Sant Gadge Baba Amravati University, Amravati

FACULTY : Science and Technology

Programme outcomes, Programme specific outcomes and Employability Potential of the Two Years PG Degree Master of Science (PHYSICS) following Three Years UG Programme wef 2023-24

(Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option)**

Programme: M. Sc. Physics (NEPv23)

POs: The MSc Physics programme equips students with advanced knowledge, general competence, and analytical skills that are required in industry, consulting, education, and research. On completion of program, it will-

1. Instill an inquisitive mindset in the students so that they are capable of independent and critical thinking.
2. Train-up the students in such a way that they can objectively carry out investigations, scientific and/or otherwise, without being biased or without having any preconceived notions.
3. Apply the knowledge and skill in the design and development of Electronics circuits to fulfil the needs of Electronic Industry.
4. Become professionally trained in the area of electronics, optical communication, nonlinear circuits, materials characterization and lasers.
5. Develop research problems related to Physics and Materials characterization and applications.
6. As technology exploits the rules of Physics, students properly trained in Physics

can be good researchers in the field of technology too.

7. 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.

PSOs: The specific outcomes will-

1. Understanding the basic concepts of physics particularly concepts in classical mechanics, quantum mechanics, statistical mechanics, electrodynamics and electronics to appreciate how diverse phenomena observed in nature follow from a small set of fundamental laws.
2. Learn how to perform experiments in basic as well as advanced areas of Physics such as Nanomaterials, Condensed Matter Physics, Electronics and Photonics.
3. Analytical and integrative problem-solving methodologies are developed through research-based learning.
4. Prepare the students to pursue research careers, careers in academics, in industries in physical science and in allied fields.

Employability Potential of the Programme:

MSc Physics programme developed the skills, particularly the ability to analyze and apply information, gives one a good head start, in any field, one wishes to get in. The skills are useful even in the management disciplines. This programme gives physics enthusiasts a chance to develop their mathematical, problem solving, communication skills and critical thinking, that helps to interpret rich scientific data and that is always a boon to scientific researchers.

Sure, makes one increase his/her employability in this field. M.Sc Physics can easily avail of technical jobs, both in the private and public sector. Some of the common job positions or profiles for a physics enthusiast are Online tutor, College lecturer, Assistant Professor, Observation Scientist, Laboratory Technician, School Science Technician or Research Analyst, Assistant Scientist, Physics Training Manager, Software Engineer, Network Administrator, IT Consultant, Security Expert, Java Developer, Systems Support Administrator, Interface Engineer etc. They can apply for jobs in Aerospace and Defence, Automobile, IT and Software, Railways, Nuclear and Renewable energy, Oil and Gas, Electronics and Telecommunications and the Manufacturing sector.

MSc Physics can pursue an MTech/MS degree in a variety of engineering or technology disciplines such as aeronautical, automobile, instrumentation, electronics and communication, or computer sciences. But, make sure to crack the GATE (Graduate Aptitude Test in Engineering) exam first, before going down this road.

For a long career in the field of research, students are advisable to pursue MPhil or PhD in Physics, after completing MSc Physics and join any science/technology research center. Students can also apply in Government or private colleges and universities; polytechnic institutes, degree colleges, engineering colleges, IITs, IISc etc for teaching job. The minimum requirement is MSc Physics and UGC-CSIR NET exam for lectureship and JRF. Moving on, an MSc Physics followed by a BEd can also land you a job in higher secondary schools and then, there is the option of physics tutor, at the convenience of one's homes. Some of the prominent national organizations, that student can try aim for, include Defence Research and Development Organisation (DRDO), Indian Space Research Organization (ISRO), BARC, SSPL, Space Application Centres, Indira Gandhi Centre for Atomic Research Centre, Variable Energy Cyclotron Centre, National Thermal Power Corporation (NTPC), Oil and Natural Gas Corporation (ONGC), Bharat Heavy Electricals Limited

(BHEL) and National Atmospheric Research Laboratory of Department of Space.

The research institutes in India such as Physical Research Laboratory, Ahmedabad, Saha Institute of Nuclear Physics, Kolkata and Nuclear Science Centre, New Delhi, TIFR (Education); IISER also recruit MSc Physics graduates, for technical jobs. At the same time, student can also look out for the national laboratories and institutes like National Geographical Research Institute, Regional Research Laboratories, National Institute of Science Communication and Information Sources, NEERI (CSIR labs) etc. These are some of the leading names to be associated with the field of science. Moving further, student can try for public sector banking to the post of Probationary Officers.

MSc Physics graduates have ample of opportunities, be it, in healthcare, manufacturing and electronics companies in most foreign countries. Those with exceptional academic excellence can go a step further and apply in the best space research organizations such as National Aeronautics and Space Administration (NASA).

After completion of this programme, the students are placed as Scientists, Radiologist, Meteorologist, Analyzers in forensic labs, IAS, SDO, Dy Superintendent of Police in wireless stream, Assistant Professors, Lecturers, Teachers, Radiologist, Telecom officers (JTO).

Sant Gadge Baba Amravati University, Amravati

FACULTY : Science and Technology

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (PHYSICS) following Three Years UG Programme wef 2023-24

(Two Years- Four Semesters Master's Degree Programme- NEPv23 with Exit and Entry Option

M.Sc. (Physics) First Year Semester- I Level 6.0

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		Marks Internal	Marks External	Grade
0	*Pre-Requisite Course(s) if applicable/MOOC/Internship/Field Work cumulatively If students wish to opt Minor Course of UG as Major for PG, **balance 12 Credits** Course will have to be completed **(As and when applicable)**	Th-Prq		0	0	0	0	**Additional Credits to be earned = (1) minus(2) (1). Credits from Major DSC Courses in UG (minus) (2).The Credits already earned from the Course as Minor at UG, now to be opted as Major at PG**			2	15	35			50	06	14	P
1	Research Methodology and IPR in PHYSICS	Th-Major	**PHY 100**	4			4	4		4	3	30	70			100	12	28	P
2	DSC-I.1 **(Mathematical Physics)**	Th-Major	**PHY 101**	3			3	3		3	3	30	70			100	12	28	P
3	DSC-II.1 **(Classical Mechanics)**	Th-Major	**PHY 102**	3			3	3		3	3	30	70			100	12	28	P
4	DSC-III.1 **(Quantum Mechanics I)**	Th-Major	**PHY 103**	3			3	3		3	3	30	70			100	12	28	P
5	DSE-I /MOOC **:** **(i) Computational Methods and C Programming** **(ii): Computational Methods and Scilab Programming** **(iii): Computational Methods and Python Programming**	Th-Major Elective	**PHY 104 (i/ii/iii/)**	3			3	3		3	3	30	70			100	12	28	P
																	Minimum Passing Marks		**Grade**
6	**Lab I: General Physics Experiments**	Pr-Major	**PHY 105**			6	6		3	3	4			50	50	100	25	25	P
7	**Lab II: Programming based Experiments (Computer Lab)**	Pr-Major	**PHY 106**			6	6		3	3	4			50	50	100	25	25	P
8	# On Job Training, Internship/ Apprenticeship; Field projects **Related to Major @ during vacations cumulatively**	Related to DSC		**120 Hours cumulatively during vacations of Semester I and Semester II**						4*									P*

9	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC,Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**															
	TOTAL									**22**						**700**			

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note : # On Job Training, Internship/ Apprenticeship; Field projects **Related to Major (During vacations of Semester I and Semester II) for duration of 120 hours mandatory to all the students, to be completed during vacations of Semester I and/or II. This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in Semester II credit grade report.**

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Sant Gadge Baba Amravati University, Amravati

FACULTY : Science and Technology

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (PHYSICS) following Three Years UG Programme wef 2023-24

(Two Years- Four Semesters Master's Degree Programme- NEPv23 with Exit and Entry Option

M.Sc. (Physics) First Year Semester- II Level 6.0

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	DSC- IV **(Quantum Mechanics II)**	Th-Major	**PHY 201**	3			3	3		3	3	30	70			100	12	28	P
2	**DSC-V: Electromagnetic Theory**	Th-Major	**PHY 202**	3			3	3		3	3	30	70			100	12	28	P
3	**DSC-VI: Atomic and Molecular Physics**	Th-Major	**PHY 203**	3			3	3		3	3	30	70			100	12	28	P
4	DSE-II /MOOC **:** **DSE II (i): Lasers and Laser Applications** **DSE-II (ii): Spectroscopic Techniques** **DSE-II (iii): Network Theorems and Solid State Devices**	Th-Major Elective	**PHY 204 (i/ii/iii/)**	3			3	3		3	3	30	70			100	12	28	P
																	Minimum Passing Marks		Grade
5	**Lab I: (DSC IV and DSC V)**	Pr-Major	**PHY 205**			6	6		3	3	4			50	50	100	25	25	P
6	**Lab II: (DSC VI and DSE)**	Pr-Major	**PHY 206**			6	6		3	3	4			50	50	100	25	25	P
8	# On Job Training, Internship/ Apprenticeship; Field projects **Related to Major @ during vacations cumulatively**	Related to DSC		**120 Hours cumulatively during vacations of Semester I and Semester II**						4*									P*
9	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC,Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**		**90 Hours Cumulatively From Sem I to Sem IV**															
	TOTAL									18 +4 =22						600			

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note : # On Job Training, Internship/ Apprenticeship; Field projects **Related to Major (During vacations of Semester I and Semester II) for duration of 120 hours mandatory to all the students, to be completed during vacations of Semester I and/or II. This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in Semester II credit grade report.**

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Sant Gadge Baba Amravati University, Amravati

FACULTY : Science and Technology

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (PHYSICS) following Three Years UG Programme wef 2023-24

(Two Years- Four Semesters Master's Degree Programme- NEPv23 with **Exit and Entry Option**

M.Sc. (Physics) Second Year Semester- III Level 6.5

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
												Maximum Marks					Minimum Passing		
				Teaching Period Per Week				Credits				Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	Contemporary Applied Technological Advancements in Research relevant/supportive to Major DSC- VII	Th-Major	**PHY 301**	3			3	3		3	3	30	70			100	12	28	P
2	DSC- VIII	Th-Major	**PHY 302**	3			3	3		3	3	30	70			100	12	28	P
3	**DSC-IX**	Th-Major	**PHY 303**	3			3	3		3	3	30	70			100	12	28	P
4	DSE-III /MOOC : **DSE III (i):** **DSE-III (ii):** **DSE-III (iii):**	Th-Major Elective	**PHY 304 (i/ii/iii/)**	3			3	3		3	3	30	70			100	12	28	P
																	Minimum Passing Marks		Grade
5	**Lab I: (DSC VII and DSC VIII)**	Pr-Major	**PHY 305**			6	6		3	3	4			50	50	100	25	25	P
6	**Lab II: (DSC IX and DSE)**	Pr-Major	**PHY 306**			6	6		3	3	4			50	50	100	25	25	P
7	**Research Project Phase-I**	**Major**			2	4	6	2	2	4		--		50	-	50	25		P
9	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**	**90 Hours Cumulatively From Sem I to Sem IV**																
	TOTAL									22						650			

L: Lecture, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note : # On Job Training, Internship/ Apprenticeship; Field projects **Related to Major (During vacations of Semester I and Semester II) for duration of 120 hours mandatory to all the students, to be completed during vacations of Semester**

I and/or II. This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in Semester II credit grade report.

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

FACULTY : Science and Technology

Scheme of Teaching, Learning, Examination & Evaluation leading to Two Years PG Degree Master of Science (PHYSICS) following Three Years UG Programme wef 2023-24

(Two Years- Four Semesters Master's Degree Programme- NEPv23 with Exit and Entry Option

M.Sc. (Physics) Second Year Semester- IV Level 6.5

S. N.	Subject	Type of Course	Subject Code	Teaching & Learning Scheme							Duration Of Exam Hours	Examination & Evaluation Scheme							
				Teaching Period Per Week				Credits				Maximum Marks					Minimum Passing		
												Theory		Practical		Total Marks			
				L	T	P	Total	L/T	Practical	Total		Theory Internal	Theory +MCQ External	Internal	External		Marks Internal	Marks External	Grade
1	Contemporary Applied Technological Advancements in Research relevant/supportive to Major DSC- X	Th-Major	**PHY 401**	3			3	3		3	3	30	70			100	12	28	P
2	DSC- XI	Th-Major	**PHY 402**	3			3	3		3	3	30	70			100	12	28	P
3	**DSC-XII**	Th-Major	**PHY 403**	3			3	3		3	3	30	70			100	12	28	P
4	DSE-IV /MOOC : **DSE IV (i):** **DSE-III (ii):** **DSE-IV (iii):**	Th-Major Elective	**PHY 404 (i/ii/iii/)**	3			3	3		3	3	30	70			100	12	28	P
																	Minimum Passing Marks		Grade
5	**Lab I: (DSC VII and DSC VIII)**	Pr-Major	**PHY 405**			6	6		3	3	4			50	50	100	25	25	P
6	**Lab II: (DSC IX and DSE)**	Pr-Major	**PHY 406**			6	6		3	3	4			50	50	100	25	25	P
7	**Research Project Phase-II**	**Major**			2	8	10	2	4	6	3	--		75	75	150	40	40	P
9	**Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts During Semester I, II, III and IV**	Generic **Optional**	**90 Hours Cumulatively From Sem I to Sem IV**																
	TOTAL									24						750			

L: Lecre, T: Tutorial, P: Practical/Practicum

Pre-requisite Course mandatory if applicable: **Prq**, Theory : **Th**, Practical/Practicum: **Pr**, Faculty Specific Core: **FSC**, Discipline Specific Core: **DSC**, Discipline Specific Elective: **DSE**, Laboratory: **Lab**, **OJT:** On Job Training: Internship/ Apprenticeship; Field projects: **FP**; **RM:** Research Methodology; Research Project: **RP, Co-curricular Courses: CC**

Note : # On Job Training, Internship/ Apprenticeship; Field projects **Related to Major (During vacations of Semester I and Semester II) for duration of 120 hours mandatory to all the students, to be completed during vacations of Semester I and/or II. This will carry 4 Credits for learning of 120 hours. Its credits and grades will be reflected in Semester II credit grade report.**

Note: **Co-curricular Courses:** In addition to the above, CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.). These can be completed cumulatively during **Semester I, II, III and IV. Its credits and grades will be reflected in semester IV credit grade report.**

Table: Comprehensive Credits distribution amongst the type of Courses over Two Years (Four Semesters) PG Programme and Minimum Credits to be earned for PG Degree [M.Sc. (Physics)]

Sr. No.	Type of Course		Total Credits Offered	Minimum Credits Required
1	**MAJOR**			
	i. DSC	**48**		**48**
	ii. DSE	**24**		**24**
		TOTAL	**72**	**72**
2	**Research Methodology and IPR (FSC/DSC: Major)**	**04**	**04**	**04**
2	On Job Training, Internship/ Apprenticeship; Field projects **Related to Major**	**04**	**04 for 120 Hours OJT/FP cum.**	**02 (Minimum 60 Hours OJT/FP is mandatory)**
3	**Research Project**	**10**	**10**	**10**
	OPTIONAL			
4	**Co-Curricular Courses (offline and/or online as applicable): Co-curricular Courses: Health and wellness, Yoga Education, Sports and Fitness, Cultural Activities, NSS/NCC, Fine/Applied/Visual/Performing Arts,** CC also include but not limited to Academic activities like paper presentations in conferences, Aavishkar, start-ups, Hackathon, Quiz competitions, Article published, Participation in Summer school/ Winter School / Short term course, Scientific Surveys, Societal Surveys, Field Visits, Study tours, Industrial Visits, online/offline Courses on Yoga (Yoga for IQ development, Yoga for Ego development, Yoga for Anger Management, Yoga for Eyesight Improvement, Yoga for Physical Stamina, Yoga for Stress Management, etc.).		**Limited to Maximum 03 only** **(For 90 Hours of CC cumulatively)**	**00**
	TOTAL			
	TOTAL		**93**	**88**

Table A: Comprehensive Credit Distribution for CC

S. N.	Activities (offline/online as applicable)	Credits at Levels						Letter Grade
		College	University	State	Zone if exist	National	International if exist	
1	Health and wellness, Yoga* Competitions *If a Course (online/offline) on Yoga is completed for 60 Hours, 2 credits will be awarded to the student (1 Credit = 30 Hours)	1	2	3	4	5	6	P (Pass)
2	Unnat Bharat Abhiyan [UBA]	1	2	3	4	5	6	P (Pass)
3	Sports and fitness activities (see separate **Table B**)	1	1 / 2	2 / 3	3 / 4	4 / 5	5 / 6	P (Pass)
4	Cultural activities, Fine/Applied/Visual/Performing Arts	1	2	3	4	5	6	P (Pass)
5	N.S.S. activities Camps	1	2	3	4	5	6	P (Pass)
6	Academic activities like Research Paper/Article/Poster presentations, Aavishkar, start-up, Hackathon, Quiz competitions, other curricular, co-curricular activities, students exchange programme etc. Research Paper/Article published	1 --	2 1	3 2	4 -	5 4	6 6	P (Pass) P (Pass)
7	Participation in Summer school/ Winter School / Short term course (not less than 30 hours 1 or 2 weeks duration) (not less than 60 hours 2 or 3 weeks duration) Scientific Surveys, Societal Surveys Field Visits, Study tours, Industrial Visits,	2 Credits 4 Credits 2 Credits 1 Credit						P (Pass) P (Pass) P (Pass) P (Pass)
8	NCC Activities	As given in **Table C**						

Table B: Credit Distribution for Sports and Fitness

Sr. No.	Particulars of Sports Status (Individual/ Team)	Credits	Letter Grade
1	College Level Participation	1	P (Pass)
2	University Level Participation	1	P (Pass)
3	University Level Rank 1, 2, 3	2	P (Pass)
4	State Level Participation	2	P (Pass)
5	State Level Rank 1, 2, 3	3	P (Pass)
6	Zonal Level Participation	3	P (Pass)
7	Zonal Level Rank 1, 2, 3	4	P (Pass)
8	National Level Participation	4	P (Pass)
9	National Level Rank 1, 2, 3	5	P (Pass)
10	International Level Participation	5	P (Pass)
11	International Level 1,2,3	6	P (Pass)

Table C: Credit Distribution for NCC activities

Sr. No.	Particulars of NCC Activities	Credits	Letter Grade
1	Participation in NCC activities	1	P (Pass)
2	'B' Certificate obtained	2	P (Pass)
3	'C' Certificate obtained	3	P (Pass)
4	State Level Participation	4	P (Pass)
5	National level Participation	5	P (Pass)
6	International Level Participation	6	P (Pass)

SANT GADGE BABA AMRAVATI UNIVERSITY AMRAVATI
Faculty of Science
Scheme for Teaching, Learning, Examination and Evaluation for M.Sc. Part-I (PHYSICS) Semester I

Subject	Teaching hours per week	Credits	Theory Exam		Practical Exam		Total	Minimum Passing	
			Internal	External	Internal	External		Internal	External
Faculty Specific Core	04	04	30	70			100	12	28
DSC - I	03	03	30	70			100	12	28
DSC - II	03	03	30	70			100	12	28
DSC - III	03	03	30	70			100	12	28
DSE - I (i/ii/iii)	03	03	30	70			100	12	28
LAB - I	06	03			50	50	100	25	
LAB - II	06	03			50	50	100	25	
Total	**28**	**22**					**700**		

1. **Faculty Specific Core: Research Methodology and Intellectual Property Rights**
2. **DSC-I: Mathematical Physics**
3. **DSC-II: Classical Mechanics**
4. **DSC-III: Quantum Mechanics**
5. **DSE-I (i): Computational Methods and C Programming**
   DSE-I (ii): Computational Methods and Scilab Programming
   DSE-I (ii): Computational Methods and Python Programming
6. **Lab I: General Physics Experiments**
7. **Lab II: Programming based Experiments (Computer Lab)**

Research Methodology and Intellectual Property Rights

Theory: 4 hours per week (4 Credits) **External Marks: 70**
Internal Marks: 30

COURSE OBJECTIVES:
The course should enable the students to:

1. Identify an appropriate research problem in their interesting domain.
2. Understand the review and planning of research.
3. Get knowledge of data collection and preparation of a research report.
4. Know about the intellectual property rights (IPR).
5. Understand the adequate knowledge on patent rights.

COURSE OUTCOMES [COS]
Upon completion of the course successfully, students would be able to

1. Understand the steps in research and pure and applied research.
2. Formulation of selected problem and understand the research design.
3. Test the research hypothesis, understand the data collection and prepare the scientific research paper.
4. Understand Characterization techniques in Physics
5. Explore on various IPR components and patent writing.
6. Understand the adequate knowledge on patent and rights

COURSE CONTENTS: Research Methodology and Intellectual Property Rights

Unit I	**Foundation of research** Meaning of research, objective of research, types of research, scientific method, pure and applied research, experimental research, steps in research.	**12**
Unit II	**Review and planning of research** Review of literature, sources of literature review work, planning, selection of problem, formulation of selected problem, hypothesis, Research Design.	**12**
Unit III	**Data collection and paper writing** Meaning and importance of data, type of data and tools for data collection, layout of a Research Paper, referencing and footnotes, Journals in Physics, Impact factor of journals, Plagiarism and Self-Plagiarism.	**12**
Unit IV	**Analytical Techniques** Block diagram, working principle and applications: UV-Visible, FT-IR, Scanning electron microscope, Transmission electron microscope, AFM, PL Spectrometer, Powder XRD, Dielectric measurement (solid/liquid), Thermal Analyzer (DSC & DTA), Ultrasonic interferometer.	**12**
Unit V	**Intellectual property rights (IPR)** Patents, Designs, Trademark, Copyright, technological research, innovation, techniques of writing a patent.	**12**
Unit VI	**Patent rights and new developments in IPR** Licensing and transfer of technology, royalty, geographical indications, rights of patentee, new developments in IPR.	**12**

REFERENCE BOOKS

1. Research Methodology a step-by-step guide for beginners. Ranjit Kumar, SAGE Publications, 3rd Edition, 2011
2. Guide to Publishing a Scientific paper, Ann M. Korner, Bioscript Press 2004.

3. Intellectual Property Rights Under WTO, T. Ramappa,S. Chand, 2008
4. Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013.
5. Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International, 4th edition, 2018.
6. Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005.
7. Conducting Research Literature Reviews: From the Internetto Paper, FinkA, Sage Publications, 2009.
8. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard, Juta & Company, 1996.
9. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell and Mark A. Lemley, Aspen Publishers, 2016.
10. Resisting Intellectual Property, Halbert,Taylor & Francis Ltd, 2007.
11. Industrial Design, Mayall, McGraw Hill, 1992.
12. Product Design, Niebel , McGraw Hill, 1974.
13. Introduction to Design, Asimov, Prentice Hall, 1962.

WEB RESOURCES:

1. https://onlinecourses.nptel.ac.in/noc22_ge08/preview
2. https://www.youtube.com/watch?v=_Mb_cNqfsdc
3. https://www.youtube.com/watch?v=hHHPGLqz6zo

DSC-I: Mathematical Physics

Theory: 3 hours per week (3 Credits) **External Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]
Upon completion of the course successfully, students would be able to

1. Explain vector spaces and transformations, the algebra of matrix, partitioning of matrices; solve the eigen value problems.
2. Analyze limits and continuity for complex functions as well as consequences of continuity; apply the concept and consequences of analyticity and the Cauchy-Riemann equations;
3. Obtain the solution of second-order differential equation and apply the properties of Legendre Polynomial to solve boundary value problems.
4. Apply the knowledge of Bessel and Hermite functions for the solution of differential equation and related problems in physical sciences.
5. Solve transfer functions in Instrumentation using Laplace transforms.
6. Apply Fourier transforms to transform the signal into different domains.

COURSE CONTENTS: DSC-I: Mathematical Physics

Unit I	Vector spaces and transformations, the algebra of matrix, partitioning of matrices. The eigen value problem. Functions of a Matrix, Kronecker sum and product of matrices.	**7**
Unit II	Complex variables and their representation, functions of a Complex variable, Analyticity, Harmonic functions, Cauchy's integral theorem and integral formula, Residue theorem.	**8**
Unit III	Second order linear differential equation with variable coefficients, Series solution, The Legendre equation, Legendre function of the second kind, Generating function, Rodrigue's formula, Orthogonality of generating functions, Recurrence relations.	**8**
Unit IV	Bessel's function of the third kind (Hankel function), Generating function, Recurrence relations, Orthogonality of Bessel's function, Hermite function, Hermite polynomials, Generating function, Recurrence relations, Rodrigue's formula, Orthogonality of Hermite Polynomials.	**8**
Unit V	Laplace Transforms - Properties of Laplace transform, differential equation method of finding Laplace transform, Inverse Laplace transform.	**7**
Unit VI	Fourier Transforms – Fourier Series, properties of Fourier Series, Fourier integral, Fourier transform of derivatives, Applications of Fourier transform.	**7**

REFERENCE BOOKS:

1. Mathematical Physics (17th Edition), B.S.Rajput, Pragati Prakashan, Meerut.
2. Mathematical Physics, H.K. Das, S.Chand Publications
3. Mathematical Physics, Satya Prakash, S.Chand & Sons.
4. Mathematical Physics, Kalani and Hemrajani, Himalaya Publishing House.
5. Mathematical Physics, (2nd Rev.Edition), B.D.Gupta, Vikas Publishing House, New Delhi.
6. Mathematical Physics, P.K.Chottopadhyay, New Age International (P.) Ltd.
7. Mathematical Physics Vol. 1 & 2, Joglekar University Press.
8. Introduction to Mathematical Physics, Charlie Harper, Prentice Hall India Pvt.Ltd.
9. Mathematical Methods for Physics George Arfken Wiley Eastern
10. Matrices and Tensors in Physics (2nd Edition), A.W.Joshi, Wiley Eastern Limited.
11. Laplace Transform Seymour, Lipschutz, Schaum Outline Series
12. Fourier Series Seymour, Lipschutz, Schaum Outline Series
13. Introduction to Complex Analysis in Several Variables, 2005, Volker Scheidemann
14. Advanced Engineering Mathematics, (10^{th} Edition), Erwin Kreyszig

Equivalent MOOC on SWAYAM:

1. https://nptel.ac.in/courses/115103036

2. https://www.edx.org/course/mathematical-and-computational-methods
3. https://www.coursera.org/specializations/mathematics-engineers
4. https://www.coursera.org/learn/complex-analysis
5. https://www.coursera.org/learn/introduction-to-calculus

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=TgnaYFlnnCk
2. https://www.youtube.com/watch?v=LYNOGk3ZjFM
3. https://www.youtube.com/watch?v=I3GWzXRectE
4. https://www.youtube.com/watch?v=pQhVDRojC1U
5. https://www.youtube.com/watch?v=GtP6CUEHDhY

***

DSC-II: Classical Mechanics

Theory: 3 hours per week (3 Credits) **External Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]
After successfully completing the course, student will be able to:

1. Define and understand basic mechanical concepts related to advanced problems involving the dynamic motion of classical mechanical systems and describe and understand the motion of the forces in non-inertial systems.
2. Describe and understand the motion of a mechanical system using Lagrange's formalism.
3. Describe and understand the motion of a mechanical system using Hamilton's formalism.
4. State the concept of two body central force problem, reduction to the equivalent one body problem, equation of motion and first integral, Virial theorem.
5. Able to explain the Canonical Transformations, figure out the Small oscillations, principal axis transformation, normal coordinates and its applications to linear molecules.

COURSE CONTENTS: DSC-II: Classical Mechanics

Unit I	Newtonian mechanics for system of particles, Limitations of Newtonian mechanics, Conservation laws: Linear momentum, Angular momentum, Total energy, Work-Energy theorem, Principle of virtual work and applications, D'Alembert's principle and applications.	**8**
Unit II	Constraints and their types. Generalized coordinates, Lagrange's equations of motion, including velocity dependent potentials. Properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation. Concept of symmetry, invariance under Galilean transformation. Gauge function for Lagrangian and its gauge invariance.	**8**
Unit III	Hamilton's equation of motion, Principle of least action, derivation of equation of motion, variation and end points, Hamilton's principle and characteristic functions, Lagrange equations from Hamilton's Principle, Hamilton - Jacobi equations - Linear Harmonic Oscillator problem by Hamilton - Jacobi method. Legendre's dual transformation.	**8**
Unit IV	Central force: definition, properties, Two-body central force problem, closure and stability of circular orbits, general analysis of orbits, Differential equations of orbits, Kepler's laws with proof, Classification of orbits, Differential equation of orbit, Virial theorem and its applications for Temperature of the interior of a star.	**7**
Unit V	Canonical transformation, generating functions, properties, group properties, examples, Lagrange and Poisson bracket, significance and applications, Infinitesimal contact transformation - Constants of motion and symmetry properties. Transition from discrete to continuous system.	**7**
Unit VI	Oscillatory motion-Theory of small oscillation -Linear Triatomic Molecule Stability of Oscillatory motion - Forced Harmonic Oscillator, non- linear oscillation in a symmetric potential. Rotating frames of reference, inertial forces in rotating frames, Larmour precession, effects of Carioles force, Foucault's pendulum.	**7**

REFERENCE BOOKS:

1. Classical Mechanics by NC Rana & PS Joag (TMH edition)
2. Classical Mechanics by H Goldstein (Addison Wesley)
3. Classical Mechanics by JC Upadhyaya (Himalaya Publishing House)
4. Classical Mechanics by Waghmare (West Wiley)
5. Classical Mechanics by G. Aruldas (PHI Learning Private Limited of EEE)
6. Classical Mechanics by Gupta, Kumar, Sharma (Pragati Prakashan)

7. Classical Mechanics by R. Mandal (Narosa Publishing House)
8. Mathematical Physics by BS Rajput (Pragati Prakashan)
9. Mathematical Physics by HK Das (S. Chand and publications)
10. Mathematical Physics by Kakani and Hemrajani (Sultan Chand and Co. Publications)
11. The Virial Theorem and its applications in the teaching of Modern Physics, Celso L. Ladera, et.al, Lat. Am. J. Phys. Educ. Vol. 4, No. 2, May 2010

Weblink to Equivalent MOOC on SWAYAM:

1. 1. https://bsc.hcverma.in/course/cm1
2. 2. https://ocw.mit.edu/courses/8-09-classical-mechanics-iii-fall-2014/
3. 3. https://nptel.ac.in/courses/115106123
4. 4. https://ocw.mit.edu/courses/8-01sc-classical-mechanics-fall-2016/

Any pertinent media (recorded lectures, YouTube, etc.):

1. https://www.youtube.com/watch?v=83QCm3LkuEg
2. https://www.youtube.com/watch?v=582_V290ozM
3. https://www.youtube.com/watch?v=lQIbcV6dQzw

DSC III- Quantum Mechanics I

Theory: 3 hours per week (3 Credits) **External Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]

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

1. discuss and explain the key concepts and principles of quantum physics
2. use quantum mechanical axioms and the matrix representation in quantum mechanics
3. Solve the Schrödinger equation for standard systems with both analytical and numerical methods, and then interpret the results.
4. describe orbital angular momentum operators and their eigen values.
5. describe angular momentum addition rules and CG coefficients.
6. use approximate methods for solving the Schrödinger equation.

COURSE CONTENTS: DSC-III: Quantum Mechanics I

Unit I	Wave nature of particle, wave packet, wave function for free particle, Physical interpretation of wave function, continuity equation, momentum and Hamiltonian operators, Schrodinger Time Dependent and Time Independent wave equations, Application for 1D infinite, finite square well and tunnelling through square potential barrier.	**8**
Unit II	Linear Vector Space, Hilbert Space, Dirac's Bra-Ket notations, Commutating operators, Expectation value, Hermitian operator. Matrix representation of state vector and operator, Schrodinger equation in matrix form, Change of representation and unitary transformations, Coordinate and momentum representations.	**8**
Unit III	1D Linear Harmonic Oscillator (Operator method); 1D Linear Harmonic Oscillator; Particle in 3D rectangular box. H-atom: radial wave equation, angular wave equation, energy states, spherical harmonics, spatial nature of electronic orbitals, quantum numbers (n, l, m_l).	**8**
Unit IV	Orbital angular momentum operators (L_z, L^2, L_+, L_-) in spherical polar coordinates, Commutation relations for general angular momentum, Eigen values of angular momentum operators, Matrix representations of J_z, J^2, J_x, J_y, J_+ and J_-.	**7**
Unit V	Spin angular momentum, Pauli Spin Matrices, Addition of two angular momenta, Clebsch - Gordan coefficients. Equation of Motion in Schrodinger and Heisenberg pictures.	**7**
Unit VI	Variational method and applications to helium atom and simple cases; WKB approximation: General formalism, validity, application to bound states for potential wells and tunnelling through barrier.	**7**

REFERENCE BOOKS:

1. Concept of Modern Physics 6th Ed. (Tata Mcgraw Hill): Aurthur Beiser
2. Quantum Mechanics Concept and Applications 2nd Ed. (Wiley): Nouredine Zettili
3. Introductory Quantum Mechanics 4th Ed. (Pearson Edu.): Richard Libboff
4. Quantum Mechanics 2nd Ed. (PHI): Arul Das
5. Quantum Mechanics Theory and Applications 5th Ed. (Macmillan India): Ajoy Ghatak and S. Lokanathan
6. Quantum Mechanics (PHI): B.K. Agrawal and Hari Prakash
7. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
8. Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education
9. Quantum Mechanics, Walter Greiner, 4thEdn., 2001, Springer.

Weblink to Equivalent MOOC on SWAYAM:

1. https://hcverma.in/QuantumMechanics
2. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-1
3. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-2
4. https://archive.nptel.ac.in/courses/115/101/115101107/

Any pertinent media (recorded lectures, YouTube, etc.):

5. https://www.youtube.com/watch?v=hyctIDPRSqY
6. https://www.youtube.com/watch?v=xnt2xSNRNn0
7. https://www.youtube.com/watch?v=K4BF7MD69_U

DSE-I (i): Computational Methods and C Programming

Theory: 3 hours per week (3 Credits) **External Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]
After successfully completing the course, student will be able to:

1. understand digital world of computer where fast calculation is the key to success, those computational methods are of great practical importance. The syllabus gives the best available methods with numerical and practical examples.
2. apply the methods of differentiation, integration to solve initial value problems and integral equation.
3. understand the important principles, methods and processes used for calculating results to the desired degree of accuracy.
4. develop and execute C to solve computational problrms.
5. develop flowchart a powerful aid for programming to find solutions of difficult problems.
6. understand critical features such as pointers that are central to C programming.

COURSE CONTENTS: DSE-I (i): Computational Methods and C Programming

Unit I	Methods for determination of zeroes of linear and nonlinear algebraic and transcendental equations: Secant Method, False Position, Newton-Raphson Method; Convergence of solutions; Solution of simultaneous linear equations, Gauss Elimination, pivoting, iterative method.	**8**
Unit II	Introduction to interpolation, Lagrange approximation, Newton polynomials, Curve fitting by least squares, Polynomial least squares and cubic splines fitting.	**8**
Unit III	Numerical differentiation, Quadrature, Simpson's rule, Gauss's quadrature formula, Newton – Cotes formula. Differential Equations**:** Euler's method, Runge Kutta methods, Finite difference method, Finite difference equations for partial differential equations and their solution.	**8**
Unit IV	Basic concepts of problem solving on computer, Flowcharts and algorithm development.. Keywords, Characters set, Data types, variables, expressions, operators and their hierarchy. I/O using scanf() and printf() functions, Variable Storage classes.	**7**
Unit V	Strings, Operations on Strings, Decision making using if, if else and switch case statements. Loops using for, while and do while loops, break and continue and go-to statements. Arrays- Defining and processing, Passing arrays to function.	**7**
Unit VI	Functions- Defining and accessing, Passing arguments. Function prototype, Concept of Pointer, Accessing address of Pointer, Declaration and Initialization of Pointer variable. Accessing a Variable through its Pointer, Recursion.	**7**

REFERENCE BOOKS:

1. Introductory Methods of Numerical Analysis Sastry Eastern Economy Edition Prentice Hall India
2. A first course in computational Physics , Paul L Devries & Javier Husbun (Jones & Barlett Pub.)
3. Numerical methods by Bhupendra Singh Pragati prakashan Meerut
4. C Programming by E. Balguruswamy Tata Mc Graw Hill

5. Complete reference with C Tata Mc Graw Hill.
6. Let Us 'C' by Kanetkar.
7. K. R. Venugopal and S R Prasad "MASTER IN C" Tata Mc Graw Hill
8. Shaums outline of Theory and practical of programming with C Gottfried
9. Computer oriented Numerical methods by Raja Raman

Weblink to Equivalent MOOC on SWAYAM:

1. https://nptel.ac.in/courses/106104128
2. https://nptel.ac.in/courses/106105171
3. https://www.coursera.org/specializations/c-programming
4. https://www.coursera.org/learn/c-programming-getting-started
5. https://nptel.ac.in/courses/115106118
6. https://nptel.ac.in/courses/111107105

Any pertinent media (recorded lectures, YouTube, etc.):

1. https://www.youtube.com/watch?v=We6zrqc9e18
2. https://www.youtube.com/watch?v=mzQFGOvH-mk
3. https://www.tutorialspoint.com/cprogramming/index.htm
4. https://www.youtube.com/watch?v=iT_553vTyzI
5. https://www.vitalsource.com/products/c-programming-absolute-beginner-39-s-guide-greg-perry-v9780133414240

DSE-I (ii): Computational Methods and Scilab Programming

Theory: 3 hours per week (3 Credits) **External Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]

On the successful completion of the course, student will be able to

1. apply the knowledge gained in computational and numerical methods to solve problems in physics.
2. analyse computationally the given problems in physics by various theoretical models.
3. evaluate the complex problems in physics based on specific theories, procedures and tools and evaluate the complex problems in physics based on specific theories, procedures and tools.
4. familiarize students with the Scilab environment and its features, develop programming skills in Scilab for scientific computations.
5. enable students to analyze and visualize data using Scilab, apply Scilab to solve physics problems and perform numerical simulations and enhance problem-solving abilities through coding and data analysis.

COURSE CONTENTS: DSE-I (ii): Computational Methods and Scilab Programming

Unit I	Methods for determination of zeroes of linear and nonlinear algebraic and transcendental equations: Secant Method, False Position, Newton-Raphson Method; Convergence of solutions; Solution of simultaneous linear equations, Gauss Elimination, pivoting, iterative method.	**8**
Unit II	Introduction to interpolation, Lagrange approximation, Newton polynomials, Curve fitting by least squares, Polynomial least squares and cubic splines fitting.	**8**
Unit III	Numerical differentiation, Quadrature, Simpson's rule, Gauss's quadrature formula, Newton – Cotes formula. Differential Equations**:** Euler's method, Runge Kutta methods, Finite difference method, Finite difference equations for partial differential equations and their solution.	**8**
Unit IV	Scilab features and applications in physics, Installation and setup, Scilab environment: Console, editor, and help resources, Basic commands and syntax, Variables and data types in Scilab, Mathematical functions in Scilab, Numeric operations: arithmetic, logical, and relational, Trigonometric and exponential functions, Complex numbers and complex arithmetic, Numeric, string, and logical data types, Variable assignment and operations, Conditional statements: if, else, and switch, Looping: for, while, and do-while loops, Loop control statements: break and continue Indexing and slicing arrays.	**7**
Unit V	Defining and using functions in Scilab, Input and output arguments, Creating scripts for repeated tasks, Writing modular and reusable code, Arrays and Matrices in Scilab: Creating and manipulating arrays and matrices, Vectorized operations, Matrix operations: addition, subtraction, multiplication, and inversion, Solving linear systems of equations.	**7**
Unit VI	Getting eigen values and eigen functions of matrix in Scilab, polynomials, Plotting 2D and 3D graphs, Computing 1D and 2D definite integrals, Solving first and second order differential equations, Curve fitting, Introduction to Xcos and its use for modelling electrical/ electronic circuits.	**7**

REFERENCE BOOKS:

1. Introductory Methods of Numerical Analysis, Sastry Eastern Economy Edition Prentice Hall India
2. A first course in computational Physics , Paul L Devries & Javier Husbun (Jones & Barlett Pub.)
3. Numerical methods by Bhupendra Singh Pragati prakashan Meerut.
4. Computational Methods in Physics and Engineering: Wong.
5. Computer Oriented Numerical Methods: Rajaraman.
6. Applied Numerical Analysis: Gerald.
7. Numerical Recipes: Teukolsky, Vetterling and Flannery
8. Introduction to Scilab, Student Edition, Rachna Verma, Arvind Kumar Verma.
9. Programming in Scilab, Rajan Goyal, Mansi Dhingra
10. SCILAB: A Begineer's Approach 2018, by Anil Kumar Verma
11. Scilab for very beginners, Scilab Enterprises S.A.S - 143 bis rue Yves Le Coz - 78000 Versailles (France) - www.scilab-enterprises.com
12. Xcos for very beginners, Scilab Enterprises S.A.S - 143 bis rue Yves Le Coz - 78000 Versailles (France) - www.scilab-enterprises.com
13. Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB:
14. Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V.Fern- ndez. 2014 Springer
15. Scilab by example: M. Affouf 2012, ISBN: 978-1479203444Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair .2011S. Chand and Company.
16. Scilab Image Processing: Lambert M. Surhone. 2010 Beta script Publishing.

Weblink to Equivalent MOOC on SWAYAM:

1. https://sites.google.com/view/pankajnagpure/online-courses/physics-with-scilab/video-lectures-lecture-notes?authuser=0
2. https://users.physics.unc.edu/~sheila/scilabtutorial.html
3. https://eduvigyan.com/category/advanced-physics/computational-physics/scilab/
4. https://spoken-tutorial.org/tutorial-search/?search_foss=Scilab&search_language=English
5. https://www.cse.iitb.ac.in/~cs626-449/scilab.pdf
6. https://archive.nptel.ac.in/courses/104/101/104101095/

Any pertinent media (recorded lectures, YouTube, etc.):

1. https://www.youtube.com/watch?v=JRQRJzN0-4I
2. https://www.youtube.com/watch?v=vQX9kLbFTDM
3. https://www.youtube.com/watch?v=AzElVPaS71U
4. https://www.youtube.com/watch?v=bHVOPECO8-o&t=608s
5. https://www.youtube.com/watch?v=czoZA3raJik
6. https://www.youtube.com/watch?v=UkZmROLRzRA
7. https://www.youtube.com/watch?v=-tKzTmBKszw&t=206s
8. https://www.youtube.com/watch?v=ZEa2xOXwrJs&t=100s

DSE-I (iii): Computational Methods and Python Programming

Theory: 3 hours per week (3 Credits)

External Marks: 70
Internal Marks: 30

COURSE OUTCOMES [COS]

On the successful completion of the course, student will be able to

1. apply the knowledge gained in computational and numerical methods to solve problems in physics.
2. analyse computationally the given problems in physics by various theoretical models.
3. evaluate the complex problems in physics based on specific theories, procedures and tools and evaluate the complex problems in physics based on specific theories, procedures and tools.
4. familiarize students with the Python environment and its features, develop programming skills in Python for scientific computations.
5. enable students to analyze and visualize data using Python, apply Python to solve physics problems and perform numerical simulations and enhance problem-solving abilities through coding and data analysis.

COURSE CONTENTS: DSE-I (iii): Computational Methods and Python Programming

Unit I	Methods for determination of zeroes of linear and nonlinear algebraic and transcendental equations: Secant Method, False Position, Newton-Raphson Method; Convergence of solutions; Solution of simultaneous linear equations, Gauss Elimination, pivoting, iterative method.	**8**
Unit II	Introduction to interpolation, Lagrange approximation, Newton polynomials, Curve fitting by least squares, Polynomial least squares and cubic splines fitting.	**8**
Unit III	Numerical differentiation, Quadrature, Simpson's rule, Gauss's quadrature formula, Newton – Cotes formula. Differential Equations**:** Euler's method, Runge Kutta methods, Finite difference method, Finite difference equations for partial differential equations and their solution.	**8**
Unit IV	Installing Python, Launch Python, Python modules, Python expression, objects and their methods, Lists, Tuples, Strings, Loops, Development Tools.	**7**
Unit V	SciPy and NumPy, arrays, array operations, scripts, contingent behaviour, nesting - importing data, exporting data, visualizing data, functions, random numbers and simulation, histograms and bar graphs, contour plots and surfaces, matrix library, Interpolation.	**7**
Unit VI	Fourier Transform - Sparse eigenvalue problem, Solving ordinary differential equations (ODEs) with numerical methods, Euler's method, Runge-Kutta methods Symbolic Computing with SymPy: Symbolic variables and expressions Symbolic simplification and manipulation, Symbolic differentiation and integration.	**7**

REFERENCE BOOKS:

1. Introductory Methods of Numerical Analysis, Sastry Eastern Economy Edition Prentice Hall India
2. A first course in computational Physics , Paul L Devries & Javier Husbun (Jones & Barlett Pub.)

3. Numerical methods by Bhupendra Singh Pragati prakashan Meerut.
4. Computational Methods in Physics and Engineering: Wong.
5. Computer Oriented Numerical Methods: Rajaraman.
6. Applied Numerical Analysis: Gerald.
7. Numerical Recipes: Teukolsky, Vetterling and Flannery
8. Jesse M Knder, Philip Nelson, "Python for Physical modelling", Princeton University Press Princeton and Oxford, 2015.
9. https://docs.python.org/3/library/tk.html

Weblink to Equivalent MOOC on SWAYAM:

1. https://onlinecourses.nptel.ac.in/noc23_ph46/preview
2. https://nptel.ac.in/courses/106106145
3. https://nptel.ac.in/courses/106106182
4. https://onlinecourses.nptel.ac.in/noc23_ph46/preview

Any pertinent media (recorded lectures, YouTube, etc.):

1. https://www.simplilearn.com/tutorials/python-tutorial/python-installation-on-windows
2. https://www.youtube.com/watch?v=Pi0RK7GJIKg
3. https://www.youtube.com/watch?v=tLsi2DeUsak
4. https://www.youtube.com/watch?v=YrNpkuVIFdg
5. https://www.youtube.com/watch?v=EXDYcc373fQ
6. https://www.youtube.com/watch?v=-Lx4M_s--Cw
7.

Lab I: General Physics Experiments

Practical: 6 hours per week (3 Credits) **External Marks: 50**
Internal Marks: 50

1. To determine the acceleration due to gravity using an Atwood's machine.
2. To analyze elliptically polarized light by means of Babinet's Compensator.
3. Determination of wavelength of sodium light and the difference between the wavelengths of sodium D-lines, using Michelson's Interferometer.
4. Determination of wavelength of sodium light and the difference between the wavelengths of sodium D-lines, using Febry Perot Interferometer.
5. Determination of Planck's constant using photoelectric cell.
6. Determination of Rydberg's constant.
7. Measurement of wavelength of Sodium Light and refractive index of given liquid using Newton's Rings Method.
8. Determination of Planck's constant by measuring radiation in fixed spectral range.
9. Verification Stefan–Boltzmann law for the tungsten filament of a light bulb.
10. Determination of Stefan's Constant Using Black Body Radiation.
11. To study spectral characteristics of a Solar cell.
12. Chi-square test for goodness of fit.
13. Determination half life time in radioactive decay analogue experiment using dice.
14. To determine the wavelengths of prominent lines of mercury by plane diffraction grating.
15. Study of Fourier series for Square and Triangular waveforms and verification of Fourier theorem using sharp filter.

Lab II: Programming based Experiments (Computer Lab)

Practical: 6 hours per week (3 Credits) **External Marks: 50**
Internal Marks: 50

(i) C – Programming (perform atleast 10 experiments from the given list)

1. Develop and execute a program to obtain addition of matrices.
2. Develop and execute a program to obtain subtraction of matrices.
3. Develop and execute a program to obtain multiplication of matrices.
4. Develop and execute a program to obtain inverse of matrix.
5. Develop execute a program to obtain roots of polynomial by Newton Raphson method
6. Develop and execute a program to fit a straight line to experimental data.
7. Develop and execute a program to obtain value of an equation using subroutine.
8. Develop and execute program to obtain solution differential equation by Euler's Method.
9. Develop and execute program to obtain solution differential equation by Runge - Kutta Method.
10. Develop and execute a program to obtain roots of polynomial by Bisection Method.
11. Develop and execute a program to evaluate the Fourier coefficients of a given periodic function.
12. Develop and execute a program to solve the equations of motion for the position and velocity of a simple harmonic oscillator using the Lagrangian and Hamiltonian approaches.
13. Develop and execute a program to solve the equations of motion for a simple pendulum using the Lagrangian and Hamiltonian approaches.
14. Develop and execute a program to solve the equations of motion for a double pendulum using the Lagrangian and Hamiltonian approaches.
15. Develop and execute a program to find the energy eigen values and to plot the corresponding eigen functions for a particle in infinite square well potential.
16. Develop and execute a program to find the energy eigen values and to plot the corresponding eigen functions for 1D linear harmonic oscillator.
17. Develop and execute a program to find the energy eigen values and to plot the corresponding radial wave functions for H-atom.
18. Solve the s-wave radial Schrodinger equation for an atom for the screened coulomb and execute a program to find the Laplace transform of a given function.
19. Write and execute a program to generate the derivative of Bessel function as sum of finite number of terms of the series expansion.
20. Any other programs to solve the problems based on the theory in DSC –I/ DSC –II/ DSC –III and DSE –I .

(ii) Scilab – Programming (perform atleast 10 experiments from the given list)

1. Develop and execute a program to obtain addition of matrices.
2. Develop and execute a program to obtain subtraction of matrices.
3. Develop and execute a program to obtain multiplication of matrices.
4. Develop and execute a program to obtain inverse of matrix.
5. Develop execute a program to obtain roots of polynomial by Newton Raphson method
6. Develop and execute a program to fit a straight line to experimental data.
7. Develop and execute a program to obtain value of an equation using subroutine.
8. Develop and execute program to obtain solution differential equation by Euler's Method.
9. Develop and execute program to obtain solution differential equation by Runge - Kutta Method.
10. Develop and execute a program to obtain roots of polynomial by Bisection Method.
11. Develop and execute a program to evaluate the Fourier coefficients of a given periodic function.
12. Develop and execute a program to solve the equations of motion for the position and velocity of a simple harmonic oscillator using the Lagrangian and Hamiltonian approaches.
13. Develop and execute a program to solve the equations of motion for a simple pendulum using the Lagrangian and Hamiltonian approaches.
14. Develop and execute a program to solve the equations of motion for a double pendulum using the Lagrangian and Hamiltonian approaches.
15. Develop and execute a program to find the energy eigen values and to plot the corresponding eigen functions for a particle in infinite square well potential.
16. Develop and execute a program to find the energy eigen values and to plot the corresponding eigen functions for 1D linear harmonic oscillator.
17. Develop and execute a program to find the energy eigen values and to plot the corresponding radial wave functions for H-atom.
18. Solve the s-wave radial Schrodinger equation for an atom for the screened coulomb and execute a program to find the Laplace transform of a given function.
19. Write and execute a program to generate the derivative of Bessel function as sum of finite number of terms of the series expansion.
20. Write and execute a program to evaluate & plot Bessel function in scilab.
21. Write and execute a program to evaluate & plot Legendre Polynomial in scilab.
22. Write and execute a program to linearly fit the given set of data by least square fitting.
23. Write and execute a program to exponentially fit the given set of data by least square fitting.
24. Modelling for Electrical/Electronic Circuits using Xcos.
25. Modelling of Spring Mass Damper System using Xcos.
26. Any other programs to solve the problems based on the theory in DSC –I/ DSC –II/ DSC –III and DSE –I.

(iii) Python – Programming (perform atleast 10 experiments from the given list)

1. Develop and execute a program to obtain addition of matrices.
2. Develop and execute a program to obtain subtraction of matrices.
3. Develop and execute a program to obtain multiplication of matrices.
4. Develop and execute a program to obtain inverse of matrix.
5. Develop execute a program to obtain roots of polynomial by Newton Raphson method
6. Develop and execute a program to fit a straight line to experimental data.
7. Develop and execute a program to obtain value of an equation using subroutine.
8. Develop and execute program to obtain solution differential equation by Euler's Method.
9. Develop and execute program to obtain solution differential equation by Runge - Kutta Method.
10. Develop and execute a program to obtain roots of polynomial by Bisection Method.
11. Develop and execute a program to evaluate the Fourier coefficients of a given periodic function.
12. Develop and execute a program to solve the equations of motion for the position and velocity of a simple harmonic oscillator using the Lagrangian and Hamiltonian approaches.
13. Develop and execute a program to solve the equations of motion for a simple pendulum using the Lagrangian and Hamiltonian approaches.
14. Develop and execute a program to solve the equations of motion for a double pendulum using the Lagrangian and Hamiltonian approaches.
15. Develop and execute a program to find the energy eigen values and to plot the corresponding eigen functions for a particle in infinite square well potential.
16. Develop and execute a program to find the energy eigen values and to plot the corresponding eigen functions for 1D linear harmonic oscillator.
17. Develop and execute a program to find the energy eigen values and to plot the corresponding radial wave functions for H-atom.
18. Develop and execute a program to solve the s-wave radial Schrodinger equation for an atom for the screened coulomb and execute a program to find the Laplace transform of a given function.
19. Write and execute a program to generate the derivative of Bessel function as sum of finite number of terms of the series expansion.
20. Write and execute a program to evaluate & plot Bessel function in Python.
21. Write and execute a program to evaluate & plot Legendre Polynomial in Python.
22. Write and execute a program to linearly fit the given set of data by least square fitting.
23. Write and execute a program to exponentially fit the given set of data by least square fitting.
24. Any other programs to solve the problems based on the theory in DSC –I/ DSC –II/ DSC –III and DSE –I.

SANT GADGE BABA AMRAVATI UNIVERSITY AMRAVATI
Faculty of Science
Scheme for Teaching, Learning, Examination and Evaluation for M.Sc. Part-I (PHYSICS) Semester II

Subject	Teaching hours per week	Credits	Theory Exam		Practical Exam		Total	Minimum Passing	
			Internal	External	Internal	External		Internal	External
DSC - IV	03	03	30	70			100	12	28
DSC - V	03	03	30	70			100	12	28
DSC - VI	03	03	30	70			100	12	28
DSE - II (i/ii/iii)	03	03	30	70			100	12	28
LAB - III	06	03			50	50	100	25	
LAB - IV	06	03			50	50	100	25	
OJT/FP/Internship/Apprt.		04							
Total	**28**	**22**					**700**		

1. **DSC-IV: Quantum Mechanics II**
2. **DSC-V: Electromagnetic Theory**
3. **DSC-VI: Atomic and Molecular Physics**
4. **DSE-II (i): Lasers and Laser Applications**

   DSE-II (ii): Spectroscopic Techniques

   DSE-II (iii): Network Theorems and Solid State Devices
5. **Lab III**
6. **Lab IV**
7. **On Job Training, Internship/Apprenticeship; Field projects**

DSC IV- Quantum Mechanics II

Theory: 3 hours per week (3 Credits)

Theory Marks: 70
Internal Marks: 30

COURSE OUTCOMES [COS]:

Upon completion of the course, students will:

1. be able to derive and apply time-independent perturbation theory to solve simple problems for which no analytic solutions exist
2. be able to derive and apply the results of time-dependent perturbation theory up to first order and to derive and apply Fermi's golden rule, and explain the relevance of selection rules for atomic transitions and opto-electronic phenomena in solids.
3. understand background allowed and forbidden transitions.
4. learn the quantum mechanics of scattering and its role to understand matter at subatomic level.
5. learn the quantum mechanics of identical particle systems.
6. learn the advanced concepts of relativistic quantum mechanics involving the Klein Gordon and the Dirac equations.

COURSE CONTENTS: DSC IV- Quantum Mechanics II

Unit I	Time-independent perturbation theory for non-degenerate and degenerate states. Applications: Anharmonic oscillator, Helium atom, Zeeman effect (with and without spin consideration), Stark effect in hydrogen atom and other simple cases.	**8**
Unit II	Time Dependant Perturbation Theory: Transition Probability, Constant and Harmonic Perturbation, Fermi Golden Rule, Concept of Adiabatic and Sudden Approximation, Interaction of atoms with electromagnetic radiation, Transition rates for Absorption and Emission of radiation.	**7**
Unit III	Electric Dipole Approximation and Selection rules, Quantum description of spontaneous emission. Quantum theory of scattering: Scattering Cross Section, Relation between cross sections in Lab and CM systems, Scattering amplitude and differential cross Section, the first Born approximation and its validity.	**7**
Unit IV	Quantum theory of scattering: Application of Born approximations to scattering by Coulomb and Screened Coulomb Potential, square well potential and Gaussian potential Partial Wave Analysis for Elastic and Inelastic Scattering, Effective Range and Scattering Length, Optical Theorem, Scattering by perfectly rigid sphere.	**8**
Unit V	System of identical particles, symmetry with respect to interchange, particle exchange operator, exchange degeneracy, symmetric and antisymmetric wave functions, wave functions for two, three and many particles systems, Pauli's exclusion principle, Inclusion of spin, spin	**7**

	statistics relation, symmetric and antisymmetric wave functions for hydrogen molecule, He in $1s^2$ and 1s2s states.	
Unit VI	Klein-Gordon equation, covariant form, Probability density and Probability current density, Plane wave solution: Isospin and Charge conjugation. Dirac equation, Dirac matrices, covariant form, Probability density and Probability current density, Spin of Dirac particle, Plane wave solution, Dirac Positron theory, Magnetic moment of Dirac particle, Charge Conjugation.	**8**

REFERENCE BOOKS:

1. Quantum Mechanics Concept and Applications 2nd Ed. (Wiley): Nouredine Zettili
2. Introductory Quantum Mechanics 4th Ed. (Pearson Edu.): Richard Libboff
3. Quantum Mechanics 2nd Ed. (PHI): Arul Das
4. Quantum Mechanics Theory and Applications 5th Ed. (Macmillan India): Ajoy Ghatak and S. Lokanathan
5. Quantum Mechanics (PHI): B.K. Agrawal and Hari Prakash
6. Modern Quantum Mechanics 2nd Ed. (Addison-Wesley): J.J. Sakurai
7. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
8. Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education
9. Quantum Mechanics, Walter Greiner, 4thEdn., 2001, Springer

Equivalent MOOC on SWAYAM:

1. https://nptel.ac.in/courses/115103104
2. https://theoreticalminimum.com/courses/advanced-quantum-mechanics/2013/fall
3. https://hcverma.in/QuantumMechanics
4. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-1
5. https://www.edx.org/course/quantum-mechanics-for-scientists-and-engineers-2
6. https://archive.nptel.ac.in/courses/115/101/115101107/

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=_OZXEb8FxZQ
2. https://www.youtube.com/watch?v=GWCXKzDY-Y0
3. https://www.youtube.com/watch?v=oEWsimmWy5E
4. https://www.youtube.com/watch?v=8mi0PoPvLvs
5. https://www.youtube.com/watch?v=ZfJn35DCyWg

DSC V- Electromagnetic Theory

Theory: 3 hours per week (3 Credits) **Theory Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]:
Upon completion of the course, students will:

1. acquire the extensive knowledge of electrostatics.
2. acquire the extensive knowledge about dielectric properties of the substances.
3. acquire the extensive knowledge of magnetostatics.
4. understand the significance of Maxwell's equations, concept of electromagnetic fields and electrodynamics.
5. apply the concepts of electrodynamics to explore power radiated by oscillating electric dipole and radiation pressure.
6. explore the propagation of electromagnetic waves in various media and wave guides.

COURSE CONTENTS: DSC V- Electromagnetic Theory

Unit I	Electrostatics-I: Review of vector differential calculus, Gauss laws, and its applications to uniformly charged sphere, cylinder, sheet, Electrostatic Potential, its applications. Electrostatic energy density, electric energy of charge distribution. Poisson's equation - Laplace's equation - Solution of Laplace's equation	**8**
Unit II	Electrostatics-II: Zonal harmonics - Addition theorem for spherical harmonics - Conducting sphere in a uniform field - Polarization vector - Field at external and internal points - displacement vector - Polar molecules - Forces on dielectrics - Dielectric sphere in a uniform field.	**7**
Unit III	Magnetostatics Magnetic field of steady current - Magnetic vector potential - Application to a long current carrying wire - ampere's law - Lorentz force - Line integral of a vector potential over a closed curve - Equation of continuity - Lorentz condition - Magnetic scalar potential - Application to a circular coil - Magnetic shielding - Energy in a magnetic field.	**8**
Unit IV	Maxwell's equations: Faraday's laws of induction - Maxwell's displacement current - Maxwell's equations - Vector and scalar potentials - Wave equation and plane wave solution - Gauge invariance - Coulomb and Lorentz gauges - Energy and momentum of the field - Poynting theorem - Lorentz force - Conservation laws for a systems of charges and electromagnetic fields.	**8**
Unit V	Application of Maxwell's equations: Fields and radiation of localised sources - Oscillating electric dipole - Radiation from an oscillating electric dipole - Poynting vector and radiated power - Radiation resistance - Radiation from a linear antenna -	**7**

	Antenna arrays - Radiation pressure and electromagnetic momentum - Electromagnetic oscillators.	
Unit VI	Wave propagation Propagation of electromagnetic waves in isotropic and anisotropic dielectrics - Propagation in conducting media - Linear and circular polarization - Reflection and refraction at a plane interface - Propagation of waves in a rectangular wave guide - Cavity resonator - Faraday and Kerr effects.	**7**

REFERENCE BOOKS:

1. J.D. Jackson, 1975, Classical Electrodynamics, Wiley Eastern Ltd., New Delhi.
2. D.J. Griffiths, 2002, Introduction to Electrodynamics, 3rd Edition, Prentice - Hall of India, New Delhi.
3. J.R. Reitz, F.J. Milford and R.W. Christy, 1986, Foundations of Electromagnetic Theory, 3rd Edition, Narosa Publication, New Delhi.
4. Elements of Electrodynamics, Gupta, Kumar, Singh, Pragati Prakashan.
5. Refresher Course in Physics, Vol-2 C.L. Arora, S. Chand Publication.
6. W. Panofsky and M. Phillips, 1962, Classical Electricity and Magnetism, Addison Wesley, London.
7. J.D. Kraus and D.A. Fleisch, 1999, Electromagnetic with Applications, 5th Edition WCB McGraw-Hill, New York.
8. B. Chakraborty, 2002, Principles of Electrodynamics, Books and Allied, Kolkata.

Equivalent MOOC on SWAYAM:

1. https://bsc.hcverma.in/course/cee1
2. https://nptel.ac.in/courses/115101004
3. https://onlinecourses.nptel.ac.in/noc21_ph05/preview
4. https://nptel.ac.in/courses/108104099
5. https://www.udemy.com/course/electrodynamics/
6. https://www.udemy.com/course/physics-in-electrodynamics/

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=LzabONBFSSM
2. https://www.youtube.com/watch?v=Lx64cq0HeXY
3. https://www.youtube.com/watch?v=FUUMCT7FjaI
4. https://www.youtube.com/watch?v=JSa7_pEVdpA
5. https://www.youtube.com/watch?v=ckUyN5XNG0Y

DSC VI- Atomic and Molecular Physics

Theory: 3 hours per week (3 Credits)

Theory Marks: 70
Internal Marks: 30

COURSE OUTCOMES [COS]

Upon completion of the course successfully, students would be able to

1. describe structure atom by drawing the vector diagram and the physical interpretation of atom using quantum numbers.
2. explain the quantum behaviour of atoms in external electric and magnetic fields.
3. explain the coupling schemes and spectral line broadening in external fields to understand the fine structure of alkali elements.
4. recognize the spectroscopy of many electron atomic systems and hyperfine splitting of spectral lines through Resonance Spectroscopy (ESR and NMR)
5. understand the importance of rotational and vibrational energy levels by studying molecular spectroscopy.
6. describe the Infrared and Raman spectra of polyatomic molecules and interpret the results from spectra.

COURSE CONTENTS: DSC VI- Atomic and Molecular Physics

Unit I	Vector atom model; Space quantization and spin of electron, significance of Principle quantum number (n), Orbital quantum number (l), Magnetic Orbital quantum number (m1), Spin quantum number (s), Magnetic spin quantum number (ms), Total Angular Momentum quantum number (j), Magnetic Total number (mj). l-s coupling for single valence electron atom. Larmor's theorem, Stern Gerlach Experiment	**7**
Unit II	Normal and Anomalous Zeeman effect. Experimental setup to study Zeeman effect. Debye's explanation of Normal Zeeman effect. Theory of Anomalous Zeeman effect. Expression of Lande's spectroscopic splitting factor (g) and effective magnetic moment for single valance electron atom. Origin of Sodium D1 & D2 lines. Anomalous Zeeman effect in Sodium D1 & D2 lines.	**8**
Unit III	Paschen Back effect; Stark effect. LS & JJ coupling in two valence electron atoms. Interaction energy in LS & JJ coupling. Pauli's exclusion principle. Spectra of alkali elements. Different series in alkali spectra, Ritz combination principle, spin-orbit interaction, Main features of alkali spectra, Fine structure of alkali spectra, Fine structure of Hydrogen lines.	**8**
Unit IV	Hyperfine structure: experimental study and interpretation, Width of spectral lines, Complex spectra, Hund's rule, Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation.	**7**
Unit V	Types of Molecules : Diatomic linear symmetric top, asymmetric top and spherical top molecules. Molecular (band) spectra. Classification of	**8**

	molecular spectra (pure rotational spectra, Rotation-vibration spectra, UV and Visible spectra), Rotational spectra of diatomic molecules as a rigid rotator. Quantum mechanical theory of pure rotational spectra (rigid rotator). Energy levels and spectra of nonrigid rotator. Isotopic effect in pure rotational spectra.	
Unit VI	Vibrational energy of Diatomic molecule. Diatomic molecule as a simple harmonic oscillator. Energy levels and spectrum. Morse poential energy curve. Molecules as a vibrating rotator. Vibration spectrum of diatomic molecule. PQR branches, Raman spectra of diatomic molecules; IR spectrometer (Qualitative).	**7**

REFERENCE BOOKS:

1. Introduction to Atomic Spectra- H. E. White
2. Fundamentals of Molecular Spectroscopy - C.B.Banwell
3. Elements of Spectroscopy - Gupta, Kumar, Sharma, Pragati Prakashan, Meerut.
4. Physics of Atoms and Molecules: Bransden and Joachain.
5. Introduction to Atomic Spectra: HG Kuhn.
6. Spectroscopy Vol. -I, II & III - Walker & Straughen
7. Introduction to Molecular Spectroscopy - G.M.Barrow
8. Spectra of Diatomic Molecules - Herzberg8.Molecular Spectroscopy - Jeanne L McHale
9. Molecular Spectroscopy - J.M.Brown
10. Spectra of atoms and molecules - P.F.Bemath
11. Modern Spectroscopy - J.M.Holias

Equivalent MOOC on SWAYAM:

1. https://archive.nptel.ac.in/courses/115/105/115105100/
2. https://nptel.ac.in/courses/115101003

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=Agu68RGaoWM
2. https://www.youtube.com/watch?v=E8PL5-T644M

DSE-II (i): Lasers and Laser Applications

Theory: 3 hours per week (3 Credits) **Theory Marks: 70**
Internal Marks: 30

COURSE CONTENTS: DSE-II (i): Lasers and Laser Applications

Unit I	Spontaneous emission, Stimulated emission, Population inversion, Fabry Perot etalon, Stable two mirror optical resonators, Longitudinal and transverse modes of laser cavity, Mode selection, Gain in a regenerative laser cavity.	**8**
Unit II	Two level laser systems, threshold for three and four level laser systems, mode locking, pulse shortening- pico second and femto second operation, spectral narrowing and stabilization.	**8**
Unit III	Nitrogen laser, Carbon dioxide laser, Excimer laser, Dye laser, Ruby laser, Nd-YAG laser, Diode – pumped solid state lasers, Semiconductor lasers, High power laser systems.	**8**
Unit IV	Laser induced fluorescence, Raman scattering and its applications, Non-linear interaction of light with matter.	**7**
Unit V	Laser induced multi-photon processes and their applications. Propagation of light in a medium with variable refractive index, Optical fibres.	**7**
Unit VI	Light wave communication, Qualitative treatment of medical and engineering applications of lasers, Material processing.	**7**

REFERENCE BOOKS:

1. Introduction to Laser Physics: Koichi Shimoda, Springer
2. Introduction to Laser Physics: B. A. Lengyl, John Wiley & Sons Inc
3. An Introduction to Lasers (Theory and Applications): M. N. Avdahanulu and P S Hemne, S. Chand
4. Principles of Lasers: Orazio Svelto, Springer
5. Introduction to Optical Electronics: Amnon Yariv, Holt McDougal
6. Laser Spectroscopy: Basic Concepts and Instrumentation: Wolfgang Demtröder, Springer
7. Nonlinear laser spectroscopy: V. S. Letokhov and V. P. Chebotayev, Springer
8. Laser Fundamentals: William T. Silfvast, Cambridge University Press

Equivalent MOOC on SWAYAM:

1. https://nptel.ac.in/courses/104104085
2. https://ocw.mit.edu/courses/res-6-005-understanding-lasers-and-fiberoptics-spring-2008/resources/laser-fundamentals-i/
3.

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=YToaWlQf6fM
2. https://www.youtube.com/watch?v=f8nG9kPcFv0
3. https://www.youtube.com/watch?v=FNp81kkxj5c

DSE-II (ii): Spectroscopic Techniques

Theory: 3 hours per week (3 Credits) | **Theory Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]
Upon completion of the course successfully, students would be able to

1. understand about interaction of electromagnetic radiations with mater.
2. understand about ultraviolet-visible spectroscopy and their applications.
3. understand infrared spectroscopy and experimental applications to determine molecular structure.
4. understand Raman Effect, principle of Raman spectroscopy, mechanism of Raman Effect, instrumentation required and Applications.
5. understand photoelectron spectroscopy, principle, instrumentation, and applications.
6. understand Mossbauer spectroscopy, principle, instrumentation, and applications.

COURSE CONTENTS: DSE-II (ii): Spectroscopic Techniques

Unit I	Ultraviolet and Visible Spectroscopy: electronic transitions, radiative processes, energy diagram, internal conversion, conical intersection, Frank Condon principle, Kasha's rule, structure determination, other applications.	**8**
Unit II	Infrared Spectroscopy: Principle, nomenclature of infrared spectra, theory required for IR spectroscopy, IR radiation sources, IR monochromators, IR detectors, modes of vibrations, position and intensities of absorption bands, potential applications of IR spectroscopy.	**8**
Unit III	Raman Spectroscopy: Introduction, principle, properties of Raman lines, difference between Raman spectra and infrared spectra, mechanism of Raman Effect, instrumentation, Applications.	**8**
Unit IV	Photoelectron spectroscopy: Introduction, principle, instrumentation, theory, applications. Mossbauer spectroscopy: Principle, theory, applications, instrumentation.	**7**
Unit V	Atomic absorption spectroscopy: Principle, Grotrian diagram, Detection of non-metals, advantages, disadvantages, detection limit and sensitivity, applications.	**7**
Unit VI	Modern spectroscopic techniques: electron energy loss spectroscopy (EELS) energy dispersive x-ray spectroscopy (EDS/EDAX), X-ray fluorescence spectroscopy (XRF), X-ray photoelectron spectroscopy (XPS).	**7**

REFERENCE BOOKS:

1. H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, Instrumental methods of Analysis; HCBS Publishing New Delhi; 2004, 7th Ed.
2. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw- Hill, New Delhi; 4 th Ed.
3. H. Gunzler & A. Williams; Handbook of Analytical Techniques, WILEY-VCH Verlag GmbH; 2001, 1st Ed.
4. Spectroscopy: Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publishing House.
5. Analytical Electron Microscopy for Materials Science: D. Shindo T. Oikawa, Springer.
6. Fundamentals of Energy Dispersive X-ray Analysis: John C. Russ, Butterworth-Heinemann

Equivalent MOOC on SWAYAM:

1. https://archive.nptel.ac.in/courses/104/106/104106075/
2. https://onlinecourses.nptel.ac.in/noc20_cy08/preview
3. https://onlinecourses.nptel.ac.in/noc22_cy45/preview
4. https://archive.nptel.ac.in/courses/103/108/103108100/
5. https://onlinecourses.nptel.ac.in/noc22_ph14/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://www.youtube.com/watch?v=yy4BowQnwzM
2. https://www.youtube.com/watch?v=yALL5cNhrtc
3. https://www.youtube.com/watch?v=rcdUa2D03Ys

DSE-II (iii): Network Theorems and Solid State Devices

Theory: 3 hours per week (3 Credits) **Theory Marks: 70**
Internal Marks: 30

COURSE OUTCOMES [COS]
Upon completion of the course successfully, students would be able to

1. analyse ac and dc networks.
2. use diodes, UJT and SCR to design circuits for various applications
3. design and construct regulated power supply and SMPS.
4. design and construct single stage and two stage amplifier circuits.
5. design and construct oscillators and multivibrators.
6. identify various transducers and use measuring instruments.

COURSE CONTENTS: DSE-II (ii): Network Analysis and Solid State Devices

Unit I	Node & mesh analysis, Superposition theorem, Thevenin's theorem, Reciprocity theorem, Norton's theorem, Maximum power transfer theorem, Network Analysis using Laplace Transformation: Step response of series RL, RC, RLC, parallel RLC, Response of series RL, RC, RLC, and parallel RLC to exponential driving sources.	**8**
Unit II	Energy Band Diagram, Conductors, Semiconductors, Insulators, Intrinsic and Extrinsic Semiconductors (P&N), currents in semiconductors, Diffusion Junction, Depletion Layer, Barrier Potential. Junction Diodes: Forward and reverse bias characteristics, breakdown phenomenon, Zener Diodes, Varactor Diode, Photo Diode, Light Emitting Diode. Unijunction Transistor (UJT): Basic Working Principle, Characteristics, Applications as relaxation oscillator. Silicon Controlled Rectifier (SCR) (Principle, Characteristics and Applications).	**8**
Unit III	Rectifiers, Capacitor filter, regulated power supply, Zener regulated power supply, fix voltage regulators ICs' 78XX series and 79XX series, adjustable voltage regulators ICs 317 and its applications. SMPS: block diagram, working principle, advantages and applications.	**7**
Unit IV	Bipolar Junction Transistor: working principle, configurations, input and output characteristics, Biasing: operating point, load line, stabilization of operating point, voltage divider bias arrangement. CE amplifier using divider bias. Coupled Amplifier: RC-coupled amplifier and its frequency response. Field Effect Transistors: JFET, basic working principle, I/O Characteristics, pinch off voltage, parameters, MOSFET, basic working principle, Characteristics.	**8**

Unit V	Feedback in Amplifiers: Effect of positive and negative feedback on input impedance, output impedance, gain stability, distortion and noise. Sinusoidal Oscillations: Barkhausens criterion for self-sustained oscillations, RC Phase shift oscillator, determination of frequency, Hartley and Colpitts oscillators. Multivibrators: astable, monostable and bistable.	**8**
Unit VI	Transducers: Basic idea of Transducers, Resistive transducers (PTC-PT-100, NTC-thermistors, capacitive (microphone) transducers, Inductive (LVDT) Transducers, Pressure transducers-Strain Gauge, photo voltaic cell, LDR, Photodiode and phototransistors (qualitative only). Basic Measuring Instruments: Analogue Multimeter, Digital Multimeter, Cathode Ray Oscilloscope.	**7**

REFERENCE BOOKS:

1. Network Analysis: M.E. Van Valkenburg
2. Network Analysis: G.K. Mithal
3. Basic Electronics and Linear Circuits by Bhargava & Kulshreshtha (TTTI)
4. Integrated Electronics by Millman and Helkian
5. Circuits and Networks by A. Sudhakar and Shyam Mohan
6. Instrumentation Repair and Maintenance by R.G. Gupta
7. Power Electronics Circuits, Devices and Applications, 3rd Edition by Muhammad H. Rashid, Pearsons Publications
8. Electronic Devices and Circuits: An Introduction by Allen Mottershed
9. Solid State Electronic Devices, 6th Edition, by Ben G. Streetman

Equivalent MOOC on SWAYAM:

1. https://vlab.amrita.edu/?sub=1
2. https://nptel.ac.in/courses/115105120
3. https://onlinecourses.nptel.ac.in/noc20_ph16/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

1. https://electronicscoach.com/switch-mode-power-supply.html
2. http://vlabs.iitkgp.ac.in/be/

Lab I:

Practical: 6 hours per week (3 Credits) **External Marks: 50**
Internal Marks: 50

- *Every students should perform at least seven experiments from the given list.*

List of Experiments

1. To study Atomic spectra of two-electron systems: He, Hg.
2. To study ESR spectra of DPPH and to find Lande's g-factor.
3. To study Zeeman Effect for Mercury.
4. To study the florescence spectrum of a dye.
5. To study quantum interference using Mach-Zehnder interferometer.
6. To study Ramsauer – Townsend effect in quantum mechanics.
7. To study Quantum Scattering and Determination of the Scattering Cross-Section of Xenon Gas in a 2D21 Thyratron Tube.
8. To study the absorption spectrum of iodine vapour with Constant Deviation spectrometer and then to determine:(a) the energy level diagram of iodine molecule (b) the electronic energy gap and vibrational energies (c) bond dissociation limit.(d) force constant for the excited state.
9. To plot characteristics of GM tube.
10. To determine absorption coefficient of beta particles in Al.

Computer based experiments (using C/ Scilab/ Python Programming)

11. To find the energy eigen values and to plot the corresponding eigen functions for a particle in infinite square we potential perturbed by the external fields.
12. To find the energy eigen values and to plot the corresponding eigen functions for 1D linear harmonic oscillator perturbed by the external fields.
13. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule for the Morse potential.
14. Plot dN/dE versus E for non-relativistic and relativistic Bosons and Fermions.

Lab II:

Practical: 6 hours per week (3 Credits) **External Marks: 50**
Internal Marks: 50

- *Every students should perform at least seven experiments from the Part A and Part B.*

List of Experiments

Part A:

1. e/m Helical/Thomson's/Magnetron method.
2. 'e' Millikan's oil drop method.
3. To study Faraday effect.
4. To study Kerr effect.
5. To study antenna Radiation Pattern for Yagi Uda antenna and Antenna and Radiowave Propagation.
6. To determine dielectric constant of liquid using Leacher wire experiment.
7. Study of transmission line.

Part B: Experiments based on DSE-II

DSE-II (i): Lasers and Laser Applications

1. Measurement of divergence and intensity distribution across the laser beam.
2. Measurement of thickness of wire using Laser.
3. Measurement of wavelength of Laser using ruler.
4. Study of Faraday Effect using He Ne Laser.
5. Study of refraction and measurement of refractive index of glass, plastic and some liquids using laser.
6. Study of total internal reflection using laser.
7. Study of Pockel effect.

DSE-II (ii): Spectroscopic Techniques

1. Designing energy level diagram from given UV-visible transmission data.
2. Determination of band gap and optical parameters from given UV-visible transmission data.
3. Recording and interpretation of UV-visible transmission data of given sample.
4. Assignment of peaks from given FT-IR spectra to functional groups.
5. Interpretation of Raman spectrograph and assignment of peaks to functional groups.
6. Interpretation of EDAX spectrum and determination of elemental concentration.
7. Interpretation of XRF spectrum and determination of elemental concentration.
8. Interpretation of XPS spectrum and determination of elemental concentration.

DSE-II (iii): Network Theorems and Solid State Devices

1. Verification of Network theorems : Thevenin's, Norton's, Milliman's, Superposition's and Maximum Power transfer theorem.
2. To design and study DC regulated power supply.
3. To study characteristics and application(s) of UJT.
4. To study characteristics and application(s) of SCR.
5. To design and determine BW, input and output impedance of CE amplifier circuit.
6. To design and study RC phase shift oscillator.
7. To design and study Hartley oscillator.
8. To design and study Colpitt's oscillator.
9. To design and study mutivibrator circuits using BJT.
10. To study characteristics of FET and MOSFET.