॥ सा विद्या या विमुक्तये ॥

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

'ज्ञानतीर्थ', विष्णुपुरी, नांदेड - ४३१ ६०६ (महाराष्ट्र राज्य) भारत

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

'Dnyanteerth', Vishnupuri, Nanded - 431 606 (Maharashtra State) INDIA

Established on 17th September, 1994, Recognized By the UGC U/s 2(f) and 12(B), NAAC Re-accredited with'B++' grade

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

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विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत राष्ट्रीय शैक्षणिक धोरण २०२० च्या अनुषंगाने शैक्षणिक वर्ष २०२३–२४ पासून संलग्न महाविद्यालये व विद्यापीठ संकुलांत पदव्युत्तर पदवी प्रथम वर्ष आणि विद्यापीठ संकुले व न्यू मॉडेल डिग्री कॉलेज मध्ये पदवी प्रथमवर्ष अभ्यासक्रम लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, शासन निर्णय क्र. एनईपी २०२०/प. क्र. ०९/विशि–३/शिकाना, दिनांक २० एप्रिल २०२३ व शासन पत्र. क्र एनईपी २०२०/प. क्र. ०९/विशि–३, दिनांक १६ जून २०२३ अन्वये सूचित केल्यानुसार राष्ट्रीय शैक्षणिक धोरण २०२०च्या अनुषंगाने दिलेल्या आराखडया नुसार दिनांक १६ जून २०२३ रोजी संपन्न झालेल्या मा. विद्यापरिषदेच्या बैठकीत ऐनवेळचा विषय क्र. ०५/५६–२०२३ अन्वये मान्यता दिल्यानुसार प्रस्तुत विद्यापीठाच्या विज्ञान व तंत्रज्ञान विद्याशाखा अंतर्गत खालील पदव्युत्तर पदवी अभ्यासक्रम (AICTE, PCL, BCI, CoA, NCTE इ. सारख्या नियमक संस्थाची मान्यता आवश्यक असलेले अभ्यासक्रम वगळून) संलग्न महाविद्यालये, विद्यापीठ परिसर व उपपरिसर संकुलांमध्ये आणि पदवी प्रथम वर्ष अभ्यासक्रम विद्यापीठ परिसर व उपपरिसर संकुले व विद्यापीठ संचलित न्यू मॉडेल डिग्री कॉलेज, हिंगोली येथे शैक्षणिक वर्ष २०२३–२४ पासून लागू करण्यात येत आहे.

1) M.Sc. Biotechnology (1st Year) - Campus School
2) M.Sc. Biotechnology (1st Year) – Affiliated colleges
3) B.Sc. Biotechnology (1st Year) – New Model Degree College, Hingoli
4) M.Sc. Botany (1st Year) - Campus School
5) M.Sc. Botany (1st Year) – Affiliated colleges
6) M.Sc. Herbal Medicine (1st Year) - Affiliated colleges
7) M.Sc. Chemistry (1st Year) - Campus School
8) M.Sc. Chemistry (1st Year) - Affiliated colleges
9) M.Sc. Computer Science / Computer Network / Computer Applications (1st Year) University campus, sub campus Latur
10) M.Sc. System Administration & Networking (1st Year) – Affiliated colleges
11) M.Sc. Computer Management (1st Year) – Affiliated Colleges
12) M.Sc. Computer Science (1st Year) – Affiliated Colleges
13) M.Sc. Dairy Science (1st Year) - Affiliated colleges
14) M.Sc. Electronic (1st Year) - Affiliated colleges
15) M.Sc. Geology (1st Year) – University Campus
16) M.Sc. Geography (1st Year) – University Campus
17) M.Sc. Applied Mathematics (1st Year) – Affiliated Colleges
18) M.Sc. Mathematics (1st Year) – Affiliated Colleges
19) M.Sc. Microbiology (1st Year) - University Campus
20) M.Sc. Microbiology (1st Year) – Affiliated colleges

21) M.Sc. Physics (1st Year) - University Campus
22) M.Sc. Physics (1st Year) – Affiliated Colleges
23) M.Sc. Statistics (1st Year) - University Campus
24) M.Sc. Statistics (1st Year) – Affiliated colleges
25) M.Sc. Biochemistry (1st Year) – Affiliated Colleges
26) M.Sc. Zoology (1st Year) – Affiliated Colleges

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी, ही विनंती.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.:शै–१/एनइपी२०२०/S&T/अक/२०२३–२४/ 130

सहा.कुलसचिव
शैक्षणिक (१–अभ्यासमंडळ) विभाग

दिनांक : ३०.०६.२०२३.

प्रत : १) मा. प्राचार्य, सर्व संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.
२) मा. संचालक, सर्व संकुले परिसर व उपपरिसर, प्रस्तुत विद्यापीठ
३) मा. प्राचार्य, न्यु मॉडेल डिग्री कॉलेज हिंगोली.
४) मा. समन्यवक, कै. श्री उत्तमराव राठोड आदिवासी विकास व संशोधन केंद्र, किनवट.

प्रत माहितीस्तव :
१) मा. कुलगुरू महोदयांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. कुलसचिव, प्रस्तुत विद्यापीठ.
३) मा. सर्व आधिष्ठाता, प्रस्तुत विद्यापीठ.
४) सर्व प्रशासकीय विभाग प्रमुख साहाय्यक, प्रस्तुत विद्यापीठ.
५) सिस्टीम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ.

SWAMI RAMANAND TEERTH

MARATHWADA UNIVERSITY, NANDED - 431 606

(R-2023)

School of Physical Sciences

TWO YEAR MASTERS PROGRAMME IN SCIENCE

M. Sc. First Year

Subject: Physics

(Campus School)

Under the Faculty of

Science and Technology

(As per NEP-2020)

With effect from academic year 2023-24

From the Desk of the Dean, Faculty of Science and Technology

Swami Ramanand Teerth Marathwada University, Nanded, enduring to its vision statement "***Enlightened Student: A Source of Immense Power",*** is trying hard consistently to enrich the quality of science education in its jurisdiction by implementing several quality initiatives. Revision and updating curriculum to meet the standard of the courses at national and international level, implementing innovative methods of teaching-learning, improvisation in the examination and evaluation processes are some of the important measures that enabled the University to achieve the **3Es, the *equity, the efficiency and the excellence*** in higher education of this region. To overcome the difficulty of comparing the performances of the graduating students and also to provide mobility to them to join other institutions the University has adopted the *cumulative grade point average* (CGPA) system in the year 2014-2015. Further, following the suggestions by the UGC and looking at the better employability, entrepreneurship possibilities and to enhance the latent skills of the stakeholders the University has adopted the *Choice Based Credit System* (CBCS) in the year 2018-2019 at graduate and post-graduate level. This provided flexibility to the students to choose courses of their own interests. To encourage the students to opt the world-class courses offered on the online platforms like, NPTEL, SWAYM, and other MOOCS platforms the University has implemented the credit transfer policy approved by its Academic Council and also has made a provision of reimbursing registration fees of the successful students completing such courses.

SRTM University has been producing a good number of high caliber graduates; however, it is necessary to ensure that our aspiring students are able to pursue the right education. Like the engineering students, the youngsters pursuing science education need to be equipped and trained as per the requirements of the R&D institutes and industries. This would become possible only when the students undergo studies with an updated and evolving curriculum to match global scenario.

Higher education is a dynamic process and in the present era the stakeholders need to be educated and trained in view of the self-employment and self-sustaining skills like start-ups. Revision of the curriculum alone is not the measure for bringing reforms in the higher education, but invite several other initiatives. Establishing industry-institute linkages and initiating internship, on job training for the graduates in reputed industries are some of the important steps that the University would like to take in the coming time. As a result, revision of the curriculum was the need of the hour and such an opportunity was provided by the New Education Policy 2020. National Education Policy 2020 (NEP 2020) aims at equipping students with knowledge, skills, values, leadership qualities and initiates them for lifelong learning. As a result the students will acquire expertise in specialized areas of interest, kindle their intellectual curiosity and scientific temper, and create imaginative individuals.

The curriculum given in this document has been developed following the guidelines of NEP-2020 and is crucial as well as challenging due to the reason that it is a transition from general science-based to the discipline-specific-based curriculum. All the recommendations of the ***Sukanu Samiti*** given in the **NEP Curriculum Framework-2023** have been followed, keeping the disciplinary approach with rigor and depth, appropriate to the comprehension level of learners. All the Board of Studies (BoS) under the Faculty of Science and Technology of this university have put in their tremendous efforts in making this curriculum of international standard. They have taken care of maintaining logical sequencing of the subject matter with proper placement of concepts with their linkages for better understanding of the students. We take this opportunity to congratulate the Chairman(s) and all the members of various Boards of Studies for their immense contributions in preparing the revised curriculum for the benefits of the stakeholders in line with the guidelines of the Government of Maharashtra regarding NEP-2020. We also acknowledge the suggestions and contributions of the academic and industry experts of various disciplines.

We are sure that the adoption of the revised curriculum will be advantageous for the students to enhance their skills and employability. Introduction of the mandatory ***On Job Training, Internship*** program for science background students is praise worthy and certainly help the students to imbibe first-hand work experience, team work management. These initiatives will also help the students to inculcate the workmanship spirit and explore the possibilities of setting up of their own enterprises.

Dr. L. M. Waghmare, ***Dean,*** *Faculty of Science and Technology*

Dr. M. K. Patil, ***Associate Dean,*** *Faculty of Science and Technology*

From Desk of Chairman, Board of Studies of the Subject Physics

Preamble:

The education system in India has acquired a new form with the inclusion of job oriented work skill in combination with traditional fundamental core subjects along with multiple entries, multiple exit option with choice based credit system. The development of vocational work skill amongst the aspirants being one of the major goal for seeking the livelihood in short spam, while competing with the world class education systems. Inclusion of multifold courses as clubbing of majors, minors, electives with skills must take cognizant for following the education quality mandates too. To achieve this, the thrust of quality needs to be addressed, discussed and carried forward in a systemic manner. Accreditation is the principle means of quality assurance in higher education and reflects the fact in achieving recognition, the institution or program of study is committed and open for external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student should have at the time of graduation from the program.

A post graduate program must ensure that, the passing students understand the basic, advanced and scientific concepts of Physics, have gone through one field in department to appreciate and use advanced, updated and recent methodologies for analysis and design, and have acquired skills for life-long learning. The transformation of students from one program to other at any level of education exit must make him/her self-reliable. PG program in Physics program must therefore have a mission statement which is in conformity with program objectives and program outcomes that are expected for specific educational process. The outcomes of a program must be measureable and must be assessed regularly through proper feedback for improvement of the program. There must be a quality assurance process in place within the Institute to make use of the feedback for improvement of the program. The curriculum must be constantly refined and updated to ensure that the defined objectives and outcomes are achieved. Students must be encouraged to comment on the objectives and outcomes and the role played by the individual courses in achieving them. In line with this Faculty of Science and Technology of Swami Ramanand Teerth Marathwada University, Nanded has taken lead in incorporating philosophy of outcome based education in the process of curriculum development.

I, as Chairman, of the Board of Studies in Physics, Swami Ramanand Teerth Marathwada University, Nanded, happy to state that, course objectives, expected outcomes were finalized in a meeting and are stated as below:

- To provide students with a strong foundation in the mathematical, scientific and physical science fundamentals necessary to formulate, solve and analyze problems and to prepare them for scientific studies.
- To prepare students to demonstrate an ability to identify, formulate and solve problems pertaining to the concepts, fundamentals and advances of the physical sciences.
- To prepare students to demonstrate ability to understand the responsibility towards energy conservation and utilization as renewable energy sources.
- To promote awareness among students for the life-long learning and to introduce them to professional ethics and codes of professional practice.
- To develop ability for resolving the fundamental aspects relating to general physical concepts and theories.
- To develop ability in identifications of physical qualities and their measurements techniques too.
- To make them aware about working of different physical instruments and gadgets and capability to increase the working efficiency of the same.
- To make students self-reliable for development of scientific temperaments fostering for acquiring the advanced knowledge in applying the concepts of Physical Sciences.

In addition to Program Objectives, for each course of postgraduate program, objectives and expected outcomes from learner's point of view are also included in the curriculum to support the philosophy of outcome based education. I believe strongly that a small step taken in right direction will definitely help in providing quality education to the stake holders.

Dr. K. S. Kanse
Chairman, Board of Studies of the Physics
Swami Ramanand Teerth Marathwada University, Nanded

Details of the Board of Studies Members in the subject Physics under the faculty of Science & Technology of S.R.T.M. University, Nanded

Sr. No	*Name of the Member*	*Designation*	*Address*	*Contact No.*
1.	Dr. K. S. Kanse	Chairman	Department of Physics, Lal Bahadur Shastri Mahavidyalaya, Dharmabad, Dist. Nanded	Mob: 09850924426 Email: kskanse@gmail.com
2.	Dr. M. K. Patil	Professor	School of Physical Sciences, S.R.T.M. University, Nanded	Mob: 08308298063 Email: patil@associates.iucaa.in
3.	Dr. M. P. Mahabole	Professor	School of Physical Sciences, S.R.T.M. University, Nanded	Mob: 9421850549 Email: mpmsrtmunsps@gmail.com
4.	Dr. S. N. Keshatti	Professor	Department of Physics, Shivaji Mahavidyalaya, Parbhani	Mob: 9422743448 Email: keshatti.shrinivas@gmail.com
5.	Dr. C. T. Londhe	Assistant Professor	Department of Physics, Mahatma Gandhi Mahavidyalaya, Ahmedpur Dist. Latur	Mob: 9850136648 Email: londhect@gmail.com
6.	Dr. M. A. Giri	Associate Professor	Department of Physics, Gramin (ACS) Mahavidyalaya, Vasantnagar Kotygal Tq. Mukhed Dist Nanded	Mob: 9423440996 Email: drmadangiri@gmail.com
7.	Dr. V. D. Mote	Assistant Professor	Department of Physics, Dayanand Science College, Latur	Mob: 9960639169 Email: vmote.physics@gmail.com
8.	Dr. A. A. Yadav	Associate Professor	Department of Physics, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur Tq. Dist. Latur	Mob: 9975213852 Email: aay_physics@yahoo.co.in
9.	Dr. R. A. Joshi	Assistant Professor	Department of Physics, Toshniwal Arts, Commerce and Science College, Sengaon Dist Hingoli	Mob.: 9096655278 Email: urajoshi@gmail.com
10.	Dr. S. S. Jadhav	Associate Professor	Department of Physics, D.S.M. Arts, Commerce and Science College, Jintur Dist Parbhani	Mob: 9405209939 Email: santosh.jadhav28@yahoo.com

11.	Dr. S. P. Yawale	Professor	Department of Physics, Govt. Vidarbha Institute of Science and Humanities, Amravati	Mob: 9423125231 Email: spyawale@rediffmail.com
12.	Dr. Ishwar Chandra	Professor	National Centre for Radio Astrophysics, TIFR, Pune	Mob: 9403136630 Email: ishwarx@gmail.com
13.	Dr. Ram Chitalkar	Industry expert	Morganite crucible (India) Ltd. Morganite crucible (India)	Mob: 9325078845 Email: ram_chitalkar@yahoo.com
14.	Dr. Pramod Watekar	Chief Manager	Sterlite Technologies Ltd., Pune	Mob: 9168187110 Email: pramodwatekar@sterlite.com
15.		Students Representative		
16.				

Invited Members:

1.	Dr. A. C. Kumbharkhane	Professor	School of Physical Sciences, Swami Ramanand Teerth Marathwada University, Nanded	Mob: 9421869112 Email: akumbharkhane@gmail.com
2.	Dr. R. S. Mane	Professor	School of Physical Sciences, Swami Ramanand Teerth Marathwada University, Nanded	Mob: 9850331971 Email: rajarammane70@gmail.com
3.	Dr. A. V. Sarode	Assistant Professor	School of Physical Sciences, Swami Ramanand Teerth Marathwada University, Nanded	Mob: 9921340727 Email: avsarode@gmail.com
4.	Dr. K. A. Bogle	Assistant Professor	School of Physical Sciences, Swami Ramanand Teerth Marathwada University, Nanded	Mob: 7350845827 Email: kashinath.bogle@gmail.com

Swami Ramanand Teerth Marathwada University, Nanded

Faculty of Science & Technology

Credit Framework for Two Year PG Program

Subject: Physics

Year & Level 1	Sem. 2	Major Subject (DSC) 3	Major Subject (DSE) 4	RM 5	OJT / FP 6	Research Project 7	Practical 8	Credits 9	Total Credits 10
1	1	**SPHYC401 (4 Cr)** (Mathematical Methods in Physics) **SPHYC402 (4 Cr)** (Classical Mechanics) **SPHYC403 (4 Cr)** (Numerical Techniques and C-Programming)	**SPHYE401** (3 Cr) Electronic Devices Or Energy Management	**SVECR 401** Research Methodology **(3 Cr)**	--		**SPHYP401 (1Cr)** (Gen. Ele. Lab) **SPHYP402 (1Cr)** (Digital Ele. Lab) **SPHYP403 (1Cr)** (Num. Tech. Lab) **SPHYP404 (1Cr)** (C-Prog. lab)	**22**	**44**
	2	**SPHYC451 (4 Cr)** (Quantum Mechanics) **SPHYC452 (4 Cr)** (Statistical Mechanics) **SPHYC453 (4 Cr)** (Condensed Matter Physics-I)	**SPHYE451** (3 Cr) Atomic Molecular Physics Or Computational Physics	---	**SPHYOJ 451 (3 Cr)**	--	**SPHYP451 (1Cr)** (Spectro Lab) **SPHYP452 (1Cr)** (Sol. Stat. Phy. Lab) **SPHYP453 (1Cr)** (Semicond Phy Lab) **SPHYP454 (1Cr)** (Nuclear Phy Lab)	**22**	
Exit option: Exit Option with PG Diploma *(after 2024-25)*									
2	3	**SPHYC501 (4 Cr)** (Electrodynamics) **SPHYC502 (4 Cr)** (Nuclear and Particle Physics) **SPHYC503 (4 Cr)** (Condensed Matter Physics-II)	**SPHYE501 (4 Cr)** ***(From same Department /School)*** Astrophysics Or Materials Science Or Electronics Or Fibre Optics & LASER	--		Research Project **SPHYR551 (4Cr)**	**SPHYP501 (1 Cr)** (Lab-I) **SPHYE502 (1 Cr)** (Lab-II)	**22**	**44**

	4	**SPHYC551 (4 Cr)** (Radiative Processes) Or (Thin Film Technology) **SPHYC552 (4 Cr)** (Energy Studies)	**SPHYE551 (4 Cr)** (From same Department /School) Astrophysics Or Materials Science Or Electronics Or Fiber Optics & Laser	**SVECP 551** Publication Ethics **(2 Cr)**		Research Project **SPHYR552** **(6 Cr)**	**SPHYP551 (1Cr)** (Lab-III) **SPHYE552 (1Cr)** (Lab-IV)	**22**	
Total Credits		**44**	**16**	**05**	**03**	**10**	**10**	**88**	

M. Sc. First Year Semester I *(Level 6.0)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	**SPHYC401**	Mathematical Methods in Physics	04	--	**04**	04	--
	SPHYC402	Classical Mechanics	04	--	**04**	04	--
	SPHYC403	Numerical Techniques and C-programming	04	--	**04**	04	--
Elective (DSE)	**SPHYE401**	Electronic Devices OR Energy Management	03	--	**03**	03	--
Research Methodology	**SVECR401**	Research Methodology	03	--	**03**	03	
DSC/ DSE Practical	**SPHYP401**	General Electronics Lab	--	01	**01**	--	02
	SPHYP402	Digital Electronics Lab	--	01	**01**	--	02
	SPHYP403	Numerical Techniques Lab	--	01	**01**	--	02
	SPHYP404	C- Programming Lab	--	01	**01**	--	02
Total Credits			**18**	**04**	**22**	**18**	**08**

M. Sc. First Year Semester I *(Level 6.0)*

Examination Scheme

[20% Continuous Assessment (***CA***) and 80% End Semester Assessment (***ESA***)]

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Avg of (T1+T2)/2 (6)	Total (7)	CA (8)	ESA (9)	
Major	**SPHYC401**	Mathematical Methods in Physics	20	20	20	80	--	--	100
	SPHYC402	Classical Mechanics	20	20	20	80	--	--	100
	SPHYC403	Numerical Techniques and C-programming	20	20	20	80	--	--	100
Elective (DSE)	**SPHYE401**	Electronic Devices OR Energy Management	15	15	15	60	--	--	75
Research Methodology	**SVECR401**	Research Methodology	15	15	15	60	--	--	75
DSC/DSE Practical	**SPHYP401**	General Electronics Lab	--	--	--	--	05	20	25
	SPHYP402	Digital Electronics Lab	--	--	--	--	05	20	25
	SPHYP403	Numerical Techniques Lab	--	--	--	--	05	20	25
	SPHYP404	C- Programming Lab	--	--	--	--	05	20	25

M. Sc. First Year Semester II *(Level 6.0)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	**SPHYC451**	Quantum Mechanics	04	--	**04**	04	--
	SPHYC452	Statistical Mechanics	04	--	**04**	04	--
	SPHYC453	Condensed Matter Physics-I	04	--	**04**	04	--
Elective (DSE)	**SPHYE451**	Atomic and Molecular Physics OR Computational Physics	03	--	**03**	03	--
On Job Training	**SPHYO451**	ON Job Training	--	03	**03**	--	06
DSC/DSE Practical	**SPHYP451**	Spectroscopy Lab	--	01	**01**	--	02
	SPHYP452	Solid State Physics Lab	--	01	**01**	--	02
	SPHYP453	Semiconductor Physics Lab	--	01	**01**	--	02
	SPHYP454	Nuclear Physics Lab	--	01	**01**	--	02
Total Credits			**15**	**07**	**22**	**15**	**14**

M. Sc. First Year Semester II *(Level 6.0)*

Examination Scheme

[20% Continuous Assessment (***CA***) and 80% End Semester Assessment (***ESA***)]

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Avg of (T1+T2)/2 (6)	Total (7)	CA (8)	ESA (9)	
Major	**SPHYC451**	Quantum Mechanics	20	20	20	80	--	--	100
	SPHYC452	Statistical Mechanics	20	20	20	80	--	--	100
	SPHYC453	Condensed Matter Physics-I	20	20	20	80	--	--	100
Elective (DSE)	**SPHYE451**	Atomic and Molecular Physics OR Computational Physics	15	15	15	60	--	--	75
On Job Training	**SPHYO451**	ON Job Training	15	15	15	60	--	--	75
DSC/ DSE Practical	**SPHYP451**	Spectroscopy Lab	--	--	--	--	05	20	25
	SPHYP452	Solid State Physics Lab	--	--	--	--	05	20	25
	SPHYP453	Semiconductor Physics Lab	--	--	--	--	05	20	25
	SPHYP454	Nuclear Physics Lab	--	--	--	--	05	20	25

M.Sc. 1st Semester

SPHYC401: Mathematical Methods in Physics

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics
2. Knowledge of number systems and mathematical operations.

Course objectives:

The main objective of this course is to introduce the students to apply mathematical formulation of mechanics problems and to interpret the solutions physically, to apply the concepts of classical mechanics to the rigid systems and to develop the skill of critical thinking and problem solving.

Course outcomes:

After completion of the course the students shall be able to apply Newton's laws of motion to solve complicated problems involving multiple bodies and use the concepts of classical mechanics to the classical rigid bodies. The knowledge acquired through this course will enable the students to lay the foundation of application of the classical dynamics, space dynamics and also for modern physics.

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Curriculum Details

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Vector Spaces and Matrices**	**15**
	1.1	Linear dependence and independence of vectors, Inner product, Schmidt's orthogonalization method;	
	1.2	Matrices – Inverse, Orthogonal, Hermitian and unitary matrices, Transformation of vectors and matrices;	
	1.3	System of linear equations, eigenvalues and eigenvectors of square matrix, diagonalisation of a matrix, rotation matrix.	
2.0		**Special functions**	**15**
	2.1	Legendre equation, Rodrigues formula for Pn(x), generation functions and recurrence relation, Associated Legendre polynomial;	
	2.2	Bessel equation, Bessel function of first kind, generating functions and recurrence relation, Associated Legendre polynomial;	
	2.3	Hermite Equation, generating function and recurrence relation for Hermite polynomial.	
	2.4	Leguerre equation, generating function and recurrence relation, Rodrigue formula, Associated Lagurre polynomials.	
3.0		**Fourier Series and Integral Transform**	**15**
	3.1	Fourier series: General properties of Fourier series, Simple applications, properties of Fourier series, convergence, integration, differentiation;	
	3.2	Fourier Transform, Laplace Transforms, Properties of	

		Fourier and Laplace transforms (Linearity, first shifting and second shifting property);	
	3.3	Fourier sine and cosine transforms, Fourier and Laplace transform of derivatives, elementary Laplace transform;	
	3.4	Inverse Fourier and Laplace transforms, shifting theorm, step function, Solution of simple differential equation using Laplace Transform technique;	
4.0		**Complex function and Calculus of Complex function**	
	4.1	Definition of complex function, exponential function and properties, circular function and properties, hyperbolic function and properties, Inverse hyperbolic function, logarithmic function;	
	4.2	limit of a complex function, continuity, derivative (theorm), anlytic functions, harmonic functions, complex integration;	**15**
	4.3	Cauchy's theorm, Cauchy's integral formula, Series of complex term-Taylor's series, Laurentz series;	
	4.4	Zeros of an analytical function, Singularities of an analytical function (isolated, removable, poles and essential singularity), Residue Theorm-Calculus of residues.	
		Total	**60**

Text Books:

1. A. W. Joshi, Matrices and Tensors in Physics,
2. Mathematical Physics, B. S. Rajput
3. Higher Engineering Mathematics, By B. S. Grewal.
4. Mathematical Physics, S. L. Kakani.
5. Mathematical Physics, S. Chandra.
6. Advance Engineering Mathematics by H.K. Dass (S. Chand Publication)

Reference Books:

1. Mathematics for Engineers and Physicists (Pipe)
2. Mathematical Methods in Physical Sciences (Massy and Bias)

SPHYC402: Classical Mechanics

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics
2. Students should possess knowledge of mechanics and systems.

Course objectives:

The main objective of this course is to introduce the students to apply mathematical formulation of mechanics problems and to interpret the solutions physically, to apply the concepts of classical mechanics to the rigid systems and to develop the skill of critical thinking and problem solving.

Course outcomes:

After completion of the course the students shall be able to apply Newton's laws of motion to solve complicated problems involving multiple bodies and use the concepts of classical mechanics to the classical rigid bodies. The knowledge acquired through this course will enable the students to lay the foundation of application of the classical dynamics, space dynamics and also for modern physics.

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Curriculum Details

Module No.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0		**Elementary Principles**	**15**
	1.1	Review of Newtonian mechanics, Inertial reference frame; Galilean transformations; Motion of a charged particle in electromagnetic field;	
	1.2	Conservative and non-conservative forces; Mechanics of a single particle; Mechanics of a System of particles; Motion in a resistive medium;	
	1.3	Constraints and its types; Generalized coordinates, cyclic coordinates and degrees of freedom; Virtual displacement and virtual work; D' Alembert's principle.	
2.0		**Lagrangian Formulation**	**15**
	2.1	Lagrangian equation of motion from D' Alembert's principle, procedure for formation of Lagrange's equation; Variation technique; Generalized momenta and cyclic coordinates;	
	2.2	Kinetic energy in terms of generalized coordinates; Jacobi integral; Jacobi integral in terms of kinetic energy; Rayleigh's dissipation function; Gauge transformation for Lagrangian;	
	2.3	Symmetry properties and conservation laws; Invariance of Lagrangian equations under Galilean transformation; Variational principle; Derivation of Lagrangian equation from Variational principle.	

3.0		**Hamiltonian Formulation and Central Force**	**15**
	3.1	Transformation from Lagrangian to Hamiltonian; Derivation of Hamiltonian equations of motion from Hamiltonian principle; Δ Variation technique; Principle of least action; Canonical transformation; Condition for a transformation to be Canonical;	
	3.2	Poisson brackets; Properties of Poisson's bracket; Poisson's bracket of Canonical variables; Jacobi identity; Poisson's theorem; Invariance of Poisson's bracket under canonical transformation; Hamilton-Jacobi method.	
	3.3	Reduction of two-body problem into one-body problem; equation of motion under Central force; equation of Orbit; inverse square law;	
	3.4	Kepler's laws of planetary motion; Virial theorem; Scattering in a central force field; Rutherford scattering cross section.	
4.0		**Rigid body dynamics and small oscillations**	**15**
	4.1	Coordinate systems; Euler's angles; Angular momentum and inertia tensor; Principle axes; Components of angular velocity;	
	4.2	Rotational kinetic energy of a body; Euler's equation of motion for a rigid body; Torque free motion of a rigid body.	
	4.3	Potential energy and equilibrium; Stable and unstable equilibriums; Small oscillations in a system with one degree of freedom;	
	4.4	Small oscillations in a system with more than one degree of freedom; Normal coordinates; Normal modes and normal frequencies of vibration.	
		Total	**60**

Text Books:

1. Classical Mechanics by J. C. Upadhyaya, Himalaya Publishing House, New Delhi
2. Classical Mechanics by V. B Bhatia, Joag, Tata Mc Graw Hill Publishing Co. Ltd., New Delhi
3. Classical Mechanics by P. V. Panat, Joag, Tata Mc Graw Hill Publishing Co. Ltd., New Delhi

Reference Books:

1. Classical Mechanics by S. L Gupta, V Kumar and H. V Sharma Pragati Prakashan Meerut.
2. Classical Mechanics by Suresh Chandra, Narosa Publishing House, New Delhi
3. Classical Mechanics by N. C. Rana and P. S. Joag, Tata Mc Graw Hill Publishing Co. Ltd., New Delhi

SPHYC403: Numerical Techniques and C-Programming

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics
2. Knowledge of computer and programming is essential for numerical analysis.

Course objectives:

The main objective of this course is to introduce students to the useful numerical methods and tools that are being adopted for handling data in Physics. The course also aimed to introduce the students to C-Programming language, which is an essential tool for handling and solving numerical problems in physics.

Course outcomes:

After completion of the course students shall be able to employ the studied numerical techniques to solve problems in physics related to the applications like data handling and fitting, finding solutions and root of equations, solving the differential and integral equations, simultaneous equations and partial differential equations. They shall also be well versed with writing their programmes using C-language of computer programming. Students can apply these learned techniques not only to physics related problems but can extend the use and their applications to Engineering science and technology, Biotechnology, Biophysics etc.

Curriculum Details

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0		**Curve fitting ,interpolation and Roots of equation**	**15**
	1.1	The Principle of Least squares, fitting a straight line, fitting a parabola, fitting an exponential curve, fitting curve of the form $y=ax^b$, fitting through a polynomial, Cubic spline fitting, Linear interpolation, difference schemes, Newton's forward and backward interpolation formula.	
	1.2	Polynomial and transcendental equations, limits for the roots of polynomial equation. Bisectional method, false position method, Newton Raphson method, direct substitution method, synthetic division, complex roots.	
2.0		**Numerical integrations and Solution of differential equations**	**15**
	2.1	Newton cotes formula, trapezoidal rule, Simpson's one third rule, Simpson's three eight rule, Gauss quadratics method, Monte Carlo method.	
	2.2	Taylor series method, Euler method, Runge Kutta method, predictor-corrector method.	

3.0		**Solution of simultaneous equation, Eigen values and eigenvectors of a matrix and Partial differential equations.**	**15**
	3.1	Gaussian elimination method, pivotal condensation method, Gauss-Jordan elimination method, Gauss-Seidal iteration method, Gauss-Jordan matrix inversion method, Gaussian-elimination matrix inversion method.	
	3.2	Computation of real eigen values and corresponding eigenvectors of a symmetric matrix, power method and inverse power method.	
	3.3	Difference equation method over a rectangular domain for solving elliptic, parabolic and hyperbolic partial differential equation	
4.0		**C- Programming**	**15**
	4.1	Elementary information about digital computer principles, compliers, interpreters, and operating systems, C programming, flow charts, integer and floating point arithmetic, expression, build in functions, executable and non-executable statements, assignment, control and input-output elements, user defined functions, operation with files: pointers	
	4.2	**Random numbers**: Random numbers, Random walk, method of importance sampling.	
		Total	**60**

Reference Books:

1. H. M. Antia: Numerical methods for scientists and engineers.
2. Suresh Chandra Computer Applications in Physics with FORTRAN, BASIC and C, Narosa Publishers
3. Vetterming, Teukolsky, press and Flannery: Numerical recipes.
4. Sastry: Introductory method of numerical analysis.
5. Rajaraman: Numerical analysis.
6. Numerical Computational methods, P. B. Patil and U. P. Verma.
7. Numerical methods and computation – B. K. Bafna.
8. Advanced engineering mathematics – Erwin Kreszing 5^{th} or 7^{th} edition john Willey and sons inc.
9. C Programming : Balgurusamy
10. Suresh Chandra Applications of Numrical Techniques with C Narosa Publishers.

SPHYE401: Electronic Devices

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics
2. Knowledge of basic electronic devices and gadgets operations and principles

Course objectives:

This paper covers the construction and working of analog and digital electronic devices, which are utilized by us in day to day life while using mobile phone, television, microwave, calculators, computer, etc. This paper is designed with an objective to expose students to the basics and advances of the electronic device technology and to inculcate them towards future device technology/research.

Course outcomes:

At the completion of this course, students will be able to explain the working and application of devices in various electronic circuits used at home/industries.

Curriculum Details

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0		**Semiconductor Devices**	**12**
	1.1	Fundamentals of semiconductor	
	1.2	Classification based on band gap (insulator, conductor, and semiconductor), n-type and p-type semiconductors.	
	1.3	Structure and characteristics of p-n junction diodes, and bipolar transistors	
	1.4	Structure and characteristics of field effect transistor, metal oxide field effect transistor, uni-junction transistors, silicon control rectifier, and gun diode.	
2.0		**Photonic Devices**	**12**
	2.1	Basics of photonic devices, Direct and indirect band gap of the semiconductor, radiative transitions,	
	2.2	Photoconductors, photodiodes, phototransistors, and photo-detectors (construction, working, and application),	
	2.3	Light emitting diodes (Visible and Infrared), solar cells (Solar radiations and ideal conversion efficiency P-N junction solar cell, spectral response, I-V characteristics)	
3.0		**Operational Amplifier**	**11**
	3.1	OP-AMP parameters, ideal OP-AMP, differential amplifier	
	3.2	OP-AMP as; Inverting amplifier, non–Inverting amplifier, adder, subtractor, differentiator, integrator, Schmitt trigger, and comparator	
	3.3	OP-AMP as: High, low, and bandpass active filters.	
	3.4	Monostable and astable multivibrators using IC555	

4.0		**Digital Electronics**	**15**
	4.1	Number system: Binary, decimal, and hexadecimal no. system and its algebra,	
	4.2	Logic devices: AND, OR, NOR, NAND, XOR (symbols, working and truth tables)	
	4.3	Registers: Flip–flop-R-S, J-K, T, D (logic symbols, working and truth tables)	
	4.4	Applications of logic devices as; Shift registers, Synchronous and asynchronous counters, Encoder and decoder (8:3 and 3:8), Multiplexer and demultiplexer (4:1 and 1:4), DAC: R-2R ladder network, ADC using comparators and introduction to 8085 microprocessor.	
		Total	**45**

Text Books:

1. V K Mehta “Principles of electronics”, S. Chand Publishing, 2022.
2. Donald P Leach and Albert Paul Malvino “Digital Principles and Applications (SIE)” Tata McGraw Hill Education Private Limited NEW DELHI
3. Floyd Thomas L. “Digital Fundamentals” Pearson Education India
4. Anil K. Maini “Digital Electronics Principles, Devices and Applications” John Wiley & Sons

Reference Books:

1. Thomas F. Schubert Jr. and Ernest M. Kim “Fundamentals of Electronics” Morgan and Claypool Life Sciences
2. B. L. Theraja “Basic Electronics: Solid State” S. Chand Publishing, 2007
3. B. Ghosh “Fundamentals Principles of Electronics” Books & Allied Ltd

SPHYP401: General Electronic Laboratory

Course pre-requisite:

1. Knowledge of Principles of work
2. Basic information about instruments, gadgets etc.
3. Knowledge of precautionary measures.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understudying of the topic studies in Physics lesson.
- To allow hand on experiments to learn and understand fundamental principle of operation.
- To develop the scientific attitude amongst student.

Course outcomes:

✓ Students will be able to understand different concepts and principles of Physical instrumentations.

✓ Student will learn about validity of concepts by doing the experiment.

Sr. No	*Name of Experiment*
1.	p-n junction diode characteristics and studying clipping and clamping circuit.
2.	Transistor characteristics, biasing and its application as amplifier.
3.	FET characteristics, biasing and its application as amplifier.
4.	MOSFET characteristics, biasing and its application as amplifier.
5.	UJT characteristics and its application as oscillator.
6.	SCR characteristics and its application as half wave and full wave rectifier.
7.	Photodiode or LDR characteristics.
8.	Phototransistor characteristics.
9.	Active filters (low pass, high pass and band pass).
10.	OP-AMP as inverting and non-inverting amplifiers.
11.	OP-AMP as adder, differentiator and integrator.
12.	Multivibrators (monostable, bistable and astable) using IC 555.
13.	Design of a Regulated Power Supply.

SPHYP402: Digital Electronic Laboratory

Course pre-requisite:

1. Knowledge of Principles of work
2. Basic information about instruments, gadgets etc.
3. Knowledge of precautionary measures.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understudying of the topic studies in Physics lesson.
- To allow hand on experiments to learn and understand fundamental principle of operation.
- To develop the scientific attitude amongst student.

Course outcomes:

✓ Students will be able to understand different concepts and principles of Physical instrumentations.

✓ Student will learn about validity of concepts by doing the experiment.

Sr. No.	***Name of experiment***
1.	Verification and interpretation of truth tables for AND, OR, NOT and NAND gates
2.	Realization of logic functions with the help of universal gates-NAND Gate.
3.	Realization of logic functions with the help of universal gates-NOR Gate.
4.	Construction of a NOR gate latch and verification of its operation.
5.	Implementation and verification of truth table for J-K flip-flop, D flip-flop and T flip-flop.
6.	Design and implementation of shift register to function as i) SISO, ii) SIPO, iii) PISO, iv) PIPO, v) shift left and vi) shift right operation.
7.	Design and implementation of i) Ring counter, ii) ripple counter.
8.	Parallel adder / subtractor using IC 7483.
9.	Code convertors using encoders and decoders.
10.	Design and set up a 4:1 Multiplexer and 1:4 demultiplexer.
11.	Basic programming of microprocessor 8085.

SPHYP403: Numerical Technique Laboratory

Course pre-requisite:

1. Knowledge of Principles of work
2. Basic information about numerical techniques.
3. Knowledge of computer utilizations and programming.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understudying of the topic studies in Physics lesson.
- To allow hand on experiments to learn and understand fundamental principle of operation.
- To develop the scientific attitude amongst student.

Course outcomes:

✓ Students will be able to understand different concepts and principles of Physical instrumentations.

✓ Student will learn about validity of concepts by doing the experiment.

Sr. No.	***Name of experiment***
1.	Lagrange's Interpolation
2.	Solution of differential equation using Euler's method
3.	Solution of differential equation using Runge-Kutta method
4.	Finding the roots of quadratic equation.
5.	Finding roots of a polynomial equation using Bisectional method
6.	Gauss elimination method
7.	Integration by trapezoidal rule
8.	Integration by Simpson rule
9.	Linear least square fitting

SPHYP404: C-programming laboratory

Course pre-requisite:

1. Knowledge of Principles of work
2. Basic information about numerical techniques.
3. Knowledge of computer utilizations and programming.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understudying of the topic studies in Physics lesson.
- To allow hand on experiments to learn and understand fundamental principle of operation.
- To develop the scientific attitude amongst student.

Course outcomes:

✓ Students will be able to understand different concepts and principles of Physical instrumentations.

✓ Student will learn about validity of concepts by doing the experiment.

Sr. No.	***Name of experiment***
1.	Factorial
2.	Largest number
3.	Addition of matrix
4.	File handling
5.	Addition of matrix by using file handling
6.	Addition of series
7.	Ascending order
8.	Eigen values & Eigen vectors of real asymmetric 2 X2 matrix.
9.	Generation of Random numbers
10.	Power method

M.Sc. 2nd Semester

SPHYC451: Quantum Mechanics

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics
2. Knowledge of basic concepts of mechanics and systems.

Course objectives:

The main objective of this course is to introduce the students to apply mathematical formulation of mechanics problems and to interprete the solutions physically, to apply the concepts of classical mechanics to the rigid systems and to develop the skill of critical thinking and problem solving.

Course outcomes:

After completion of the course the students shall be able to apply Newton's laws of motion to solve complicated problems involving multiple bodies and use the concepts of classical mechanics to the classical rigid bodies. The knowledge acquired through this course will enable the students to lay the foundation of application of the classical dynamics, space dynamics and also for modern physics.

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Curriculum Details

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Basics Of Quantum Mechanics**	**15**
	1.1	Derivation of time dependent and time independent Schrodinger equation, Physical significance of wavefunction, Quantum numbers, Postulates of Quantum Mechanics ;	
	1.2	Commutation relations for position and momentum operator, Dirac Delta function and its properties, Ket and Bra notations, Completeness of Eigen functions;	
	1.3	Matrix representation of an operator, Unitary Transformation.	
2.0		**Angular Momentum**	**15**
	2.1	Angular momentum and rotations, Orbital angular momentum, Spin angular momentum, Rotational symmetry and conservation of angular momentum;	
	2.2	Commutation relations for Spin, orbital and total angular momentum, Ladder operators, eigen values of the angular momentum operators; L2 , Lz, J2 , Jz, J+ and J-;	
	2.3	Reflection invariance and Parity, Addition of two angular momenta– Clebsch –Gorden Coefficient , calculation of C.G.coefficient;	
3.0		**Approximation methods**	**15**
	3.1	**Time independent Perturbation Theory:** Stationary perturbation theory, Non-degenerate case; First order	

		correction to energy, First order correction to wave function, Second order perturbation, and corrections, Stark effect in the ground state of hydrogen atom, Time independent perturbation theory: degenerate case, application for the He atom, degenerate case – Stark effect.	
	3.2	**Time dependent perturbation Theory:** Zero order perturbation, First order perturbation, second order perturbation, Fermi Golden rule, adiabatic and sudden approximation.	
	3.3	**Variational Method:** The basic Principle, expectation value of energy in ground state, application to excited state, application to two electrons atom,	
	3.4	**WKB approximation:** The classical limit, One dimensional case, turning point, connection formulae, the application to bound state	
4.0		**Collision in 3-d and Scattering**	
	4.1	Laboratory and Centre of Mass reference frames, scattering amplitude, differential scattering cross section, total scattering cross section, Asymptotic form of scattering states,	**15**
	4.2	Relation between angles and cross sections in the laboratory and center of mass systems, Scattering by spherically symmetric potentials, Integral equation of scattering,	
	4.3	The Born approximation, Partial Waves and Phase shifts, Scattering by a perfectly rigid sphere and by square well potential, Complex potential and absorption.	
	4.4	Identical particles, symmetric and asymmetric wave functions and their construction for N particle system, Slater's determinant, Collision of identical particles (Mathematical derivations are not expected)	
		Total	**60**

Text Books:

1. 1.Quantum mechanics - Ghatak and Loknathan
2. Modern quantum mechanics - J. J. Sakurai (Addison Wesely)
3. Quantum Mechanics - G.Aruldhas

Reference Books:

1. Quantum mechanics - L. I. Schiff (McGraw Hill)
2. Quantum mechanics (concepts and Application)- Nouredine Zettili
3. Perspectives of Modern Physics (Arthur Beiser (McGraw-Hill Int.Edition)
4. Quantum mechanics - A. P.Messiah

SPHYC452: Statistical Mechanics

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics
2. Knowledge of basic concepts of mechanics and systems.

Course objectives:

The main objective of this course is to make students aware of studying physical properties of matter "in bulk" on the basis of dynamical behavior of its microscopic constituents. Fundamentals of heat and laws of thermodynamics with the help of statistics will be covered in order to obtain physical properties on the basis of distribution laws including their applications in view of classical and quantum statistics. The course also includes basics of phase transition with their applications.

Course outcomes:

The main outcome after learning the course is that students can apply and extend concepts learned in this course to theoretical physics. Students will be well acquainted with the particle nature on the basis of distribution laws and their uses in order to illustrate properties of most exotic systems like white dwarf stars, superfluid materials, etc.

Curriculum Details

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0		**Classical Statistics**	**15**
	1.1	**Fundamentals** Foundation of statistical mechanics, specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox	
	1.2	**Ensembles** Micro canonical ensemble; phase space; trajectories and density of states; Liouville's theorem; Canonical ensemble and Grand Canonical ensemble; partition function, Calculation of statistical quantities, Energy and density fluctuations.	
	1.3	**Maxwell-Boltzmann Statistics** Maxwell-Boltzmann System: Maxwell-Boltzmann distribution formula; Evaluation of constants α and β, Maxwell-Boltzmann velocity distribution formula;	
2.0		**Quantum Statistics**	**15**
	2.1	Density matrix, statistics of ensembles, statistics of indistinguishable particles.	

	2.2	**Fermi-Dirac Statistics** Fermi-Dirac Gas:- Fermi Dirac distribution formula, ideal F.D. gas, Weakly degenerate Fermi gas; Strongly degenerate Fermi gas; thermodynamic functions of degenerate F.D. gas,	
	2.3	Thermionic emission; electron gas, Free electron model, Photo electric emission, Pauli's theory of Para magnetism, Statistical equilibrium in a white dwarf star.	
3.0		**Bose-Einstein Statistics and condensation phenomenon**	**15**
	3.1	**Bose-Einstein Statistics** Bose-Einstein Gas :-Bose-Einstein distribution formula, Ideal B.E. gas,	
	3.2	Black body radiation, Photon statistics, Phonon statistics,	
	3.3	B.E. condensation, liquid helium, London Theory, Tisza's two fluid model, Landau's theory.	
4.0		**Theory of Imperfect gas and Phase Transitions**	**15**
	4.1	**Cluster Exapansion** Cluster expansion for a classical gas, Virial equation of state, Ising model, mean field theories, Ising model in one, two, three dimensions, and exact solution of one dimensions.	
	4.2	**Phase Transitions** Landau's theory of phase transition, Critical indices.	
	4.3	Fluctuations and transport phenomena, Brownian motion, Langevin's theory, fluctuation dissipation theorem, The Fokker-Plank equation	
		Total	**60**

Reference Books:

1. Statistical Mechanics by R. K Patharia, Pregamon Press, Oxford
2. Statistical Mechanics by J. K Bhaltacharjee, Allied Pubishers Limited, New Delhi
3. Fundamentals of Statistical Mechanics and thermal Physics by F. Reif, McGraw- Hill International Editions
4. Statistical Mechanics by S. K Sinha, Tata M2 Graw-Hill Publishing Co. Ltd. New Delhi
5. Statistical Mechanics by Suresh Chandra, CBS Publishers & Distributors, New De
6. Statistical Mechanics by K. Haung (2008) Wiley.
7. Statistical mechanics by R. K. Pathria and P. D. Beale, (2011) Elsevier.
8. Statistical Mechanics by D. A. Mcquarrie, (2018) Viva Books.
9. Introduction to Statistical Mechanics, by D. Chandler, (1987) Oxford University Press.

SPHYC453: Condensed Matter Physics-I

Course pre-requisite:

1. M.Sc. Ist sem Physics students
2. Basic knowledge about materials properties and types

Course objectives:

The main objective is to provide an overview of different types of materials and illustrate how their properties depend on the microscopic structure. The course will deliver basic knowledge about the materials, its crystal and electronic structure.

Course outcomes:

After completing the course students will have knowledge of different types of solids and their microscopic structure. In addition to this they will understand the effect of microscopic structure on transport of charges through it.

Curriculum Details

oduleNo.	UnitNo.	Topic	Hrs. Required to cover the contents
1. 0		**Crystal structure**	**15**
	1.1	Basic of crystal structure, Bravais lattices in two and three dimension, packing fraction, symmetric properties and coordination number.	
	1.2	Some important crystal structure: Simple cubic (SC), body centered cubic (BCC), face centered cubic (FCC), hexagonal close packed (HCP), NaCl and diamond structure	
	1.3	Miller indices and spacing between set of a crystal planes.	
2.0		**X-ray diffraction and Crystal defects**	**15**
	2.1	Generation and interaction of X-ray and Braggs law, X-ray Diffraction methods: Laue method, Rotating crystal method and power method	
	2.2	The Reciprocal lattice and its properties, Reciprocal lattices of simple, body centered and face centered cubic lattices	
	2.3	Crystal defects: Point defects, line defects and surface defects	
3.0		**Band theory**	**15**
	3.1	Electron motion in crystal (one dimensional), Density of states and Fermi-Dirac statistics	
	3.2	Bloch theorem and its implementation in Kroning-penny model, Concept of effective mass of electron	
	3.3	Distinguish between metal, insulator and semiconductor	

		using band theory	
	3.4	Free electron model, nearly free electron model, tight binding approximation, orthogonalized plane wave model and pseudopotential model.	
4.0		**The Fermi surface**	**15**
	4.1	Fermi surface and Brillouin zones,	
	4.2	Fermi surface in metals	
	4.3	Characteristics of Fermi surface	
	4.4	Experimental determination of Fermi surface	
		Total	**60**

Text Books:

1. A. J. Dekker "Solid State Physics" Springer Link 1969
2. B. S. Saxena "Solid State Physics" Pragati Prakashan 2013
3. S. O. Pillai "Solid State Physics" NEW AGE International Pvt Ltd 2022

Reference Books:

1. L. Azaroff "Introduction To Solids" McGraw Hill Education; New edition (2017)
2. Charles Kittle "Introduction to Solid State Physics" Wiley; Eighth edition (2012)
3. Omar Ali "Elementary solid state physics", Pearson India; 1st edition (2002).

SPHYE451: Atomic and Molecular Physics

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics.
2. Knowledge about materials properties and characterization techniques

Course objectives:

Atomic and molecular physics is of great importance and very basic field in physics. The basic of all matter, which exist in nature, is based on atomic and molecular structure. It is one of the most important subjects for the testing grounds of the quantum theory. Specific objectives are:

- To introduce the world of atoms and molecules to the students.
- To focus on development of various atomic models and to explain the importance and application of Bohr atomic model for atomic spectra of hydrogen like atoms.
- To shed light on various basic concepts like vector atomic model, introduction of spin, coupling schemes for many electron atoms, term symbols to designate quantum states.
- To bring into notice the basic concepts of molecular spectroscopy and their types, origin of rotational, vibrational , electronic and Raman spectra of various molecules and to explain the importance of polymeric materials to humanity and molecules
- To introduce the working principle of various spectroscopic techniques and instrumentation used for analyzing spectra of various types of molecules.

Course outcomes:

Upon successful completion of these modules, students will be able to understand and explain the following;

- ✓ The atomic spectra of one valance electron atoms.
- ✓ what is meant by LS and JJ coupling in case of two valance electron atoms and the origin of spinorbit interaction
- ✓ Use appropriate quantum numbers for labeling of energy levels/terms symbols.
- ✓ The change in behavior of atoms in external applied electric and magnetic field.
- ✓ Diatomic molecules, the origin of electronic, vibrational and rotational energy levels, calculate energy levels,
- ✓ Analyze rotational, vibrational, electronic and Raman spectra of molecules
- ✓ To undertake simple calculations of bond lengths, rotational constant, dissociation energy, and relative level populations

Curriculum Details

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0		**Atomic structure and atomic spectra**	**15**
	1.1	**Spectra of Monovalent atoms** Quantum mechanical results of hydrogen atom, Atomic spectra of Hydrogen, Quantum numbers and their role, atomic orbitals, orbital and spin angular momenta., spin orbit interaction, vector atom model, spectroscopic terms and their notations, Fine structure in hydrogen energy levels, spectra of alkali elements, different series in alkali spectra. The doublet fine structure.	
	1.2	**Spectra of Divalent atoms** Coupling scheme, L-S and j-j coupling, Building up principle: the Aufbau principle, Equivalent and non-equivalent electrons: Pauli's exclusion principle, Hund's rules. spectral terms, Breit's scheme.	
	1.3	**Magnetic and electric field effects** Normal and anomalous Zeeman effect, Lande g factor, Interaction energies's, Paschen Back effect, interaction energy, co-relation between Zeeman and Paschen Back effects, Stark effect with weak and strong field, Hyperfine structure	
2.0		**Microwave Spectroscopy of Molecules**	**15**
	2.1	Preliminaries, Types of molecules	
	2.2	Diatomic molecules -Rotational spectra of diatomic molecule, Rigid rotator and Non-rigid rotator, energy levels, selection rules and resulting spectra, the effect of isotopic substitution, Intensities of spectral lines in rotational spectra	
	2.3	Polyatomic molecules - Linear molecules, determination of inter-atomic distances using isotopic substitution, Symmetric top molecules: calculation of energy, selection rule, spectra. Microwave spectrometer, problem solving	
3.0		**Infrared and Electronic spectroscopy of molecules**	**15**
	3.1	**Vibrational spectroscopy of diatomic molecules** Vibrational energy of diatomic molecule, the simple harmonic oscillator model energy The anharmonic oscillator, Morse potential curve, Energies, selection rules, spectra, frequencies of fundamental and overtones and hot band The diatomic vibrating rotator with and without Born-Oppenheimer approximation, energy levels, selection rules, P, Q and R branches.	
	3.2	**Polyatomic molecules** Fundamental vibrations and their symmetry, CO2 and H2O molecules, techniques and instrumentations, IR spectrometer	
	3.3	Electronic spectra of diatomic molecules Born-Oppenheimer approximation, vibrational coarse structure	

		of electronic bands, progressions and sequences, P, Q and R branches. The band head formation and shading of bands, Franck Condon principle, dissociation energy and dissociation products	
4.0		**Raman spectroscopy of molecules**	**15**
	4.1	Introduction, quantum theory of Raman effect, classical theory of Raman effect, molecular polarizability,	
	4.2	**Pure rotational Raman spectra** linear diatomic molecules, intensity alteration in Raman spectra of diatomic molecules, Raman spectra of symmetric top molecule, R and S branches in Raman spectra	
	4.3	**Vibrational Raman spectra** Raman activity of vibrations (H2O and CO2 molecules), rule of mutual exclusion, nature of polarized light, structure determination from Raman and infra-red spectroscopy, Experimental setup for Raman spectroscopy	
		Total	**60**

Text Books:

1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell (Tata MacGrawHill, New Delhi)
2. Spectra of Atoms and Molecules by Peter Bernath (Oxford Uni. Press, USA)
3. Introduction to Atomic Spectra by H. E. White (Tata McGraw Hill, New Delhi)
4. Spectroscopy Vol. 1, 2 & 3 by Straughan B. P. and Walker M. A. (Chapman and Hall, London)
5. Atoms, Molecules and Lasers by K. P. Rajappan Nair (Narosa Publishing House, Delhi)

Reference Books:

1. Atomic Spectroscopy by K. P. Rajappan Nair (MJP Publishers, Chennai)
2. Atom, Laser and Spectroscopy by S. N. Thakur, D. K. Rai (PHI Learning Private Ltd., Delhi) Faculty of Science, M.Sc. Physics Syllabus (2016) Page 18
3. Elements of Spectroscopy by Gupta-Kumar-Sharma (PragatiPrakashan, Meerut
4. Atomic Spectra and Atomic Structure by G. Herzberg, New York Dover Publication 1944
5. Introduction to Molecular spectroscopy by C. M. Barrow

SPHYE451: *Computational Physics*

Course pre-requisite:

1. B. Sc. Students with Physics and Mathematics
2. Sound background of Python language

Course objectives:

This paper covers techniques used in modeling physical systems numerically and analyzing data. It is designed to help the students gain experience with programming languages in carrying out this work and use of computer programming to solve scientific problems in physics and related areas.

Course outcomes:

After completion of this course, students can get knowledge about how to solve problems in physics using computer programming and simulation.

Curriculum Details

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1. 0		**Approximations and Errors in Computation**	**11**
	1.1	Approximate numbers and Significant Figures, rounding off errors, Mathematical Preliminaries,	
	1.2	Types of errors, general formula, Formula to the fundamental operations of arithmetic and logarithms	
	1.3	Accuracy in the evaluation of formula, error in series approximation, floating point arithmetic.	
2.0		**Introduction to Numerical Methods**	**11**
	2.1	Basics of Linear algebra, matrices and vectors,	
	2.2	Interpolation and curve fitting	
	2.3	Numerical Integration and Ordinary differential equations	
3.0		**Introduction to Python, Simulation, Particle and Planetary motions and dynamics of many particle systems**	**12**
	3.1	Introduction to Python	
	3.2	Optimization techniques	
	3.3	Simulating single particle motion and visualizing trajectories in 2D and 3D	
	3.4	Planetary motions and other few body problems	
4.0		**Monte Carlo Simulation**	**11**
	4.1	Deterministic randomness , Random sequences (theory), Random number generation (algorithm)	
	4.2	Implementation: Random Sequence, Assessing randomness and uniformity	

	4.3	Monte Carlo Applications: A random walk problem, Random walk simulation, Implementation: Random walk, Radioactive decay (Problem), discrete decay (model), continuous decay (model), decay simulation with Geiger counter sound.	
		Total	**45**

Reference Books:

1. Computational Physics Problem Solving with Computers; Rubin H. Landau Manuel Jose Paez, Cristian C. Bordeianu
2. An Introduction to Computer Simulation Methods Applications to Physical System Harvey Gould, Jan Tobochnik, and Wolfgang Christian
3. Numerical analysis by Bhupendra Singh
4. Numerical Methods In Engineering & Science by Dr. B.S. Grewal
5. H. M. Antia: Numerical methods for scientists and engineers.
6. Sastry: Introductory method of numerical analysis.
7. Rajaraman: Numerical analysis.
8. Numerical Computational methods, P. B. Patil and U. P. Verma.
9. Numerical methods and computation – B. K. Bafna.
10. Advanced engineering mathematics – Erwin Kreszing 5^{th} or 7^{th} edition john Willey and sons inc.
11. Suresh Chandra Applications of Numrical Techniques with C Narosa Publishers.

SPHYP451: Spectroscopy Laboratory Experiments

Course pre-requisite:

1. Knowledge of Principles of work
2. Basic information about spectroscopic instruments, gadgets etc.
3. Knowledge of precautionary measures, light theory etc.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understudying of the topic studies in Physics lesson.
- To allow hand on experiments to learn and understand fundamental principle of operatation.
- To develop the scientific attitude amongst student.

Course outcomes:

✓ Students will be able to understand different concepts and principles of Physical instrumentations.

✓ Student will learn about validity of concepts by doing the experiment.

Sr. No.	***Name of experiment***
1.	Michelson Interferometer
2.	Talbott's Bands
3.	Constant deviation spectrometer
4.	Hartmann dispersion formula
5.	λ by biprism
6.	Polarizibility of liquids

SPHYP452: Solid State Physics Laboratory Experiments

Course pre-requisite:

1. Knowledge of Principles of work
2. Basic information about materials properties and instrumentation handling etc.
3. Knowledge of analysis of properties is must.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understudying of the topic studies in Physics regrading materisl properties.
- To allow hand on experiments to learn and understand fundamental principle of operation and analysis of properties.
- To develop the scientific attitude amongst student.

Course outcomes:

✓ Students will be able to understand different concepts and principles of Physical instrumentations.

✓ Student will learn about validity of concepts by doing the experiment.

Sr. No.	***Name of experiment***
1.	To study the variation of energy band gap (Eg) of diode with temp.
2.	Determination of electronic charge by investigating rectifier equation of solid state diode.
3.	Determination of dielectric const. of liquids.
4.	Determination of elastic const. using piezoelectric effect.
5.	Determination of Specific Heat of Solids.
6.	Conductivity and resistivity of graphite rod.
7.	Determination of Fermi energy of metals.
8.	Determination of Boltzmann Constant

SPHYP453: Semiconductor Physics Laboratory

Course pre-requisite:

1. Knowledge of Principles of electronic devices working.
2. Basic information about semiconductors and properties.
3. Knowledge of precautionary measures, electricity is essentials.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understanding about electronic devices and semiconductors.

Course outcomes:

- ✓ Students will be able to understand different concepts and principles of Physical instrumentations.
- ✓ Student will learn about validity of concepts by doing the experiment.

Sr. No.	*Name of experiment*
1.	Determination of Hall co-efficient, number of majority carriers and type of a given semiconductor specimen
2.	Temperature dependence of current of p-n junction diode – estimation of band gap of semiconductor materials
3.	Determination of resistivity and band gap of semiconductors using Four Probe Method
4.	To study the band gap of thermister
5.	To determine value of Planks constant using LED
6.	Determination of dielectric constant of some dielectric materials

SPHYP454: Nuclear Physics Laboratory

Course pre-requisite:

1. Knowledge of Principles of Nuclear physics.
2. Basic information about nuclear fusion and fissions.
3. Knowledge of precautionary measures, handling is essentials.

Course objectives:

- The main objective of practical course is to engage the student in the subject and help them get a better understanding about nuclear physics and technologies.
- To make aware about the use of nuclear methodologies for human welfare.

Course outcomes:

✓ Students will be able to understand different concepts and principles of Physical instrumentations.

✓ Student will learn about validity of concepts by doing the experiment.

Sr. No.	***Name of experiment***
1.	Study the characteristics of a GM tube and determination of its operating voltage.
2.	Determination of the dead time using single source.
3.	Study of nuclear counting statistics.
4.	Verification of Inverse square law for γ- rays.
5.	Attenuation of β- rays
6.	Measurement of short half-life.
7.	Measurement of long half-life.
8.	Calibration of Gamma-ray spectrometer using Cesium and Cobalt 60 sources.
9.	Determination of energy of any unknown gamma source

Course Assessment:

A. Continuous Assessment (CA) (20% of the Maximum Marks):

This will form 20% of the Maximum Marks and will be carried out throughout the semester. It may be done by conducting **Two Tests** (Test I on 40% curriculum) and **Test II** (remaining 40% syllabus). Average of the marks scored by a student in these two tests of the theory paper will make his **CA** score (col 6).

B. End Semester Assessment (80% of the Maximum Marks):

(For illustration we have considered a paper of 04 credits, 100 marks and need to be modified depending upon credits of an individual paper)

1. **ESA Question paper will consists of 6 questions, each of 20 marks.**
2. **Students are required to solve a total of 4 Questions.**
3. **Question No.1 will be compulsory and shall be based on entire syllabus.**
4. Students need to solve **ANY THREE** of the remaining Five Questions (Q.2 to Q.6) and shall be based on entire syllabus.

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