sc. Part II Semester IV (Physics): Elective Course (Select only one)

PHY-403(A): Renewable Energy Sources		
	Course description: This course is aimed at introducing the fundamentals of Renewable Energy Sources to the students. **Course objectives:** 1) To impart knowledge of basic concepts Renewable Energy Sources and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**Solar Energy**: Solar Energy conversion systems and their applications, Fundamentals of photovoltaic. Energy conversion, Principles of photo voltaic cell, Materials and fabrication technologies of P. V cell, P.V. systems: configuration, output power and conversion efficiency, Basic P.V. system for power generation, Applications and limitations of P.V systems. **(H-9, M-10)**	**09 L**
Unit 2	**Biomass Energy Conversion Technologies**: Origin of biomass, Biomass energy resources, Biomass energy conversion processes, generation of gaseous fuels from biomass, digesters and their designs, Energy from Cereals, grains, sugar, fruits, starch etc. **(H-8 M-10)**	**08 L**
Unit 3	**Wind Energy**: Introduction to wind energy, Nature & Origin of winds, Power in a wind stream, principles and basic components of wind mill, Efficiency of wind turbine, horizontal and vertical axis wind mills, performance of wind mills, merits and limitations of wind energy conversions. **(H-9, M-10)**	**09 L**
Unit 4	**Ocean Energy**: Ocean as the potential energy resource: various ocean energy	**07 L**

	conversion technologies, Introduction to OTEC, Principle of OTEC, Open cycle OTEC system, closed cycle OTEC system, Ocean waves, energy and power from ocean waves, origin of tidal energy, Tidal energy conversion. **(H-7, M-8)**	
Unit 5	**Geothermal Energy**: Geothermal energy as are new able source of energy, Types of geothermal resources, Origin of geothermal resources, Hydro geothermal, Geopressure, geothermal and Petro geothermal resources, Basics of geothermal electric power plant. **(H-6, M-7)**	**06 L**
Unit 6	**Emerging trends in Renewable Energy sources:** Fuel Cells: Principle and operation of fuel cell, classification and types of fuel cells, Phosphoric acid fuel cell (PAFC), Alkaline fuel cell (AFC),Molten carbonate fuel cell (MCFC), Solid oxide fuel cell(SOFC), Fuels for fuel cells, Performance characteristics of fuel cells. Hydrogen Energy: Hydrogen as clean source of energy, sources Production, storage, Use of hydrogen as fuel, conversion to energy, Applications. **(H-13, M-15)**	**13 L**

Suggested Readings: Reference Books:

1. Energy Technology Non-Conventional, Renewable and Conventional, S. Rao, Dr.B.B. Parulekar, Khanna Publications, 3rdEd, 2005.
2. Non-Conventional Energy Sources, G. D. Rai, Khanna Publications, 2000.
3. Solar Energy Utilization, G.D. Rai, Khanna Publishers (1996).
4. Non-Conventional Energy Resources, Khan B.H., Tata McGraw Hill. 2006.
5. Solar Energy Conversion, S. P. Sukhatme (2ndedition).
6. Solar Cells, M.A. Green.
7. Hydrogen as Energy carrier Technologies systems Economy-Winter & Nitch.
8. Solar Energy Conversion– A. E. Dixnon & J. D. Leslie.
9. Biomass Energy– S.H. Pawar, L.J. Bhosale, A.B. Sabale, S.K. Goel.
10. Renewable Energy Sources and Conversion Technology, Bansal, N.K., M.KM. Meliss (1990)Tata McGraw Hill.
11. Non Conventional and Renewable energy sources, S.S. Thipse, Narosa Publishing House Pvt. Ltd.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C403.A.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of the Renewable Energy Sources course to real life problems.	
C403.A.2	2. Understanding of the Renewable Energy Sources of Physics course which will create scientific temperament..	
C403.A.3	Students will have hand on experience of Theory Based on: • Solar Energy: Solar Energy conversion systems and their applications. • Bio mass Energy Conversion Technologies: Origin of biomass, Biomass energy resources. • Ocean Energy: Ocean as the potential energy resource. • Emerging trends in Renewable Energy sources.	

PHY-403(B):Microwaves: Theory and Applications		
	Course description: This course is aimed at introducing the fundamentals of Microwaves: Theory and Applications to the students. **Course objectives:** 1) To impart knowledge of basic concepts Microwaves: Theory and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**Transmission Lines:** Introduction to microwaves, applications of microwaves, Skin effect, Transmission line theory, Transmission line equations and their solutions, Open and terminated transmission lines, Line impedances, Line admittance, reflection coefficient, transmission coefficient, standing wave ratio, Impedance matching, Smith chart, Single stub matching and double stub matching. **(H-8, M-10)**	**08 L**
Unit 2	**Waveguides:** Rectangular and Circular waveguides, Solution of wave equation in rectangular coordinate, TE and TM modes in rectangular waveguide, Power transmission in rectangular waveguides, Power losses and excitation modes in rectangular waveguides. **(H-7, M-8)**	**07 L**
Unit 3	**Waveguide components:** Attenuators, filters, junctions, rectangular cavity resonator, circular cavity resonator, Enplane (series tee), H-plane (shunt tee), magic tee (Hybrid tee), directional couplers, hybrid rings (Rat-Race), waveguide corners, bends, loads, Microwave circular isolators. **(H-7, M-8)**	**07 L**
Unit 4	Microwave Generators: Microwave generation problems and principles, Tubes: Two cavity klystron and Reflex-klystron. Two cavity Klystron operation as amplifiers and oscillators, velocity modulation, bunching process, output power and beam loading efficiency of klystron. Reflex Klystron: Velocity modulation, power output efficiency, electronic admittance. Magnetron, Traveling wave tube amplifier: construction and operation. Microwave transistors: Principle of operation, microwave characteristics-cutoff frequency, current gain, power gain. Varactor diode: Principle of operation, use of varactor diode for frequency multiplication. Microwave Tunnel diode: Principle of operation, Gunn diode, PIN diode: Principle of operation, microwave characteristics. **(H-10, M-12)**	**10 L**
Unit 5	**Microwave Antennas:** Transmitting and receiving antenna: Horn antenna, Microwave dish antenna, antenna gain, resistance and band width, Beam width and polarization, Introduction to Micro strip antenna. **(H-6, M-6)**	**06 L**
Unit 6	**Measurements:** Smith chart: Derivation, use of chart for solving various problems in wave guide/ transmission lines, Microwave measurements: Measurement of impedance, power, frequency, attenuation, SWR, dielectric constant, quality factor. **(H-7, M-8)**	**07 L**
Unit 7	**Applications:** Radar: Block diagram and working of pulsed Radar system. Satellite: Active, passive, design requirements, payload, launching sequence. Microwave link, Microwave Remote Sensing Microwave ovens: Design requirements, sizes available, and application areas, Applications of microwaves in the medical field. **(H-7, M-8)**	**07L**

Suggested Readings: / Reference Books:

1. Microwave Devices and Circuits - Samuel Y. Liao, Prentice-Hall, New Delhi, 2006.
2. Microwave Engineering – Annapurna das & S.K. Das, Tata McGraw Hill, 2009.
3. Foundation of microwave engineering – Colin R.E. McGraw Hill 1969.
4. Introduction to microwaves – Atwater, McGraw Hill 1962-63.
5. Introduction to microwave – Wheeler, McGraw Hill 1962-63.
6. Microwave semiconductor devices and their circuit application.- Watson , McGraw-Hill 1962-63.
7. Microwave circuits and elements – M.L.Sisodia 8. Microwave circuits & passive Devices–M. L. Sisodia, G.S. Raghuvanshi, Wiley Eastern Ltd, 1987.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C403.B.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Microwaves: Theory and Applications course to real life problems.	
C403.B.2	2. Understanding of the Microwaves: Theory and Applications Physics course which will create scientific temperament..	
C403.B.3	Students will have hand on experience of Theory Based on : • Transmission Lines: Introduction to microwaves, applications of microwaves. • Waveguides: Rectangular and Circular waveguides. • Microwave generation problems and principles. • Microwave Antennas: Transmitting and receiving antenna. • Applications: Radar: Block diagram and working of pulsed Radar system. • Satellite: Active, passive, design requirements.	

PHY-403(C): Environmental Physics		
	Course description: This course is aimed at introducing the Environmental Physics: Theory and Applications to the students. **Course objectives:** 1) To impart knowledge of basic concepts Environmental Physics s: Theory and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.	
Unit 1	**Introduction:** Meaning of Environment, Environmental science an overview, definition, concept & scope, types of environmental approaches, Nomenclature, environmental segments, Natural cycles (hydrologic, oxygen, nitrogen cycle). **(H-7, M-8)**	**07 L**
Unit 2	**Atmosphere:** Composition of atmosphere, Major regions of atmosphere, evolution of atmosphere, earth's radiation balance, Particles in the atmosphere, chemical & photochemical reactions in the atmosphere. **(H-8, M-8)**	**08 L**
Unit 3	**Environmental Resources:** Forest-Utilization, degradation & conservation, water-water cycle, degradation & conservation, Soil-utilization degradation & conservation. **(H-7, M-8)**	**07L**
Unit 4	**Pollution & environmental problems:** Meaning of pollution, sources, causes elementary fluid dynamics, factors governing air, water and noise pollution Green house effect/Global warming ozone hole. El Nino phenomenon. Acid Rain. **(H-6, M-8)**	**06 L**
Unit 5	**Water Pollution:** Aquatic environment, water pollutant, Sources of contamination of water pollution, waste water treatment, water quality parameters & standards, sampling, preservation, monitoring techniques pH dissolved oxygen, chemical oxygen demand, total oxygen demand, analysis of water quality parameter. **(H-9, M-10)**	**09 L**
Unit 6	**Air Pollution:** Air pollutant, air quality standard, sampling, monitoring, sampling, analysis technique, Gaseous and particulate matter. **(H-7, M-8)**	**07L**
Unit 7	**Global & Regional Climate:** Elements of weather and climate, stability and vertical and horizontal motion of air and water, viscous force, inertia force, Reynolds number, energy balance, pressure gradient force, global climate model and climate of India. **(H-8, M-10)**	**08L**
Suggested Readings: / Reference Books: 1. Environmental Chemistry: A.K. De		

2. Environmental Chemistry: O.D. Tyagi, M. Mehra (Anmol Publications).
3. Physics of atmosphere: J.T. Hougtion (Cambridge Uni.Press:1977)
4. Renewable Energy Sources: Elbs.1988.J.T.Widell & J. Weir.
5. Water Pollution (problems and Prospects): V.K. Prabhakar (Anmol Publications).
6. The Physics of Mansoons: R. N. Keshavmurthy & M. Shankar Rao Allied Publishers, 1992.
7. Solar Energy: S.P. Sukhatme.
8. Solid State Energy Conversion: S.H. Pawar, V.H.Shinde.
9. Environmental Physics: Egbert Boekar and Rienk Van Groundelle (John Willey).
10. An Introduction to Solar Energy for Scientists and Engineers: Sol-Wieder John Wiley, 1982.
11. Numerical Weather Prediction: G.J. Haltiner and R.T. Williams John Wiley, 1980.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C403.C.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Environmental Physics: Theory and Applications course to real life problems.	
C403.C.2	2. Understanding of the Environmental Physics: Theory and Applications Physics course which will create scientific temperament..	
C403.C.3	Students will have hand on experience of theory based on: • Meaning of Environment, Environmental science an overview, definition, concept & scope. • Composition of atmosphere, Major regions of atmosphere, evolution of atmosphere, earth's radiation balance. • Environmental Resources: Forest-Utilization, degradation & conservation, water-water cycle. • Water Pollution.. • Air Pollution.	

M.Sc. Part II Semester IV (Physics): Core Based Courses

PHY-404 Special Laboratory II	
	Course description: This course is aimed at introducing the Special Laboratory II: Practical and Applications to the students. **Course objectives:** 1) To impart knowledge of basic concepts Special Laboratory II: Practical and its Applications 2) The graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications. 3) The **graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.**
	Perform at least **TEN** experiments from the following.

1	1. To find water of crystallization in Copper sulphate by TGA. 2. Differential thermal analysis [DTA] of $CuSO_4$, $5H_2O$. 3. Schottky barrier determination for various semiconductors. 4. To analyses the Raman Spectrum of a sample. 5. To determine Young's modulus of a metallic rod by Searle's optical interference method (Newton's Rings). 6. To analyses the photoluminescence spectrum of a given sample. 7. Determination of Curie temperature of a given sample. 8. Determination of calorific value of wood/cow dung. 9. Determination of wind power. 10. Wind data analysis of a given site. 11. Study of power vs. load characteristics of solar P.V. systems and study of series and parallel combination of solar P.V. panels. 12. Study of Optical Properties of Selective Coatings. 13. Hyperfine structure of spectral lines using FP etalon/L.G. plate. 14. To study the Quantum defects of S and P states of Na atom using constant deviation spectrometer. 15. Study of dielectric behavior of $BaTiO_3$ sample.
2	**Nanomaterials** 1. Synthesis of metal nanoparticles. 2. Synthesis of porous silicon. 3. Absorption by metal nanoparticles. 4. X-ray Diffraction of nanoparticles. 5. Photoluminescence of nanoparticles. 6. Synthesis of semiconductor nanoparticles by chemical method. 7. Optical absorption of nanoparticles (observation of Blue shift with size of particles). 8. Photoluminescence of nanoparticles (Luminescence decay time). 9. X-ray diffraction studies of nanoparticles (effect of temperature). 10. Density of states calculation of small clusters (experiments on computer).
3	**LASERS:** 1. To verify Heisenberg uncertainty principle using He-Ne laser source. 2. Study of Faraday's effect using Laser source. 3. Diameter of a given wire by diffraction. 4. Determination of bandwidth of a given optical fiber. 5. Measurement of reflectivity and transferability of thin film by using He-Ne laser. 6. Verification of Brewster's law of polarization using He-Ne laser. 7. Study of magneto-optic rotation and magneto-optic modulation. 8. To determine the wavelength of a LASER source using an engraved scale as a reflecting diffraction grating.
4	**Astrophysics :** 1. To estimate the temperature of an artificial tar by photometry. 2. To study characteristics of a CCD camera. 3. To study the solar limb darkening effect. 4. To polar assign an astronomical telescope. 5. To estimate there active magnitudes of a group of stars by a CCD camera.
5	**Microwaves :** 1. Study of passive components. 2. Study of various loads. 3. To study characteristics curve of Klystron. 4. Determination of constants of transmission line, strip lines. 5. Study of cavity resonator.

	6. Study of ring resonator and rejection filter. 7. To design, fabricate and test astripline resonator. 8. To find dielectric constant of given liquid using microwave bench. 9. Measurement of Quality factor Q of a microwave resonator.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C404.1	Course outcome: Learner will be able to …. 1. Apply the concept and use of knowledge of Special Laboratory II: Practical and Applications course to real life problems.	
C404.2	2. Understanding of Special Laboratory II: Practical Physics and Applications Physics course which will create scientific temperament.	
	Students will have hand on experience of theory based on : • Schottky barrier determination for various semiconductors. • To analyse the Raman Spectrum of a sample. • Nanoparticles. • LASERS. • Astrophysics. • Microwaves.	

M.Sc. Part II Semester IV (Physics): Skill Based Courses

PHY-405: M. Sc. Project – II (Project Dissertation)
Course Objectives: 1. To give exposure to the students to research culture and technology 2. To introduce students how to select a research topic, plan, perform experiments, collect data and analyse the data 3. To foster self-confidence and self-reliance in the students as he/she learns to work and think independently
Activities: 1. To complete the experimental work. 2. To carry out the measurements. 3. To characterize the samples. 4. To obtain the results. 5. To draw the conclusions. 6. To write the project report. 7. To appear for Internal examination 8. To appear for External examination **Project Report:** 1. Students have to write a 'project report'. 2. A report should be a concise account of project work containing full descriptions of the aims, method and outcomes. 3. Length of report should not normally exceed 40 pages. Assessment Criteria of the project: The

following criteria are to be used in assessing the project work:

(i)The conduct of project work:

The following questions are considered in assessing how well students have carried out the project work.:

1. How difficult was the project?
2. How well did the student understand the scientific principles behind the project?
3. How well did the student plan the project work?
4. How much effort was put into the project?
5. Was an interim report presented on time?
6. Is the student's project logbooks adequate?
7. How much initiative and/or originality did the student contribute to the project?
8. How well did the student cope with problems that arose during the course of project?
9. Did a project reach a stage of completion where meaningful results were obtained and definite conclusions could be drawn?

(ii) The Project Report:

1. How well did the report set out the background?
2. How well did the report describe the underlying them?
3. Was the report a reasonable length?
4. How well was the report structured?
5. How understandable was the written content?
6. How well did the report describe the execution of the project?
7. Did the report have an adequate summary or conclusions?

(iii) Oral Examination:

1. Did the student adequately describe what he/she had done in their project?
2. Did the student have a clear interpretation of his/her results?
3. What was the clarity and overall standard of the presentation?
4. How well was the talk/presentation structured?
5. Did the student cover all the relevant material in a reasonable time?

The project is allotted during the third semester. The students will get an opportunity to become a part of ongoing research activities in the respective supervisor's laboratory. The students will acquire skill to write, compile and analyze data if any, and present the detailed technical/scientific report. At the end of successful project semester training, potentially the students become employable in the industries/organizations.

It is expected that the students will design experiments and collect experimental data. At the end, they will submit a detailed thesis for evaluation. The students should be introduced to research methodology in the beginning through few lectures.

The systematic approach towards the execution of project should be as follows:

1. Selection of topic relevant to priority areas of Physics.
2. Collection of literature on the topic of research from libraries, internet, online journals, Planning of research experiments.
3. Performing the experiments with scientific and statistical acceptability.
4. Presentation of observations and results.
5. Interpretation of results and drawing important conclusions.
6. Discussion of obtained results with respect to literature reports.
7. Writing monthly progress report

8. Preparation of report (Dissertation) containing introduction, materials and methods, results and discussion, conclusions, bibliography and submission of at least 3 copies (1 copy retained in the department and after examination submitted to Library, 1 copy submitted to the guide and 1 copy kept with the candidate). 9. Presentation of research data during university examination and submission of project dissertation in abound form.
1. **Internal examination (40 marks):** Components of continuous internal assessment: Submission of progress report (8 marks), Literature collected, experiment planning and design (10 marks), Experiments conducted (10 marks), outcome of the experiments and viva (8 marks) and regular attendance (4 marks) recorded: Research Supervisors 2. **External examination, [PHY-305(60 Marks) + PHY-405 (60 marks)]** and Components of external assessment: Subject matter (5+5 marks), Review of literature (10+10 marks), Writing of dissertation submitted in bound form at the time of examination (Title page, Certificate, Main content: Abstract, Introduction, Literature, Materials and methods, results and discussion and conclusion with relevant references) (15+15 marks), Presentation structure (PPT format) (10+10 marks), Overall presentation reflecting contribution of work (5+5 marks), Response to questions (15+15 marks).
Suggested readings: Refer the topic in research papers, review articles published in peer reviewed and SCI indexed journals, reference books, abstracts, etc. related to topic of project dissertation

Course Outcomes (COts):
On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
C405.1	Conceive a problem based on published research and carry out comprehensive survey of literature	**4**
C405.2	Plan and carry out task in given framework of dissertation and present the work in written and viva	**6**
C405.3	Use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.	**6**
C405.4	Learn handling of instruments, use of chemicals and how to conduct the experiments	**3**
C405.5	Learn how to present the project in power point and answer the queries to examiners as well as science of writing	**6**

M.Sc. Part II Semester IV (Physics): Audit Courses

	AC-401(A): Human Rights **(Professional and Social + Value Added Audit course; Practical; 2 Credits)** **(Optional:)**	
	Course Objectives (CObs): • To make students aware about human rights and human values.	
Unit 1	**Introduction to Human Rights** 1.1 Concept of Human Rights 1.2 Nature and Scope of Human Rights 1.3 Fundamental Rights and Fundamental Duties 1.4 Interrelation of Rights and Duties	**6 H**
Unit 2	**Human Rights in India** 2.1 Meaning and Significance of **:** 1) Right to Equality 2) Right to Freedom, 3) Right against Exploitation, 4) Right to Freedom of Religion, 5) Cultural and Educational Rights, and 6) Right to Constitutional Remedies.	**8 H**

	2.2 Constitutional Provisions for Human Rights 2.3 Declaration of Human Rights 2.4: National Human Rights Commission	
Unit 3	**Human Values** 3.1: Meaning and Definitions of Values 3.2: Importance of values in the life of Individual 3.3: Types of Values 3.4: Programmes for conservation of Values	**8 H**
Unit 4	**Status of Social and Economically Disadvantaged people and their rights** 4.1: Rights of women and children in the context of Social status 4.2: The Minorities and Human Rights 4.3: Status of SC/ST and other Indigenous People in the Indian Scenario 4.4: Human rights of economically disadvantaged Society	**8 H**

Suggested readings:

1. Human rights education – YCMOU, Nasik
2. Value education – SCERT, Pune
3. Human rights reference handbook – Lucille whare

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401A.1	Practice the learned issues under human rights and human values in real life.	**3**
AC401A.2	Provide social justices to people around them and provide guidance about human rights to their friends, parents and relatives.	**5**

AC-401(B): Current Affairs

(Professional and Social + Value Added Audit course; Practical; 2 Credits)
(Optional:)

Course Objectives (CObs):

- To make students updated about current affairs of India and world.

	Title	Content	Hours
Unit 1	Politics & Economy	• National & International Political Activity, Organization. • Economy & Business, Corporate world	**08**
Unit 2	Awards and recognitions	• National & International Awards and recognitions • Books and authors	**07**
Unit 3	Science & Technology	• Software, Automobile, Space Research • New inventions and discoveries	**07**
Unit 4	Environment & Sports	• Summit & conference, Ecology & Climate, Organization. • National & International Games, Olympics, commonwealth etc.	**08**

Suggested readings (Use recent years' data and current literature):

1. India 2019, by Publications Division Government of India.
2. Manorama Year Book by Philip Mathew.
3. India 2019, Rajiv Maharshi.
4. Quick General Knowledge 2018 with Current Affairs Update, Disha Experts.
5. General Knowledge 2018: Latest Who's Who & Current Affairs by RPH Editorial Board.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401B.1	Identify important issues currently/ recently happening in India or world.	**5**
AC401B.2	Summarize current affairs regularly.	**6**

AC-401(C): Seminar + Review Writing

(Technology + Value added Audit course; Optional: Program-level; Practical; 2 Credits)

Course Objectives (CObs):

- To motivate students to develop skills to search, retrieve, interpret, organize, and present relevant biological information.

Writing a Scientific Literature Review:

- Choosing a topic, Deciding the scope of topic, Significance and impact of scientific problem being addressed, Relevance to subject, current issues and social relevance, Strengths and limitations of the study, Enticing broad audience.
- Literature Survey and Information to consider in the review:
  - Literature search using authentic library resources (print and non-print, digital and virtual) for Almanacs, Encyclopaedia, Dissertations, Theses, Research papers, Review articles, Reference/ Textbooks, and Popular articles (INFLIBNET, Google Scholar, PubMed, Highwire, Google patents, Indian patent database, etc.)
  - Analyzing the literature quality (indexing, peer review, citations, journal impact factor, etc.)
- Deciding a writing approach (theoretical, experimental, interpretive, clinical, etc.), prepare the highlights and drawing important conclusion from literature
- Sections to include and tips for writing them: Abstract, Introduction, Body, Discussion, Conclusion, References
- Reference styles (MLA, APA, etc.), Use of bibliography/ reference/ citation managers and generators (Reference Manager, End Note, Ref Works, Mendeley, Zotero, Qiqqa, etc.)
- Ethics of publication: Approval and consent, Data ethics (accuracy, falsification, fabrication, and confidentiality), Plagiarism and self-plagiarism, collaborative authorship, conflict of interest, legal consequences
- Content similarity detection, Use of anti-plagiarism services (Urkund, iThenticate, Turnitin, Copyscape, Grammarly, etc.)

Seminar Activity:

- Students are encouraged to deliver seminars on the topics of research, preferably published research paper in a reputed and indexed journal to develop presentation skills and enable to build confidence which will lead them to read different themes and enhance their scientific approach and knowledge assimilation abilities.
- Presentations must be created and presented by students using digital platform using a suitable software in the presence of student audience and faculty for evaluation

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401C.1	Retrieve, analyse, comprehend the scientific information on a given topic and derive logical inferences.	**4**
AC401C.2	Compile the scientific information on a topic, verify for similarity index or plagiarism.	**2**
AC401C.3	Deliver the interactive presentation of scientific data before audience and participate in open discussion with confidence.	**2**

	AC-401(D): Intellectual Property Rights (IPR) (Professional and Social + Value Added Audit course; Practical; 2 Credits) (Optional: Program-level)	
	Course Objectives (CObs): • To provide basic knowledge on intellectual property rights and their implications. • To understand ethical issues relevant to biology from the perspective of national and international law.	
Unit 1	**History and Introduction to Intellectual Property Rights:** Evolution of patent Laws, History of Indian Patent System, Concept of IPR, Designs, Trademarks TM, Trade Secret (TS), Domain Names, Geographical Indications, Copyright	**6 H**
Unit 2	**Classification of patents and ownership:** Classification of patents in India, Classification of patents by WIPO, Categories of Patent, Special Patents Ownership of patent, Rights of patent holder and co-owners, Duties of patent holder and co-owners, Transfer of patent Rights, Limitations of patent Rights, Restoration of Patents, Infringement of patent Rights and Offences, Actions against Infringement and Remedies and Relief	**6 H**
Unit 3	**Protection of biological materials and Biodiversity** Methods of protection of plant and plant products, Essentialities of plant protection, Plant variety protection and Farmers' Right Act, UPOV convention (plant Varieties) 1961, National Biodiversity Act- 2002, Protection of environment and biodiversity	**6 H.**
Unit 4	**Biosafety and good laboratory practices** Overview of biosafety, Risk assessment, Cartagena protocol on Biosafety, Biosafety Levels, GMOs and LMOs, Gene flow and environmental impact, opportunities and challenges Roles of Institutional Biosafety Committee, RCGM, GEAC in food and agriculture Risk analysis, assessment and management, International regulatory bodies Importance of good laboratory practices, General good laboratory practices	**6 H**
Unit 5	**Bioethics** Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies etc Bioethics in research – cloning and stem cell research in human, animal rights/welfare in experimentation Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations, biopiracy	**6 H**

Suggested readings:

1. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
2. Deepa Goel, Shomini Parashar (2013) IPR, Biosafety and Bioethics Always learning, Pearson Education India, ISBN 9332514240, 9789332514249.
3. Department of Biotechnology http://dbtindia.gov.in/guidelines-biosafety.
4. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
5. International Union for the Protection of New Varieties of Plants. http://www.upov.int.
6. Kuhse, H. (2010). Bioethics: An anthology. Malden, MA: Blackwell.
7. National Biodiversity Authority. http://www.nbaindia.org.
8. National Portal of India. http://www.archive.india.gov.in.
9. Office of the Controller General of Patents, Design & Trademarks; Government of India. http://www.ipindia.nic.in/.
10. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). Problem formulation in the environmental risk assessment for genetically modified plants. Transgenic Research, 19(3), 425-436. doi: 10.1007/s11248-009-9321-9.
11. World Intellectual Property Organisation. http://www.wipo.int.
12. World Trade Organisation. http://www.wto.org.

Course Outcomes (COts):

On completion of this course, the student will be able to:

CO No.	CO	Cognitive level
AC401D.1	Understand to classify, identify advantages of intellectual property and IPR	**3**
AC401D.2	Understand the need to protect biological diversity and follow bioethical practices in research work, awareness to protect intellectual property relevant to biology	**2**

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Equivalence Subject:

Old Course		New Course	
Course Number	**Title of the Course**	**Course Number**	**Title of the Course**
Sem. I		**Sem. I**	
PHY-101	Mathematical Methods for Physics	PHY-101	Mathematical Methods for Physics
PHY -102	Classical Mechanics	PHY -102	Classical Mechanics
PHY-103	Quantum Mechanics	PHY-103	Solid State Physics
PHY-104	Solid State Physics	PHY -104(A)	**A)**:Physics of Semiconductor Devices Or
		PHY -104(B)	**B)**: Electronic Instrumentation Or
		PHY -104(C)	**C)**Bio- Physics
PHY -105	Basic Physics Laboratory – I	PHY-105	Basic Physics Laboratory – I
Sem. II		**Sem .II**	
PHY-201	Statistical Mechanics	PHY-201	Statistical Mechanics
PHY -202	Classical Electrodynamics	PHY -202	Classical Electrodynamics
PHY -203	Material Science	PHY -203	Quantum Mechanics
PHY-204(A)	PHY 204 (A) : Physics of Semiconductor Devices	PHY-204	Material Science
PHY-204(B)	PHY 204 (B) : Electronic Instrumentation		
PHY-204(C)	PHY 204 (C) : Bio- Physics		
PHY-205	Basic Physics Laboratory – II	PHY-205	Basic Physics Laboratory – II
Sem. III		**Sem. III**	
PHY-301	Atomic and Molecular Physics	PHY-301	Atomic and Molecular Physics
PHY-302(A)	A)Materials Synthesis Methods	PHY-302(A)	A) Materials Synthesis and preliminary analysis
PHY-302(B)	B)Microprocessor and its Applications	PHY-302(B)	B) Computational Method sand Programming Using 'C' Language OR
PHY-302(C)	C)Communication Electronics	PHY-302(C)	C) Acoustics and Entertainment Physics
PHY-303	A)Systematic Materials Analysis	PHY-303(A)	A)Systematic Materials Analysis)OR
	B) Computational Methods and Programming Using 'C' Language	PHY-303(B)	B) Microprocessor and its Applications OR
	C) Acoustics and Entertainment Electronics	PHY-303(C)	C) Communication Electronics
PHY-304	Special Laboratory-I	PHY-304	Special Laboratory-I
PHY-305	Project Work-II (Literature Survey, Definition of Problem, Experimental work, Oral etc.)	PHY-305	Project Work-II (Literature Survey, Definition of Problem, Experimental work, Oral etc.)
Sem. IV		**Sem. IV**	
PHY-401	Nuclear Physics	PHY-401	Nuclear Physics
PHY -402(A)	A)Nanomaterials : Synthesis, Properties and Applications	PHY -402(A)	A)Nanomaterials: Synthesis, Properties and Applications OR

PHY -402(B)	B) LASER and it's Applications	PHY -402(B)	B) LASER and it's Applications OR
PHY -402(C)	C) Astrophysics	PHY -402(C)	C) Astrophysics
PHY-403(A)	A) Renewable Energy Sources	PHY-403(A)	A) Renewable Energy Sources OR
PHY-403(B)	B) Microwave: Applications	PHY-403(B)	B) Microwave: Applications OR
PHY-403(C)	C) Environmental Physics	PHY-403(C)	C) Environmental Physics
PHY -404	Special Laboratory-II	PHY -404	Special Laboratory-II
PHY -405	Project Work-II (Characterization, Analysis of Result, Conclusions, Project Report, Oral etc.)	PHY -405	Project Work-II (Characterization, Analysis of Result, Conclusions, Project Report, Oral etc.)