।। सा विद्या या विमुक्तये ।।

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

"ज्ञानतीर्थ" परिसर, विष्णुपुरी, नांदेड - ४३१६०६ (महाराष्ट्र)

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY NANDED

"Dnyanteerth", Vishnupuri, Nanded - 431606 Maharashtra State (INDIA)

Established on 17th September 1994 – Recognized by the UGC U/s 2(f) and 12(B), NAAC Re-accredited with 'A' Grade

ACADEMIC (1-BOARD OF STUDIES) SECTION

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प्रस्तुत विद्यापीठाच्या भौतिकशास्त्र संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील प्रथम वर्षाचा CBCS Pattern नुसारचे अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, **दिनांक २० जून २०२० रोजी संपन्न झालेल्या ४७व्या मा. विद्या परिषद बैठकीतील ऐनवेळेचा विषय क्र.१४/४७—२०२०** च्या ठरावानुसार **प्रस्तुत विद्यापीठाच्या भौतिकशास्त्र संकुलातील विज्ञान व तंत्रज्ञान विद्याशाखेतील पदव्युत्तर स्तरावरील प्रथम वर्षाच** खालील विषयांचा **C.B.C.S. (Choice Based Credit System) Pattern** नुसारचा अभ्यासक्रम शैक्षणिक वर्ष २०२०—२१ पासून लागू करण्यात येत आहेत.

01. M.Sc.-I Year-Energy Studies

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

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड — ४३१ ६०६.
जा.क्र.: शैक्षणिक—१/परिपत्रक/पदव्युत्तर(संकुल)—सीबीसीएस अभ्यासक्रम/२०२०—२१/५९२
दिनांक : २४.०८.२०२०.

स्वाक्षरित/—
उपकुलसचिव
शैक्षणिक (१—अभ्यासमंडळ) विभाग

प्रत माहिती व पुढील कार्यवाहीस्तव :
१) मा. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मूल्यमापन मंडळ यांचे कार्यालय, प्रस्तुत विद्यापीठ.
३) मा. संचालक, भौतिकशास्त्र संकुल, प्रस्तुत विद्यापीठ.
४) साहाय्यक कुलसचिव, पदव्युत्तर विभाग, प्रस्तुत विद्यापीठ.
५) उपकुलसचिव, पात्रता विभाग, प्रस्तुत विद्यापीठ.
६) सिस्टम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ.

SWAMI RAMANAND TEERTH MATHAWADA UNIVERSITY, NANDED

Syllabus of M. Sc. Renewable Energy (CBCS)

(Effective from the Academic Year 2020-2021)

Disclaimer

Syllabus of ***M. Sc. Renewable Energy (Campus School)*** *given in this document was prepared following requirements of the* ***Choice Based Credit System (CBCS)*** *pattern as recommended by* ***UGC, New Delhi,*** *and has been duly approved by the* ***Faculty of Science and Technology, the Academic Council*** *and the* ***Management Council*** *of* ***S.R.T.M. University****. The same has been implemented from the academic year* ***2020-2021****.*

The Board of Studies in Physics of S. R. T. M. University, Nanded is as follows

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Mr. Dayanand Mane, Yog Kunj, 15, Sudashan Nagar, Pipri Meghe, Wardha Contact No.	**Dr. K. M. Jadhav,** *Professor*, Department of Physics, Dr.B.A.M.University, Aurangabad Contact No. 09422686061 Email: drjadhavkm@gmail.com
Dr. Tarun Sourdeep Ghosh, *Professor H,* IUCAA, Ganeshkhind, Pune Contact No. 020 25604212 Email: tarun@iucaa.in	**Dr. A. G. Bidwe,** Professor & Registrar, Sharanbasawa University, Kalburgi, Karnataka Contact No. 09243219188, email: agbidve@gmail.com
Ms. Aishwarya V. Patil, *Invitee Member, Students Representative (UG)*	**Mr. Nand Kiran Kishor,** *Invitee Member, Students Representative (PG)*

Preamble:

Master of Science (M Sc) Renewable Energy is a post graduation, two year, four semester course of S.R.T.M. University, Nanded. The Credit Based Grading System (CBCS) adopted under this course enables its stakeholders (the students) to develop a strong foundation of the fundamental Physics and also elevates their knowledge base to apply these foundations to the applied and advanced electives, specializations of their own choices. The students pursuing this course will develop in-depth understanding of various aspects of the core subjects of Physics by developing the deeper understanding level of different analogies, laws of the Nature through the subjects like quantum mechanics, electrodynamics, condensed matter physics, atomic and molecular physics, nuclear physics, etc. The course also helps the students in enhancing their analytical skill through the embedded component of the problem solving skills, seminar activities and hands-on and minds-in activities of the course. The courses offered by the University are of student-centric nature and help them to understand the basic laws of nature and develop necessary skills to apply them to the advanced areas of studies.

Outline of the M. Sc. Renewable Energy Program (Choice Based Credit System):

Students of M Sc Renewable Energy program are required to complete a total of 100 credits to acquire M Sc Renewable Energy degree. These required 100 credits constitute following components:

i. Core Courses: Every student completing post graduation in Renewable Energy from this university is required to have a comprehensive knowledge of few of the core or compulsory courses**, which includes classical mechanics, quantum mechanics, statistical mechanics, electrodynamics, nuclear physics, etc. and the related practical courses.** There shall be **ten** such theory papers (four each in first and second semesters and one each in third and fourth semester) and corresponding laboratory courses distributed over the span of four semesters. These courses are designed and upgraded looking at the recent developments in the subject and are inducted in the course so as to prepare the students to apply the acquired knowledge in various skill based advanced elective courses. This forms about **70%** of the total credits of M Sc Renewable Energy Program.

ii. Elective: Students have freedom to earn remaining 30% credits by opting courses of their own choice. The available elective courses are of two different natures: **a. Discipline Specific Electives** or **Skill Enhancement courses** and **b. Open or Generic Electives**.

a. Skill Enhancement or Specialization Courses: These courses are aimed at providing advanced knowledge in specialized courses, where the students can employ the fundamental knowledge that they have acquired through the core courses. These courses are of advanced nature and enable the students to acquire highest level skills in the fields of **Renewable Energy**. As these courses are primarily of **do-it-yourself** and **hands-on-training** type, therefore, students are expected to devote much of their time in laboratory activities in addition to the conventional classroom teaching. Therefore, roughly half of the time allocated to this course shall be utilized for the classroom teaching, imparting instructions, etc., while remaining half shall be utilized by the students in developing their skills through the hands-on exercises. The exercises to be undertaken for this purpose shall be of different nature than that of their regular laboratory / practical courses. There shall be four such skill enhancement courses offered by the School each of four theory papers and related laboratory courses and will be spread over two semesters (Semester III and IV) and the students have freedom to choose any one of these special courses depending on their interest and inclination.

Credit transfer from other Institutes:

Depending on the feasibility and availability, a maximum of four credits can be completed by the student in any of the national or reputed academic institutes/ organizations/ industries.

Audit Courses and Additional courses:

If the student wishes to complete more number of credits, he can opt additional courses up to a maximum of 10% of the total credits of the program depending on the interest and other feasibilities, however, such extra courses will be regarded as Audit or Additional courses. In general audit courses are of qualitative assessment without grades, while the additional credits are with grades. These additional credits shall be reflected on the Marks sheets / transcript of the student.

Objectives of M Sc Renewable Energy program:

1. To develop skills of critical thinking, hypothesis building and applying the scientific method of physics concepts, theoretical models and laboratory experiments
2. To develop problem solving skill for identifying and formulating problems independently and creatively employing the theoretical and/or experimental methods that he has acquired during the course
3. To train the students with a working knowledge of experimental/computational techniques and instrumentation required to work independently in research and industrial environments
4. To acquire advanced knowledge in specialized areas in physics that are in tune with the front-line research in physics
5. To prepare the students to successfully compete for current employment opportunities.

Program Outcome:

Students after completing their post graduation in Renewable Energy will

1. be eligible to get employment as an assistant professor, teacher, etc. in private, semi-government, government in colleges and schools after fulfilling the requirements and can rise up to the top positions
2. pursue their higher studies in related fields including M Phil, Ph D in the national and international universities depending upon the eligibility conditions of the concerned universities
3. work as research fellow, scientist in research institutes and carry out research after qualifying the NET/SET/PET examinations
4. handle standard and advanced laboratory equipment, modern instrumentation and classical techniques to carry out experiments.
5. work as entrepreneurs

Duration:

The duration of M. Sc. Renewable Energy programme offered by the School is of 2 Years (4 semesters) with a total of 100 credits

Eligibility for Admissions to M Sc Renewable Energy Program:

Any science graduate (B. Sc.) with Physics, Chemistry, Mathematics, Computer, Electronics is eligible to apply for admission to the M. Sc. Renewable Energy offered by this School. B.E/B.Tech in Electronics / ECE /Electrical /EEE /Optics /Engineering Physics /Applied Physics /Mechanical /Instrumentation/Computer Science/Civil Engineering with a minimum percentage of 55 marks are also be eligible for the admission to M Sc Renewable Energy program

Examination/Evaluation Rules:

- For all the courses, 1 credit corresponds to 25 marks and requires 15 contact hours, which includes teaching, tutorials, remedial classes and seminars
- A minimum of 75 % attendance for theory and practical courses is a pre-requisite for appearing for examinations and qualifying a particular course
- The assessment of each of the theory course shall be done in two modes: i. Continuous Internal Assessment or **Mid Semester Assessment (MSA)**, and ii. **End Semester Assessment (ESA)**
- The Mid Semester Assessment shall be done throughout the semester in the form of mid-semester examinations, tests, home assignments, group discussions etc. Normally, there shall be two written tests, each of 20 marks and shall be of two hours duration, and one home assignment of 10 marks.
- The first test shall be conducted after five weeks of the commencement of the particular course and the other test shall be conducted after the 10 weeks.
- The **Semester End Assessment (ESA)** shall be usually conducted at the end of the respective semester in co-ordination with external examiners
- The MSA and ESA carries equal weightages i.e. **50:50** percent.
- **There shall be no internal or Mid Semester Assessment (MSA) for the laboratory courses. Assessment of the laboratory courses shall be done at the end of the respective semester by a panel of examiners appointed by the University**
- The minimum score required for passing a particular course is 40%

- There shall be independent passing for the MSA and ESA separately; otherwise the candidate shall be declared FAIL in that particular course. However, they shall be **Allowed-To-Keep-Term (ATKT)** at the most up to 25% and shall be eligible to get admission in to the third semester.
- A student passing end semester evaluation shall have to independently pass the internal assessment as per the schedule announced by the School. There shall be no provision of conducting the repeat examination either in MSA or ESA. If a student remains absent for the internal assessment he shall be declared FAIL for that particular course
- Failed candidates reappearing for the concerned SEA have to appear for the next regular examination conducted at the end of the following semester.
- Every students admitted to M Sc Renewable Energy third semester have to complete one project dissertation of 4 credits (100 marks) under the guidance of the faculty member as allocated him in the beginning of the third semester. The performance of the student in project work shall be assessed in both the modes i.e., the MSA of 50 marks and the ESA of 50 marks. ESA will be conducted by a panel of external examinations, where the candidate shall give a presentation on the work that he has conducted throughout the year.
- The **evaluation and grading** of the courses shall be as per the guidelines of UGC, New Delhi and the modified **Grades and Grade Points** (As per UGC) shall be as follows:

UGC Letter Grade	UGC Grade Points	UGC Marks obtained
O : Outstanding	10	>80
A+: Excellent	9	70-79
A: Very Good	8	60-69
B+: Good	7	55-59
B: Above Average	6	50-54
C: Average	5	45-49
P: Pass	4	40-44
F: Fail	0	<40
Ab: Absent	0	---

(Prof. M. K. Patil)
Chairman
Board of Studies in Physics

Course Structure and Marking Scheme
M. Sc. First Year (Semester I) Renewable Energy

Subjects	Marks (Int.)	Marks (ext.)	Credits
Nuclear Physics	50	50	04
Electrodynamics	50	50	04
Electronic Devices and Applications	50	50	04
Energy Devices (Elective)	50	50	04
General Electronics Lab (10 practical's)	50	50	04
Nuclear and Laser Physics Lab	50	50	04
Field visit	-	25	01
Total:	**300**	**325**	**25**

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M. Sc. First Year (Semester II) Renewable Energy

Subjects	Marks (Int.)	Marks (ext.)	Credits
Condensed Matter Physics	50	50	04
Quantum Mechanics	50	50	04
Instrumentation Technology	50	50	04
Atomic and Molecular Physics	50	50	04
Solid state and Semiconductor Physics (10 practical's)	50	50	04
Skill Enhancement Lab (10 particals)	50	50	04
Research awareness	-	25	01

M. Sc. Second Year (Semester III) Renewable Energy

Subjects	Marks (Int.)	Marks (ext.)	Credits
Computational Simulations	50	50	04
Electronic Devices and Applications	50	50	04
Sensors and Microcontroller (elective)	50	50	04
Renewable Energy Part I	50	50	04
(Solar, Catalysis and water splitting)			
Renewable Energy Part II	50	50	04
(Battery, fuel cell and tidal)			
Sensors and Microcontroller Lab			
(10 practicals)	50	50	04
Renewable Energy Lab	50	50	04
(10 practicals)			
Instrumentation Training	-	25	01
Total:	**300**	**325**	**25**

M. Sc. Second Year (Semester IV) Renewable Energy

Energy Audit and Management	50	50	04
Research Project			
Project Monitoring	**200**		**08**
Dissertation and Viva	---	200	08
Research outcome	---	125	05
Total:	**250**	**375**	**25**
Total	**1150**	**1350**	**100**

REN 101 – Nuclear and Particle Physics

Credits: **04**	*Contact Hours*: **60** *(L+T+R)*	*Total Marks:* **100** **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

Learning Objective: *This paper is about the Physics of Nucleus. It helps to introduce students about the fundamental principles of nucleus and understanding at deeper level concepts governing nuclear and particle physics and new phenomenon at each level. It gives information about elementary particles*

Learning Outcome: *After the completion of the subject the students are able to know its Scientific and technological applications in addition with social, economic and environmental implications.*

Module-I: Basic Nuclear Properties and Interaction of Radiation with Matter (15 Hrs)
Basic Nuclear Properties: Nuclear mass, Nuclear size : Nuclear Radius & its determination by Rutherford scattering, electron scattering & mirror nuclei method, Nuclear quantum numbers, Angular momentum, nuclear dipole moment, electric quadruple moment, Nuclear Binding , average binding energy and its variation with mass number, Semi empirical mass formula & its applications.

Module-II: Interaction of nuclear radiation with matter and elementary particles (15 Hrs)
Interaction of charged particles & electromagnetic rays with matter, range, straggling, stopping power, interaction of alpha, beta, gamma rays with matter, absorption law of gamma rays, photoelectric effect, Compton effect, pair production, annihilation of electron- positron pair
Nuclear Detectors: Classification, Ionization chamber: Principle, construction and working,
Proportional counter: Principle, construction and working,
Geiger Muller counter: Principle, construction and working (pulse formation, dead time, recovery time etc), quenching of discharge, Regions of multiplicative operations,
Scintillation Detector: photo multiplier tube, organic and inorganic scintillators, scintillation process, theory, characteristic and detection efficiency
Semiconductor Detector: properties, types (diffuse junction and surface barrier), Li drifted junction detector
Elementary particles: classification, their interaction, types: weak, strong and electromagnetic interactions, their quantum numbers (charge, lepton number, baryon number, iso-spin, strangeness etc), conservation laws: elementary ideas of CP and CPT invariance, Quark theory: assumptions, properties, classification, Gell- Mann mass formula colour of quark & its importance.

Module-III: Nuclear Forces and Nuclear Models (15 Hrs)
Nuclear Forces: Introduction , properties, characteristics, spin dependence of nuclear forces, charge independence & charge symmetry of nuclear forces, Elements of two body problem (Deuteron), its properties, Meson theory of nuclear forces, exchange force and tensor forces, its properties, neutron-proton scattering at low energy, partial wave analysis, phase shift.
Nuclear Models:
Nuclear shell model: spin orbit coupling, nuclear magic numbers, experimental evidences of magic numbers, Angular momenta and parities of nuclear ground states, significance, achievements and limitations, magnetic moment and Schmidt lines.

Liquid drop model: assumptions, achievements, Bohr Wheeler theory of fission, Failure and limitations of liquid drop model,
Collective model: vibration and rotation states, achievements of Bohr and Mottelson collective model
Fermi gas model: assumptions, achievements, limitations of Fermi gas model

Module-IV: Nuclear decay & Nuclear decay Reactions (15 Hrs)
Radioactive decay, laws of successive transformation, dosemetry, nuclear reactions: types, kinematics, transmutation, fission & fusion concept, energy production in stars, P-P and C-N cycles .
β – decay, three forms of β- decay, Fermi and Gamow Teller transitions, Fermi theory of β- decay, Kurie plot, Angular momentum and parity, selection rules, allowed and forbidden transitions, non conservation of parity in β- decay, neutrino hypothesis: detection and properties.

Reference Books:

1. Nuclear Physics, D.C.Tayal,(Himalaya Publishing House, Mumbai)
2. Introduction to Elementary Particles, D. Griffiths, 2nd Ed., Academic Press, 2008.
3. Introductory Nuclear Physics, S.S.M. Wong, 2nd Ed., Wiley VCH, 2004
4. Nuclear Physics, Kaplan, Addison Wesley, (Indian Ed., from Narosa Publishing House, New Delhi), 2002.
5. Introduction to nuclear physics , S.B Patel
6. Concept of Nuclear Physics, B.L. Cohen, McGraw-Hill, 2003.
7. Nuclear & Particle Physics: An Introduction, B. Martin, Willey, 2006.

REN 102 – Electrodynamics

Credits: 04	*Contact Hours*: 60 (*L+T+R*)	*Total Marks:* 100 **[MSA: 50** (*T1+T2+HA=20+20+10*); **ESA=*50*]**

Learning Objectives: *Objective of this course is to introduce the students to the concepts of electromagnetic field theory, interaction of EM waves matter, propagation in continuous media, reflection-refraction of EM waves at the boundaries separating two media and its application in communication theory. This paper also introduces the students to the sources of EM waves and antenna theory. Relativistic EM enables them to understand the effect of the radiation when sources are moving with relativistic velocities. Prerequisite for this course is that the students must have the idea of electrostatics, magnetostatics and electromagnetic induction phenomenon.*

Learning Outcome: *Upon successful completion of this course students will be able to apply the knowledge of Maxwell's equations to a variety of problems including various types of charge distributions including time-dependent processes, tackle the problems related to the propagation and scattering of EM waves in a variety of media, understand how to design EM sources of different powers, and will also be able to have a good understanding of the relativistic electrodynamics.*

Module-I: Maxwell equations and Electromagnetic waves (15 Hrs)

Maxwell's equations and their physical significance. Equation of continuity & relaxation time, Vector and scalar potentials, Lorentz and Coulomb gauge, gauge transformation, electromagnetic energy and Poynting's theorem, electromagnetic wave equations in free space, their plane wave solutions, waves in conducting medium: skin effect and skin depth, waves in ionized medium (ionospheric propagation), polarization of EM waves. Concept of radiation pressure

Module-II: Electromagnetic waves in bounded media (15 Hrs)

Reflection and refraction of plane electromagnetic waves at a plane interface: normal incidence, oblique incidence, Fressnel's equations, Brewster's angle. Total internal reflection. Reflection and refraction from metallic surfaces, Electromagnetic wave propagation between two parallel conducting plates, waves in hollow conductors, Rectangular wave guides - TE and TM modes.

Module-III: Radiations from moving charges (15 Hrs)

Concept of retarded potential, The Lienard-Wiechert potentials, Field produced by moving charges, radiation from a linearly accelerated charged particle at low velocity, radiation from accelerated charged particles at low velocities in circular orbits-Larmor formula, radiation from accelerated charged particles at relativistic velocities in circular orbits-relativistic generalization of Larmor formula Multipole expansion of EM field, Electric dipole radiation, field due to oscillating electric dipole, magnetic dipole radiations, electric quadrupole radiation, fields due to linear centre-fed half wave and full wave antenna, array of antennae

Module-IV: Covariance and Relativistic Electrodynamics (15 Hrs)

Basic kinematical results of special relativity (length contraction, time dilation, addition of velocities, charge invariance, field transformation, etc), relativistic momentum and energy of a particle, 4-vectors in electrodynamics, 4-potential and 4-current, electromagnetic field tensor, Lorentz force and equation of motion of a charged particle in an electromagnetic field, Covariance of Maxwell's equations, transformation of EM fields and field tensor. Electromagnetic wave equation and plane wave solution in 4-vector form.

Reference Books:

1. Classical Electrodynamics - J.D.Jackson (John Wiley & Sons)
2. Introduction to Electrodynamics, (3rd Edition) by David J.Griffith. (Prentice-Hall, India)
3. Classical Electromagnetic Radiation - J.B.Marion (Academic Press)
4. The Classical theory of Fields - Landau & Lifshitz (Pergman Press)
5. Electrodynamics of continuous media - Landau & Lifshitz (Butter Worth)
6. Electricity and Magnetism - David J.Griffiths (PHI)
7. Electricity and Magnetism - Panofsky and Philips
8. Electromagnetic waves and fields - R.N.Singh (Tata McGraw Hill)
9. Electromagnetic Waves and Radiation system - Jordan and Balman (PHI)
10. Electromagnetic Fields and waves -Paul Lorrain and Dale Corson (CBSPub)
11. Electromagnetics - B.B.Laud (New Age Intl. Pub.)
12. Introduction to Electrodynamics- A. Z. Capri and P. V. Panat (Narosa)

REN 103 – Electronic Devices and ApplicationS

Credits: 04	*Contact Hours*: 60 *(L+T+R)*	*Total Marks:* 100 **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

Learning Objective: *This paper is aimed to enhance comprehension and application capabilities of the electronic devices that are being used in day to day life in the form of various gadgets like, mobile phone, television, microwave, calculators, computer, etc. This paper is designed with an objective to expose students to the basics and advancements in the electronic device technology and to inculcate them towards future device technology/research.*

Learning Outcome: *After completion of this course, students will be able to explain the working principles and application of various electronic devices used in various electronic gadgets of domestic uses. They will also understand the construction, working and operational characteristics of semiconductor devices and their applications in advanced electronics industries.The students will also understand the utility and functioning of the microprocessors, the heart of the advanced computing machines.*

Module-I: Semiconductor Devices (15 Hrs)

- Fundamentals of semiconductor: Classification based on band gap (insulator, conductor and semiconductor), n-type and p-type semiconductors, understanding p-n junction
- Devices: Structure and characteristics of diodes, bipolar transistors, field effect transistor, metal oxide field effect transistor, uni-junction transistors and silicon control rectifier
- Applications of semiconductor devices as amplifiers and oscillators

Module-II: Photonic Devices (15 Hrs)

- Basics of photonic devices: Direct and Indirect band gap of semiconductor, radiative transitions, photoconductors
- Photodiodes, Phototransistor and Photo-detectors (construction, working and application)
- Light emitting diodes (Visible and Infrared)
- Solar cells (Solar radiations and ideal conversion efficiency P-N junction solar cell, spectral response, I-V characteristics)

Module-III: Operational Amplifier & Its Applications (15 Hrs)

- OP-AMP parameters, ideal OP-AMP, differential amplifier
- OP-AMP as an 1) Inverting amplifier 2) Non –Inverting amplifier 3) Adder 4) Subtractor 5) Differentiator 6) Integrator 6) Schmitt trigger 7) Comparator
- Applications of OP-AMP as active filters: First order High pass, Low Pass & Band Pass Filters

Module-IV: Digital Electronics (15 Hrs)

- Number system: Binary, Decimal & Hexadecimal no. system and its algebra,
- Logic devices: AND, OR, NOR, NAND, XOR (Symbols, working and truth tables)
- Registers: Flip–flop-R-S, J-K, T, D (logic symbols, working and truth tables)
- Shift registers: 4-bit left to right and right to left
- Digital counters: Synchronous and asynchronous

- Encoder and decoder: 1:4 and 4:19 (logical diagram and truth table)
- Multiplexer and demultiplexer: Logical diagram and truth table
- DAC: R-2R ladder network
- ADC using comparators
- Monostable and astable multivibrators using IC555
- Application of Digital devices: Microprocessor

Reference Books:

1. Principles of electronics: V K Mehta
2. Digital Electronics: Malvino and Leech
3. Electronic devices: Milman and Halkias
4. Electronic devices: Thomas Flyod
5. Introduction to microprocessors: Gaonkar
6. Microprocessors: B.Ram
7. Digital and Microprocessor: Flyod

REN 104 – Energy Devices

Credits: 04	*Contact Hours*: 60 *(L+T+R)*	*Total Marks:* 100 **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

E**<u>nergy Devices</u>**

Unit 1: *Thermal Energy:* Basics of Thermodynamics Zeroth law and temperature, Energy interaction, First Law: Flow processes, Second Law, Entropy and availability, Combined First and Second Laws, Gas Power cycles: Carnot, Stirling, Brayton, Otto, Diesel and Duel cycles

Unit II Types of polarisations, Piezoelectricity & Ferroelectricity, Luminescence, Photoconductivity. Introduction to renewable energy device, solar cells, supercapacitors, batteries, fuel cells (basics, operation, types)

Unit III Introduction, types of wind machines, Cp-λ curve & betz limits, wind recourse analysis; Systems, stand alone, grid connected, hybrid, system design

Unit IV: Biomass, Biomass resources, wood composition, pyrolysis, gasifies, biogas, biodisel, ethanol

Unit V Hydro-systems, Hydro-resources, types of hydro-turbine, small-hydro systems, geothermal, wave energy, ocean energy

Unit VI: Design of a hydropower station (dams, spillways and waterways), meteorology and hydrology, applied fluid dynamics (hydraulic losses, torque on a runner blade), turbine and draft tube, electrical generators, transmission of electrical power, hydraulic transients

REN 201 – Condensed Matter Physics

Credits: 04	*Contact Hours*: 60 (*L+T+R*)	*Total Marks:* 100 **[MSA: 50** (*T1+T2+HA=20+20+10*); **ESA=50]**

Learning Objective: *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, but it should also serve as an orientation on the current issues in the different branches of condensed matter physics, providing additional arguments for the choice of master thesis topic.*

Learning Outcome: *After completing the course students will have knowledge of different types of solids and an understanding of how their microscopic structure affects their mechanical, thermal and electrical properties*

Module-I: Crystal structure, X-ray diffraction and Crystal imperfections (15 Hrs)

- **Crystal structure**
  - Basic of crystal structure, Bravais lattices in two and three dimension
  - Some important crystal structure: Simple cubic (SC), Body centered cubic (BCC), Face centered cubic (FCC), Hexagonal close packed (HCP), NaCl and diamond structure
  - Miller indices and spacing between set of a crystal planes
- **X-ray diffraction and Reciprocal lattice**
  - Generation and interaction of X-ray, Braggs law and experimental methods: Laue method, Rotating crystal method, powered method
  - Reciprocal lattice and diffraction condition
  - Atomic scattering factor and Geometrical structure factor
- **Crystal Imperfections**
  - Point defects, line defects and Surface defects
  - Energies of dislocations

Module-II: Band theory and Fermi Surface (15 Hrs)

- **Band theory**
  - Electron motion in crystal (one dimensional)
  - Bloch theorem and implementation in Kroning-penny model
  - Concept of effective mass, Concept of holes
  - Metals, insulators and semiconductor
  - Other model and methods
- **Fermi Surface**
  - Fermi surface and Brillouin zones,
  - Experimental determination of Fermi surface

Module-III: Semiconducting, Dielectric and optical properties of materials (15 Hrs)

- **Semiconductor:**
- Basics of semiconductors: Carrier concentration in semiconductors and impurity states, Fermi level position as a function of charge carrier concentration
- semiconductor, optical methods to determine the forbidden gap, Direct and indirect band gap

   - Transport properties in semiconductor (resistivity, carrier concentration, mobility, temperature dependence, Hall Effect)
- **Dielectric and optical property of material**
   - The dielectric constant and polarizability, Sources of polarizability
   - Dipolar polarizability and Dipolar dispersion in solids
   - Ionic polarizability, Electronic polarizability, Piezoelecricity and Ferroelectricity

Module-IV: Superconductivity and Magnetic properties of materials (15 Hrs)

- **Superconductivity**
   - Introduction to superconductivity
   - Meissner effect, Critical temperature and persistent current
   - Type-1 & Type-II superconductors
   - The London theory, BCS theory, Cooper pair Flux quantization
- **Magnetic properties:**
   - Origin of Magnetic properties of materials, Magnetic susceptibility, Curie Weiss law for susceptibility,
   - Classification of magnetic materials,
   - Weiss molecular field theory of ferromagnetism,
   - Heisenberg model,
   - Ferromagnetic domain and Hysteresis, Closure domains,
   - Exchange interactions in Ferromagnets,
   - The Bloch wall and Bloch wall energy,
   - Antiferromagetism: two sublattice model,
   - Neel temperature, Susceptibility below Neel temperature,
   - Ferrimagnetism: Structure of ferrites, Spin arrangement in Ferrite,
   - Spin waves and magnons.

Reference Books:

1. Elementary solid state physics - Omar Ali
2. Solid state physics - C. Kittle.
3. Introduction to solids - Azaroft.
4. Solid state physics - Aschrott and Mermim
5. Solid state physics - Dekkar
6. Solid state physics - Ajay Kumar Saxena
7. Solid state physics - S.O. Pillai

REN 202 – Quantum Mechanics

Credits: **04**	*Contact Hours*: **60** (L+T+R)	*Total Marks:* **100** **[MSA: 50** (*T1+T2+HA=20+20+10*); **ESA=50]**

Learning objectives: *Quantum mechanics helps to understand of number of aspects of physics, chemistry, and modern technology.*
1. To introduce the physical principles and the mathematical background important to quantum mechanical descriptions.
2. To introduce the mathematical properties of the waves that describe free particles
3. To give basic understanding of the basic postulates of quantum mechanics which are helpful to formalize the rules of quantum mechanics.
4. To explain the importance and applications of quantum mechanics to various industries.

Learning outcome: *Upon successful completion of these modules, students will be able to understand that quantum mechanics is basic of many branches of Physics and will be able to apply quantum theory to other applied areas like nuclear physics, atomic and molecular physics, solid state physics, laser physics etc. The students will be able to relate the ideas and concepts from physics to chemistry, materials science and engineering. Students will be able to use quantum theory to model natural and physical phenomena in materials science, chemistry and nanotechnology. Students will be able to understand and explain the differences between classical and quantum mechanics. They will be able to understand the idea of wave function and to solve Schrodinger equation for simple potentials.*

Module-I: (15 Hrs)
Derivation of time dependent and time independent Schrodinger equation, Physical significance of wavefunction, Quantum numbers, Postulates of Quantum Mechanics, Commutation relations for position and momentum operator, Dirac Delta function and its properties, Ket and Bra notations, Completeness of eigen functions, Matrix representation of an operator, Unitary Transformation.

Module-II: Angular Momentum (15 Hrs)
Angular momentum and rotations, Orbital angular momentum, Spin angular momentum, Rotational symmetry and conservation of angular momentum, Commutation relations for Spin, orbital and total angular momentum, Ladder operators, eigen values of the angular momentum operators; L^2, L_z, J^2, J_z, J+ and J-, Reflection invariance and Parity, Addition of two angular momenta– Clebsch –Gorden Coefficient , calculation of C.G.coefficient

Module-III: Approximation methods **(15 Hrs)**
(a) **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.
(b) **Time dependent perturbation Theory**
Zero order perturbation, First order perturbation, second order perturbation, Fermi Golden rule, adiabatic and sudden approximation.

(c) **Variational Method**
The basic Principle, expectation value of energy in ground state, application to excited state, application to two electrons atom,
(d) **WKB approximation**
The classical limit, One dimensional case, turning point, connection formulae, the application to bound state

Module-IV: Collision in 3-d and Scattering (15 Hrs)
Laboratory and Centre of Mass reference frames, scattering amplitude, differential scattering cross section, total scattering cross section, Asymptotic form of scattering states, Relation between angles and cross sections in the laboratory and center of mass systems, Scattering by spherically symmetric potentials, Integral equation of scattering, The Born approximation, Partial Waves and Phase shifts, Scattering by a perfectly rigid sphere and by square well potential, Complex potential and absorption. 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)

Reference books:

1. Quantum mechanics - L. I. Schiff (McGraw Hill)
2. Quantum mechanics - Ghatak and Loknathan
3. Quantum mechanics - A. P. Messiah
4. Modern quantum mechanics - J. J. Sakurai (Addison Wesely)
5. Quantum mechanics - Mathews and Venkatesar.

REN 203 – Instrumentation technology

Credits: 04	*Contact Hours*: 60 *(L+T+R)*	*Total Marks:* 100 **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

<u>Instrumentation Technology</u>

Unit I Lasers

Introduction Properties of Lasers, directionality, intensity, monochromaticity, coherence Einstein's quantum theory of Radiation, Einstein's coefficients, momentum transfer, lifetime, possibility of amplification Basic properties of Lasers, Population inversion, Laser pumping, 2 Level & 3- Level Systems, Resonators (Reference: BB Laud) Gas Lasers: He-e Lasers, N2 Lasers, Excimer Lasers Solid State Laser: Neodymium Laser, Ruby Laser Pumping sources: Flash and Arc Lamps(Reference: Young, shimoda and verdeyen)

Unit II X – ray photolectron, X- ray diffraction. Differential thermal analysis thermo gravimetric analysis : Fundamentals, working and analysis, Energy Dispersive X-ray analysis

Unit III Atomic absorption spectrometry Principle primary radiation source, sources of free atoms, optical dispersion systems, detectors, signal measurement, sensitivity, chemical and spectral interferences. Nuclear Magnetic Resonance spectroscopy: Theory experimental methods of NMR. Applications of proton NMR applications of NMR to isotopes other than proton, Hall effect, Vibration Sample Magnetormeter

Unit IV: Microscopes: Types of microscopes (basics of compound light microscope, Stereo microscope, digital microscope, USB computer microscope, pocket microscope, electron microscope, scanning probe microscope acoustic microscope) and UV-VIS spectrophotometer, Field-emission scanning electron microscopy, High-resolution transmission electron Mossbauer and FTIR microscopy details.

REN 204 – Atomic and Molecular Physics

Credits: 04	*Contact Hours*: 60 *(L+T+R)*	*Total Marks:* 100 **[MSA: 50** *(T1+T2+HA=20+20+10)*; **ESA=*50*]**

Learning 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. It helps in understanding, many fields of science and technology, namely spectroscopy, Laser Physics & Technology, Plasma Physics, Nuclear physics, Particle Physics, Astrophysics, Condensed Matter Physics and Material Sciences, Metrology, Biosciences, Atmospheric Sciences, Chemical sciences, biological physics, energy research and fusion studies. Specific objectives are:*
1. To introduce the world of atoms and molecules to the students.
2. 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.
3. 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.
3. 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
4. To introduce the working principle of various spectroscopic techniques and instrumentation used for analyzing spectra of various types of molecules.

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

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

Module-I: Atomic structure and atomic spectra (15 Hrs)

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.

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
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

Module-II: Microwave Spectroscopy of Molecules (15 Hrs)
Preliminaries, Types of molecules
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,
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

Module-III: Infrared and Electronic spectroscopy of molecules (15 Hrs)
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.
Polyatomic molecules
Fundamental vibrations and their symmetry, CO_2 and H_2O molecules, techniques and instrumentations, IR spectrometer
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,

Module-IV: Raman spectroscopy of molecules (15 Hrs)
Introduction, quantum theory of Raman effect, classical theory of Raman effect, molecular polarizability,
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
Vibrational Raman spectra
Raman activity of vibrations (H_2O and CO_2 molecules), rule of mutual exclusion, nature of polarized light, structure determination from Raman and infra-red spectroscopy, Experimental setup for Raman spectroscopy

Reference 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)

6. Atomic Spectroscopy by K. P. Rajappan Nair (MJP Publishers, Chennai)

7. 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

8. Elements of Spectroscopy by Gupta-Kumar-Sharma (PragatiPrakashan, Meerut)

9.Atomic Spectra and Atomic Structure by G. Herzberg, New York Dover Publication 1944

10. Introduction to Molecular spectroscopy by C. M. Barrow