Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY,
CHHATRAPATI SAMBHAJINAGAR.

CIRCULAR NO.SU/ Sci. & Tech./Sub-Campus/NEP/03/2024

It is hereby inform to all concerned that, the syllabi prepared by the Departmental Committee and recommended by the Dean, Faculty of Science & Technology, **Academic Council at its meeting held on 08 April 2024 has accepted** the following curriculum of All Post Graduate Degree Courses as per National Education Policy – 2020 under the Faculty of Science & Technology **run at Dr.Babasaheb Ambedkar Marathwada University, Sub-Campus, Dharashiv** as appended herewith.

Sr.No.	Syllabi of Deptt of BAMU, Sub Campus, Dharashiv .	Semester
1.	M.Sc. Chemistry specialization Analytical Chemistry, Organic Chemistry, Drug Chemistry.	IIIrd & IVth Semester
2.	M.Sc.Microbiology	IIIrd & IVth Semester
3.	M.Sc.Mathematics	IIIrd & IVth Semester
4.	M.Sc.Physics	IIIrd & IVth Semester
5.	M.Sc.Water & Land Management	IIIrd & IVth Semester

This is effective from the Academic Year 2024-25 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus, *
Chhatrapati Sambhajinagar.- *
431 004. *
REF.NO.SU/NEP/2024/901-09 *****
Date:- 18.06.2024.

Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

1] **Head of the Department, All Departments**, Dr.Babasaheb Ambedkar Marathwada University, Sub-Campus, Dharashiv.
2] The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.

Copy to :-

1] **The Director, Board of Examinations & Evaluation,** Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
2] The Section Officer,[M.Sc.Unit] Examination Branch, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
3] The Programmer [Computer Unit-1] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
4] The Programmer [Computer Unit-2] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
5] The In charge,[E Suvidha Kendra], Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
6] The Public Relation Officer, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
7] The Record Keeper, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

Dr. Babasaheb Ambedkar Marathwada University,
Chhatrapati Sambhajinagar - 431004 (M.S.), India

Faculty of Science and Technology

Master of Science in Physics

(M. Sc. In Physics)

(2 Years P. G. Programme)

As Per
National Education Policy - 2020

Course Structure and Curriculum

(Outcome-Based Curriculum)

For University Department

Department of Physics, Sub-campus, Dharashiv

(Academic Autonomous)

Dr. Babasaheb Ambedkar Marathwada University, Sub-campus, Dharashiv – 413501 (M.S.), India

Effective from the Academic Year 2024 - 25

Head
Department of Physics
Dr. Babasaheb Ambedkar Marathwada
University Sub-Campus, Dharashiv.

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY,

CHHATRAPATI SAMBHAJINAGAR-431004 (M.S.), INDIA

FACULTY OF SCIENCE AND TECHNOLOGY

Master of Science in Physics

(M. Sc. in Physics)

(2 Years P.G. Program)

As Per

National Education Policy-2020

Course Structure and Curriculum

(Outcome-based Curriculum)

For University Departments

DEPARTMENT OF PHYSICS

(Academic Autonomous)

Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar

Effective from the Academic Year 2024-25

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PREFACE

The National Education Policy (NEP) 2020, implemented in India, marks a significant stride towards a holistic and transformative educational framework. This policy aims to revolutionize the country's education system by fostering a learner-centric approach, promoting critical thinking, and nurturing creativity among students. With its emphasis on early childhood education, vocational training, and multi-disciplinary learning, the NEP 2020 seeks to equip students with relevant skills for the 21st-century world. It also focuses on bridging the digital divide and leveraging technology for effective teaching and learning. By encouraging flexibility in curriculum and assessment methods, promoting the mother tongue as a medium of instruction, and ensuring inclusive education, the NEP 2020 endeavors to build a robust and inclusive education ecosystem that prepares learners for the challenges and opportunities of the future.

On the other hand Outcome Based Education (OBE) is the educational approach which focuses on student centric education in the context of the development of personal, social, professional and knowledge (KSA) requirements in one's career and life. It is the decade ago curriculum development methodology. The educational triangle of *LEARNING-ASSESSMENT-TEACHING* is the unique nature of the OBE approach. The curriculum practices such as the Competency Based Curriculum, Taylor's Model of Curriculum Development, Spadys' Curriculum principles, Blooms taxonomy and further use of assessment methodologies like, Norm-reference testing and Criterion reference testing, etc is being practiced since decades. It is also interesting to know that, globally, different countries and universities adopts the curriculum development models/approaches such as, CDIO (Conceive-Design-Implement-Operate), Evidenced Based Education, Systems' Approach, etc as the scientific and systematic approaches in curriculum design.

The authorities of Dr. Babasaheb Ambedkar Marathwada University, CHHATRAPATI SAMBHAJINAGAR (M.S.) in-lieu of accreditation standards of National Assessment and Accreditation Council, decided to opt for National Education and Policy and Outcomes Based Education (OBE). As the part of the decision, different meetings, workshops and presentations were held at the campus of university.

This document is the outcome of different meetings and workshops held at university level and department level. The detailed document is designed and the existing curriculum of the department is transformed in to the framework of NEP with OBE. This is the first step towards the implementation of NEP with OBE in the university departments and affiliated colleges. The document will serve all stakeholders in the effective implementation of the curriculum. The OBE is continuous process for quality enhancement and it will go a long way in order to enhance the competencies and employability of the graduates/Post-graduates of the university departments and affiliated colleges.

Course Structure and Curriculum for

Master of Science (M. Sc.) in Physics

Course and Credit Distribution Structure for

Two Years Post Graduate Programme with Multiple Entry Exit Options

Year / level	Sem.	Major subject		RM	OJT /FP	RP	Credits	Degree
		DSC Core Mandatory	DSE (Elective)					
First year 6.0	I	3(4) +2=14	4	4	--	--	22	PG Diploma (after 3 years degree)
	II	3(4) +2=14	4	--	4	--	22	
Cum. Cr. For PG Diploma		28	08	4	4	--	44	
Exit option with Post-graduate Diploma (44 credits) after first year or two semester with completion of courses equivalent to 44 credits								
Second Year 6.5	III	3(4)+2=14	4	---	---	4	22	PG Degree after 3 years UG or PG Degree after 4 years UG
	IV	3(4)=12	4	---		6	22	
Cum. Cr. For 1 year PG Degree		26	8			10	44	
Cum. Cr. For 2 years PG Degree		54	16	4	4	10	88	
2 Years -4 sem.PG Degree (88 credits) after three year UG Degree or 1 Year -2 sem. PG Degree (44 credits) after four year UG degree								

Note- DSC - is Discipline specific Core courses and are mandatory
Major – Comprising Mandatory – based on core subjects
DSE- Discipline Specific Elective based on specialization
OJT – On-the- Job Training
FP – Field Project (Corresponding to the Major (Specialization) Subject
RP – Research Project (Corresponding to the Major (Specialization) Subject
Internship/Apprenticeship - (Corresponding to the Major (Specialization) Subject

Course and Credit Distribution Structure for

Two Years Post Graduate Programme with Multiple Entry Exit Options

Class: M. Sc. First Year, Semester: First Semester, Subject: Physics

Course Type	Course Code	Course Name	Teaching Scheme (Hrs./Week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Discipline Specific Core Course (DSC) Mandatory	PHYT/MJ/500	Linear and Digital Electronics	2	--	2	--	14
	PHYT/MJ/501	General Condensed Matter Physics	2	--	2	--	
	PHYT/MJ/502	General Nuclear Physics	2	--	2	--	
	PHYT/MJ/503	Atomic and Molecular Physics	2	--	2	--	
	PHYP/MJ/526	Practical Based on PHYT/MJ/500	--	4	--	2	
	PHYP/MJ/527	Practical Based on PHYT/MJ/501	--	4	--	2	
	PHYP/MJ/528	Practical Based on PHYT/MJ/502 & 503	--	4	--	2	
DSE (Choose any one from pool of Course)	PHYT/DSE/504 PHYP/DSE/529	8086 Microprocessor and Programming Practical Based on PHYT/DSE/504	2	4	2	2	4
	OR						
	PHYT/DSE/505 PHYP/DSE/530	Atomic Spectroscopy Practical Based on PHYT/DSE/505	2	4	2	2	
	OR						
	PHYT/DSE/506 PHYP/DSE/531	Radioactivity and Nuclear Decay Practical Based on PHYT/DSE/506	2	4	2	2	
	OR						
	PHYT/DSE/507 PHYP/DSE/532	Electrical Properties of Solid and Superconductivity Practical Based on PHYT/DSE/507	2	4	2	2	
RM	PHYT/RM/546	Research Methodology	2	--	2	--	4
	PHYP/RM/547	Practical Based on PHYT/RM/546		4	--	2	
			12	20	12	10	22

Course and Credit Distribution Structure
for

Two Years Post Graduate Programme with Multiple Entry Exit Options

Class: M. Sc. First Year, Semester: Second Semester, Subject: Physics

Course Type	Course Code	Course Name	Teaching Scheme (Hrs./Week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Discipline Specific Core Course (DSC) Mandatory	PHYT/MJ/550	Quantum Mechanics –I	2	--	2	--	14
	PHYT/MJ/551	Mathematical Methods in Physics-I	2	--	2	--	
	PHYT/MJ/552	Classical Mechanics-I	2	--	2	--	
	PHYT/MJ/553	Statistical Mechanics-I	2	--	2	--	
	PHYP/MJ/576	Practical Based on PHYT/MJ/550	--	4	--	2	
	PHYP/MJ/577	Practical Based on PHYT/MJ/551	--	4	--	2	
	PHYP/MJ/578	Practical Based on PHYT/MJ/552 & 553	--	4	--	2	
DSE (Choose any one from pool of Course)	PHYT/DSE/554 PHYP/DSE/579	The 8051 Microcontroller Practical Based on PHYT/DSE/554	2	4	2	2	4
	OR						
	PHYT/DSE/555 PHYP/DSE/580	Molecular Spectroscopy Practical Based on PHYT/DSE/555	2	4	2	2	
	OR						
	PHYT/DSE/556 PHYP/DSE/581	Nuclear Reaction and Energy Practical Based on PHYT/DSE/556	2	4	2	2	
	OR						
	PHYT/DSE/557 PHYP/DSE/582	Thin Film and Vacuum Technology Practical Based on PHYT/DSE/557	2	4	2	2	
OJT/FIELD PROJECT	PHYP/OJT/FP/596		--	8	--	4	4
			10	24	10	12	22

Course and Credit Distribution Structure for

Two Years Post Graduate Programme with Multiple Entry Exit Options

Class: M. Sc. Second Year, Semester: Third Semester, Subject: Physics

Course Type	Course Code	Course Name	Teaching Scheme (Hrs./Week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Discipline Specific Core Course (DSC) Mandatory	PHYT/MJ/600	Quantum Mechanics –II	2	--	2	--	14
	PHYT/MJ/601	Mathematical Methods in Physics-II	2	--	2	--	
	PHYT/MJ/602	Classical Mechanics-II	2	--	2	--	
	PHYT/MJ/603	Statistical Mechanics-II	2	--	2	--	
	PHYP/MJ/626	Practical Based on PHYT/MJ/600	--	4	--	2	
	PHYP/MJ/627	Practical Based on PHYT/MJ/601	--	4	--	2	
	PHYP/MJ/628	Practical Based on PHYT/MJ/602 & 603	--	4	--	2	
DSE (Choose any one from pool of Course)	PHYT/DSE/604 PHYP/DSE/629	Microwaves Practical Based on PHYT/DSE/604	2	4	2	2	4
	OR						
	PHYT/DSE/605 PHYP/DSE/630	Modern Trends in Spectroscopy Practical Based on PHYT/DSE/605	2	4	2	2	
	OR						
	PHYT/DSE/606 PHYP/DSE/631	Reactor Physics Practical Based on PHYT/DSE/606	2	4	2	2	
	OR						
	PHYT/DSE/607 PHYP/DSE/632	Crystallography Practical Based on PHYT/DSE/607	2	4	2	2	
RP/FIELD PROJECT	PHYP/RP/FP/646	Research Project	--	8	--	4	4
			10	24	10	12	22

Course and Credit Distribution Structure
for

Two Years Post Graduate Programme with Multiple Entry Exit Options

Class: M. Sc. Second Year, Semester: Fourth Semester, Subject: Physics

Course Type	Course Code	Course Name	Teaching Scheme (Hrs./Week)		Credits Assigned		Total Credits
			Theory	Practical	Theory	Practical	
Discipline Specific Core Course (DSC) Mandatory	PHYT/MJ/650	Computational Methods in Physics	2	--	2	--	12
	PHYT/MJ/651	Electrodynamics	2	--	2	--	
	PHYT/MJ/652	Renewable Energy	2	--	2	--	
	PHYP/MJ/676	Practical Based on PHYT/MJ/650	--	4	--	2	
	PHYP/MJ/677	Practical Based on PHYT/MJ/651	--	4	--	2	
	PHYP/MJ/678	Practical Based on PHYT/MJ/652 & 653	--	4	--	2	
DSE (Choose any one from pool of Course)	PHYT/DSE/653 PHYP/DSE/679	Advanced Sensor Technology Practical Based on PHYT/DSE/654	2	4	2	2	4
		OR					
	PHYT/DSE/654 PHYP/DSE/680	Applied Spectroscopy Practical Based on PHYT/DSE/655	2	4	2	2	
		OR					
	PHYT/DSE/655 PHYP/DSE/681	Elementary Particle Physics Practical Based on PHYT/DSE/656	2	4	2	2	
		OR					
	PHYT/DSE/656 PHYP/DSE/682	Advances in Magnetic Materials Practical Based on PHYT/DSE/657	2	4	2	2	
RP/FIELD PROJECT	PHYP/RP/FP/696	Research Project	--	12	--	6	6
			08	28	10	14	22

Preamble:

Dr. Babasaheb Ambedkar Marathwada University proposes to offer a two years / one year Master programme in Science (M. Sc.) in Physics. The curriculum design of this program is undertaken in the following framework (assumptions).

a) Although there has been remarkable progress in all sectors of education in last couple of decades, there has been increasing crisis for truly able manpower to address the growing demands for work sectors. This has led to the widening gap between the supply and demand for skilled manpower across teaching institutions, R&D organizations and industries. Such inadequacy of knowledge acquisition and dissemination has translated directly into unemployment among an increasing number of post-graduates who pass-out every year and are forced to bare-trained in order to become marketable.

   A scientifically designed framework, which will enable students at post graduate level to be ready to face the challenges of the demand driven socio-economic profile is therefore, a call of the day. Such a course should not be occupation specific and should enable students to choose from a variety of options for their career.

   This programme is designed to produce a skilled manpower in Physics with Sensors, materials science and process control as specialized sectors of training to improve the opportunities for the unemployed youths in both the private and public sectors.

b) According to a study conducted by the Associated Chambers of C ommerce and Industry of India (ASSOCHAM), there will be a deficit of 40 million working professionals and the employers would face the difficulty of filling positions because of the dearth of suitable talent and skilled person all in their industry. **This Programme aims to provide some solution for this problem and this would facilitate to improve:**

   (i) **Quality of training**
   (ii) **High drop-out rates**
   (iii) **Linkages with Universities and industry**
   (iv) **Inadequacy of resources.**

c) **This programme is intended to offer practical training and skills needed to pursue an occupation straight away. It will provide options to the students to be trained in directions which are directly aligned to land a job in a chosen profession or a skilled trade.**

d) **This program is intended to offer students with life-long independent and reflective learning skills in their career.**

Vision

To structure the Department of Physics of University to be an Epitome of Excellence in Research and Development in the area of Material Science, Renewable Energy, SupercapacitrsSensor Technology by creating and imparting time responsive Quality Education to address Changing Scenario, keeping Research and Development at its core, for 'Anyone' at 'Anytime' and 'Anywhere'.

Mission

To achieve the vision, the Department / College will:

- Provide a platform for the students with broad spectrum of diversity to achieve Academic Excellence with in-built Employability in the area of Physics, Materials Science and Sensor Technology.
- Establish a unique learning environment to enable the students to face the challenges in the area of Physics, Materials Science and Sensor Technology.
- Identify the gaps between academics and industry, design the courses to impart technical and life skill as per the requirements of the region so as to improve employability and develop entrepreneurial capabilities.
- Adopt a perennial process for bringing in excellence in teaching pedagogy by providing ICT based state-of-the-art infrastructural facilitation
- Provide student centric learning environment and to establish platform for inclusive research leading to the development of creative thought process amongst research scholars keeping in mind societal needs.
- Establish centre of excellence in the area of Physics viz. Electronics devices, Spectroscopy, Nuclear Physics and Condensed Matter Physics to nurture innovative ideas shaping into products facilitating the spinoff and creating awareness to protect Intellectual Property (IP).
- Provide ethical and value based education by promoting activities addressing the societal needs.

Program Educational Objectives:

The objectives of M. Sc. (Physics) program are to produce graduates who –

1. Are equipped with time relevant knowledge of Physics to address multi-disciplinary demands of R & D organizations, educational institutes and automated process in modern industries in capacity of Scientist, Education Professionals, System Developers and System Integrators.

2. Have sound background to practice advanced concepts of electronics in the areas sensor technology, Semiconductor Devices in R & D organizations, educational institutes, industry and Government settings meeting the growing expectations of stakeholders.

3. Have an ability to pursue higher studies and succeed in academic and professional careers.

4. Have the ability to address professional demands individually and as a team member communicating effectively in technical environment using modern tools.

5. Recognize the need for and possess the ability to engage in lifelong learning and will be sensitive to consequences of their work both ethically and professionally for productive professional career.

Programme Outcomes (POs):

Graduates of the M. Sc. (Physics) program are expected to -

PO1. **The citizenship and society:** Apply broad understanding of ethical and professional skill in electronics technology in the context of global, economic, environmental and societal realities while encompassing relevant contemporary issues.

PO2. **Environment and sustainability**: Apply broad understanding of impact of electronics technology in a global, economic, environmental and societal context and demonstrate the knowledge of, and need for sustainable development.

PO3. **Ethics:** Apply ability to develop sustainable practical solutions for electronics technology related problems within positive professional and ethical boundaries.

PO4. **Individual and team work:** Function effectively as a leader and as well as team member in diverse/ multidisciplinary environments.

PO5. **Communication:** Communicate effectively on complex electronics technology related activities with the scientific community in particular and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO6. **Project management and finance**: Demonstrate knowledge and understanding of the first principles of electronics technology and apply these to one's own work as a member and leader in a team, to complete project in any environment.

PO7. **Life-long learning**: Recognize the need for lifelong learning and have the ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes:

PSO1. **Domain knowledge:** Apply the knowledge of electronics fundamental, Sensor Technology, and Semiconductor Devices to provide comprehensive solution of problems in complex electronics.

PSO2. **Problem Analysis:** Identify electronics related problems at varied complexity and analyze the same to formulate/ develop substantiated conclusion using first principles of Sensor Technology, Semiconductor Devices and scientific literature.

PSO3. **Design Development of solutions:** Design/ develop solutions for problems at varied complexity in the area Sensor Technology, and Semiconductor Devices to address changing challenges put forward by market demand/ stakeholder

PSO4. **Conduct Investigation of complex problems:** Use research-based knowledge and methods to design of experiments, analyze resulting data and interpret the same to provide valid conclusions.

PSO5. **Modern tools:** Create, select, and apply appropriate techniques, resources, and modern electronics and relevant IT tools including prediction and modeling to complex electronics technology related activities with clear understanding of the limitations

Course - Program outcome Matrix:

The Program Outcomes are developed through the curriculum (curricular/co-curricular-extra-curricular activities). The program outcomes are attained through the course implementation. As an educator, one must know, ***"to which POs his/her course in contributing?"*** So that one can design the learning experiences, select teaching method and design the tool for assessment. Hence, establishing the Course-PO matrix is essential step in the OBE. The course-program outcomes matrix indicates the co-relation between the courses and program outcomes. The CO-PO matrix is the map of list of courses contributing to the development of respective POs.

The CO-PO MATRIX is provided in the following Table.

Course	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO 1	PSO 2	PSO 3	PS O4	PSO 5
Semester-I												
PHYT/MJ/500	√			√			√	√	√	√	√	√
PHYT/MJ/501	√			√			√	√	√	√	√	√
PHYT/MJ/502	√			√			√	√	√	√	√	√
PHYT/MJ/503	√			√			√	√	√	√	√	√
PHYP/MJ/526	√				√	√	√	√	√	√	√	√
PHYP/MJ/527	√			√	√	√	√					
PHYP/MJ/528	√			√	√	√	√					
PHYT/DSE-504 to 507	√				√	√	√	√	√	√	√	√
PHYP/DSE/529-532	√			√	√	√	√					
RM	√				√	√	√	√	√	√	√	√
Semester-II												
PHYT/MJ/550	√			√			√	√	√	√	√	√
PHYT/MJ/551	√			√			√	√	√	√	√	√
PHYT/MJ/552	√			√			√	√	√	√	√	√
PHYT/MJ/553	√			√			√	√	√	√	√	√
PHYP/MJ/576	√				√	√	√	√	√	√	√	√
PHYP/MJ/577	√			√	√	√	√					
PHYP/MJ/578	√			√	√	√	√					
PHYT/DSE-554 to 557	√				√	√	√	√	√	√	√	√
PHYP/DSE/579-582	√			√	√	√	√					
PHYP/OJT/FP/596	√				√	√	√	√	√	√	√	√

Semester-III												
PHYT/MJ/600	√			√			√	√	√	√	√	√
PHYT/MJ/601	√			√			√	√	√	√	√	√
PHYT/MJ/602	√			√			√	√	√	√	√	√
PHYT/MJ/603	√			√			√	√	√	√	√	√
PHYP/MJ/626	√				√	√	√	√	√	√	√	√
PHYP/MJ/627	√			√	√	√	√					
PHYP/MJ/628	√			√	√	√	√					
PHYT/DSE-604 to 607	√				√	√	√	√	√	√	√	√
PHYP/DSE/629-632	√			√	√	√	√					
PHYP/RP/FP/646	√				√	√	√	√	√	√	√	√
Semester-IV												
PHYT/MJ/650	√			√			√	√	√	√	√	√
PHYT/MJ/651	√			√			√	√	√	√	√	√
PHYT/MJ/652	√			√			√	√	√	√	√	√
PHYP/MJ/676	√				√	√	√	√	√	√	√	√
PHYP/MJ/677	√			√	√	√	√					
PHYP/MJ/678	√			√	√	√	√					
PHYT/DSE-653 to 656	√				√	√	√	√	√	√	√	√
PHYP/DSE/679-682	√			√	√	√	√					
PHYP/RP/FP/696	√				√	√	√	√	√	√	√	√

Target levels for Attainment of Course Outcomes:

The course outcome attainment is assessed in order to track the graduates' performance w.r.t target level of performance. The CO-PO attainment is the tool used for continuous improvement in the graduates' abilities through appropriate learning & teaching strategies. In order to assess students' performance with respect to abilities (at the end of course teaching/by the end of program) the course outcome attainment are measured/calculated. In order to calculate the program outcome attainment, the course outcome attainment is calculated. Prior to that, the course-program outcome mapping is done.

Target level for Attainment of Program Outcomes:

The program outcome attainment is assessed in order to track the graduates' performance w.r.t target level of performance. The CO-PO attainment is the tool used for continuous improvement in the graduates' abilities through appropriate learning and teaching strategies. In order to assess students' performance with respect to abilities (at the end of course teaching/by the end of program) the course outcome attainment and program outcome attainment is measured/calculated. The program outcome attainment is governed by curricular, co-curricular and extra-curricular activities including the stakeholders' participation. The direct method and indirect method is adopted to calculate the PO attainment. The direct method implies the attainment by course outcomes contributing to respective program outcomes. And indirect method is the satisfaction/feed-back survey of stakeholders. In order to calculate the program outcome attainment, the course outcome attainment is calculated. Prior to that, the course-program outcome mapping is done.

The set target level is the set benchmark to ensure the continuous improvements in the learners/ graduates' performance.

Course Attainment Levels:

a. CO attainment is defined/set at three levels;
b. The CO attainment is based on end term examination assessment and internal assessment;
c. The Co attainment is defined at three levels in ascending order-
    i. e.g. For end term and internal examination;
    ii. Level-1: 20% students scored more than class average
    iii. Level-2: 30% students score more than class average;
    iv. Level-3: 40% students score more than class average.

d. The target level is set (e.g. Level-2). It indicates that, the current target is level-2; 30% students score more than class average. The CO attainment is measured and the results are obtained. Based on the results of attainment, the corrective measures/remedial action are taken.

e. CO Attainment = 80% (Attainment level in end term examination) + 20% (Attainment level in internal examination).

Program attainment Level:

a. PO attainment is defined at five levels in ascending order;

b. The PO attainment is based on the average attainment level of corresponding courses (Direct Method) and feed-back survey (Indirect method);

c. The PO attainment levels are defined / set as stated below;

   i. Level-1: Greater than 0.5 and less than 1.0 (0.5>1) - Poor
   ii. Level-2: 1.0>1.5 - Average
   iii. Level-3: 1.5>2.0 - Good
   iv. Level-4: 2.0>2.5 - Very Good
   v. Level-5: 2.5>3.0 - Excellent

d. The PO attainment target level is set/defined (say, Level-4). It implies that, the department is aiming at minimum level-4 (very good) in the performance of abilities by the graduates. Based upon the results of attainment, the remedial measures are taken;

e. PO Attainment = 80% (Average attainment level by direct method) + 20% (Average attainment level by indirect method).

Examples of CO Attainment:

<u>FOR EXAMPLE</u>: COURSE CODE/TITLE: DSC-12

e.g. For end term and internal examination;

i. Level-1: 20% students scored more than class average
ii. Level-2: 30% students score more than class average;
iii. Level-3: 40% students score more than class average

Average of Total Marks in Examination: 61.00 % Students score more than 61 is 4/12 i.e. 33.33% i.e. Levl-2

A (CO) DSC-12 = 100(2)

= 2.00

Hence, the attainment level is Level-2 and the set target level is Level-2 and therefore the CO is fully attained.

Table No. 1.0: CO Attainment Level

Course Code	CO attainment Value	Attainment	Fully Attained/Not attained	Remedial measures
PHYT/MJ/500	1	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.
PHYT/MJ/501	2	2	Fully Attained	
PHYT/MJ/502	1	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.
PHYT/MJ/503	3	2	Fully Attained	
PHYT/MJ/504-507	3	2	Fully Attained	
RM	2	2	Fully Attained	
PHYT/MJ/550	0	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.
PHYT/MJ/551	3	2	Fully Attained	
PHYT/MJ/552	3	2	Fully Attained	
PHYT/MJ/553	1	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.
PHYT/MJ/554-557	3	2	Fully Attained	
OJT/FP	1	1	Fully Attained	Assignments
Course Code	CO attainment Value	Attainment	Fully Attained/Not attained	Remedial measures
PHYT/MJ/600	1	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.
PHYT/MJ/601	2	2	Fully Attained	
PHYT/MJ/602	1	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.
PHYT/MJ/603	3	2	Fully Attained	
PHYT/MJ/604-607	3	2	Fully Attained	
RP/FP	2	2	Fully Attained	Filed Project, Assignments
PHYT/MJ/650	0	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.

PHYT/MJ/651	3	2	Fully Attained	
PHYT/MJ/652	3	2	Fully Attained	
PHYT/MJ/653	1	2	Not Attained	Assignment, tutorials, exercise and Remedial coaching.
PHYT/MJ/654-657	3	2	Fully Attained	
RP/FP	1	2	Fully Attained	Assignment, tutorials, exercise and Remedial coaching.

Example of PO Attainment:

The attainment of PO will have to be calculated after declaration of IInd year result every year.

Table No. 2.0 PO Attainment Level

PO/PSO number	Description of PO/PSO	Attainment level	Target level	Fully attained/ Not Attained	Remedial Measures

i) Planned Actions for Course Attainment:
ii) Planned Actions for Program Outcome Attainment:

After calculating attainment of COs and POs, gap needs to be identified and a comprehensive plan needs to be prepared for bridging the gaps.

Eligibility:

Those who have completed B. Sc. With Physics as an optional subject or Hons from any recognized University/ Institution are eligible for registration subject to the rules and regulations laid down by Dr. Babasaheb Ambedkar Marathwada University, CHHATRAPATI SAMBHAJINAGAR time to time.

Candidates seeking admission to the first Semester of M. Sc. in Physics must possess following eligibility criteria.

- Must have passed B. Sc., (10 + 2 + 3) degree with Physics as one of the optional subjects OR have passed B. Sc. (Hons.) with Physics.

Course Fees:

Rs. 1541/- per year (For Open Category) and Rs. 541/- per year (For reserve category)

Number of Seats: 48

The Intake capacity of M. Sc. Physics will be 48 as under

Admission / Promotion Process:

In response to the advertisement for registration, interested students will have to register themselves. One of the following methods will be adopted for admission.

- Admission will be done on the basis of performance of students at Common Entrance Test (CET). The CET will be conducted in the month of June every year.

  OR

- Admission process declared by the University

There is Full Carry on for M. Sc. i.e. **irrespective** of individual performance in first year; a student will be promoted to Second Year. However, for obtaining M. Sc. Degree, a student will have to complete all semesters successfully within 4 years/08 semesters. It also offers multiple exit/entry. Students can exit after completion of one year and can enter into the system (second year) with 5 years from the date of first time registration.

Dropout students will be allowed to register for respective semester as and when the concerned courses are offered by the department, **HOWEVER HE / SHE SHOULD NOT EXCEED MORE THAN TWICE THE DURATION OF THE COURSE FROM THE DATE OF FIRST REGISTRATION AT PARENT DEPARTMENT / COLLEGE.** The admission of the concern student will be automatically cancelled if he / she fails to complete the M. Sc. degree within a period of maximum four years / eight semesters.

Choice Based Credit System (CBCS):

The choice based credit system is going to be adopted by the University. This provides flexibility to make the system more responsive to the changing needs of our students, the professionals and society. It gives greater freedom to students to determine their own pace of study. The credit based system also facilitates the transfer of credits. Students will have to earn 88 credits for the award of two years Master of Science (M. Sc.)

Credit-to-contact hour Mapping:

(a) One Credit would mean equivalent of 15 periods of 60 minutes each for theory lecture.

(b) For lab course/ workshops/internship/field work/project, the credit weightage for equivalent hours shall be 50% that for lectures /workshop

(c) For self-learning, based on e-content or otherwise, the credit weightage for equivalent hours of study should be 50% or less of that for lectures/workshops.

Attendance:

Students must have 75 % of attendance in each course for appearing examination, otherwise he / she will be strictly not allowed for appearing the semester examination of each course. Frequent absence from regular lecture/practical course may lead to disqualification from continuous assessment test (CAT) process in respective subject.

Departmental Committee:

The Departmental Committee (DC) of the Department will monitor smooth functioning of the program.

Results Grievances / Redressal Committee

Grievances / redressal committee will be constituted in the department to resolve all grievances relating to the evaluation. The committee shall consist of Head of the department, the concerned teacher of a particular course and senior faculty member of Department of Committee. The decision of Grievances / redressal committee will have to be approved by Department committee.

Evaluation Methods:

- The assessment will be based on **40:60 ratio** of **continuous assessment test (CAT) and end semester examination**. **Separate and independent passing in continuous assessment test (CAT) and end semester examination will be mandatory**. In case of failure in CAT of a particular course, students will have to appear for the same CAT, at his/her own responsibility in the next academic year, when the same course is offered during regular academic session. However, in case of failure in **end semester examination** in particular course(s), exam will be conducted in immediate subsequent semester.

- In case a student fails in certain course(s) in a particular semester and the same course(s) are modified/ revised/ removed from the curriculum in due course, the student will have to appear as per the newly framed curriculum and/or pattern in subsequent semester, at his/her own responsibility.

Continuous Assessment Test (CAT):

Three CAT, each of 20 marks would be conducted at different phases (25 %, 50 % and 75 % of completion of syllabus OR 25, 50 and 75 working days out 90 working days of the semester) throughout the semester. Each concurrent assessment (CAT-I, II, III) will be mapped to the course learning outcomes. Total performance in CAT (i.e. 40 %) would be based on best two out of three CAT examination. Course teacher will have liberty to choose from variety of assessment tools/ methods (class test, assignment, tutorial, seminar, case study, field work, project work, quiz) which may be deemed to appropriate for assessing the relevant course outcome.

End Semester Examination:

- The question paper of end semester examination must be designed to test all levels of cognitive domain and should include all types questions- essay, short, quantitative problems/ numerical, MCQs etc. The end semester theory examination for each theory course will be of 60 marks. The total marks shall be 100 for 4 credit theory course (60 marks end semester examination + 40 marks CAT) and 50 for 2 credit theory course (30 marks end semester examination + 20 marks CAT)

- End Semester examination time table will be declared by the University (as per the university annual calendar).
- Pattern of semester end examination question paper will be as below:
  - The end semester examination of theory course will have two parts (20 + 40 = 60 Marks)
  - Part A will be consisting of 10 questions having 2 marks each (multiple choice questions / fill in the blanks/ answer in sentence) as compulsory questions and it should cover entire course curriculum (20 Marks)
  - Part B will carry 6 questions (10 marks for each question) (02 questions from each of 03 units) and students will have to attempt any 04 questions out of 06 (40 Marks).
  - 20 to 30% weightage can be given to problems/ numerical wherein use of non-programmable scientific calculator may be allowed.
  - Number of sub questions (with allotment of marks) in a question may be decided by the examiner.

Earning Credits:

At the end of every semester, a letter grade will be awarded in each course for which a student had registered. A student's performance will be measured by the number of credits that he/she earned by the weighted Grade Point Average (GPA). The SGPA (Semester Grade Point Average) will be awarded after completion of respective semester and the CGPA (Cumulative Grade Point Average) will be awarded at the final exit.

Grading System:

1. The grading reflects a student-own proficiency in the course. A ten point rating scale shall be used for the evaluation of the performance of the students to provide letter grade for each course and overall grade for the Master Programme. Grade points are based on the total number of marks obtained by

him / her in all heads of the examination of the course. The grade points and their equivalent range of marks are shown in Table-I

Table – I: Ten point grade and grade description

Marks Obtained (%)	Grade Point (GPA/CGPA)	Letter Grade	Description
90-100	9.00- 10	O	Outstanding
80-89	8.00-8.99	A^+	Excellent
70-79	7.00-7.99	A	Very Good
60-69	6.00-6.99	B^+	Good
55-59	5.50-5.99	B	Above Average
50-54	5.00-5.49	C	Average
40-49	4.00-4.99	P	Pass
Below 40	Below 4.0	F	Fail
Absent	Absent	Ab	Absent

2. Non-appearance in any examination / assessment shall be treated as the students have secured zero marks in that subject examination / assessment.
3. Minimum P grade (4.00 grade points) shall be the limit to clear / pass the course / subject. A student with F grade will be considered as "failed" in the concerned course and he / she has to clear the course by appearing in the next successive semester examinations.
4. Every student shall be awarded grade points out of maximum 10 points in each subject (based on 10 point scale). Based on the grade points obtained in each subject, Semester Grade Point Average (SGPA) and then Cumulative Grade Point Average (CGPA) shall be computed. Results will be announced at the end of each semester and CGPA will be given at final exit.

Computation of SGPA (Semester Grade Point Average) and CGPA (Cumulative Grade Point Average)

Grade in each subject / course will be calculated based on the summation of marks obtained in all five modules.

The computation of SGPA and CGPA will be as below

5. Semester Grade Point Average (SGPA) is the weighted average points obtained by the students in a semester and will be computed as follows

$$SGPA = \frac{\text{Sum (Course Credits) X Number of Grade Points in concerned Course Gained by the Student}}{\text{Sum (Course Credits)}}$$

The SGPA will be mentioned on the grade card at the end of every semester.

6. The Cumulative Grade Point Average (CGPA) will be used to describe the overall performance of a student in all semester of the course and will be computed as under.

$$CGPA = \frac{\text{Sum (All four Semester SGPA)}}{\text{Total Number of Semester}}$$

The SGPA and CGPA shall be rounded off to the second place of decimal.

Grade Card

Results will be declared by the Centre and the grade card (containing the grades obtained by the student along with SGPA) will be issued by the university after completion of every semester. The grade card will be consisting of following details.

7. Title of the courses along with code opted by the student.
8. Credits associated with the course.
9. Grades and grade points secured by the student.
10. Total credits earned by the student in a particular semester.
11. Total credits earned by the students till that semester.
12. SGPA of the student.
13. CGPA of the student (at final exit).

Cumulative Grade Card

The grade card showing detail grades secured by the student in each subject in all semesters along with overall CGPA will be issued by the University at final exit.

AS PER NEP 2020

SEMESTER – I

Course Name: Linear and Digital Electronics

Course Code: PHYT/MJ/500, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To establishes the general method for analyzing and predicting the performance of operational amplifiers and related circuits.
2. To develop the students for designing realistic circuits to perform specified operations.
3. To enable the students to select available devices for intended operations.

Course Outcomes: At the end of the course, students will be able to:

1. Discuss the general properties of an operational amplifier.
2. Define the terms, input impedance, output impedance, bandwidth, input offset voltage, input offset current, CMRR, open loop voltage and slew rate.
3. Design an inverting and non-inverting amplifier circuit or its special cases to meet the given requirement.
4. Analyze or design op-amp for the intended operations: A stable Multivibrator, Monostable Multivibrator, Wien bridge Oscillator and some related circuits.
5. Explain gates, its related circuits, truth table and its realization.
6. Analyze or designing of combinational and sequential circuits.

Unit No.	Course Content	Contact Hours
I	**Operational amplifier** Symbol and terminals, the ideal op-amp, the practical op-amp. Operational amplifier parameters: Input offset voltage, Input offset current, Input bias current, Input impedance, Output impedance, Open loop voltage gain, Common – Mode rejection ratio, Slew rate. Inverting, non – inverting amplifier. Applications of Operational Amplifier and Timing Circuits: Adder, Subtractor, Integrator, differentiator, Comparator & Schmitt's trigger; Wave form generators: Astable Multivibrator, Monostable Multivibrator, and Wien Bridge Oscillator using IC741. Integrated circuit timer: Monostable, Astable Multivibrator using IC-555.	12
II	**Numbers systems, Codes and Combinational Logic** Decimal, Binary, & Hexadecimal numbers systems, and its arithmetic's. BCD code. AND, OR, NOT operations, NAND and NOR operations, NAND and NOR as building blocks, Exclusive –OR operation. Boolean algebra, Standard Representation for Logical Functions, Half & Full adder, Parallel 4-bit adder, encoder (decimal to binary), Decoder (Decimal to BCD), BCD to seven segment decoder, Multiplexer: (4:1) and (8:1), Demultiplexer: (1:8) and (1:16) and their applications.	08
III	**Sequential Logic** Flip-Flops: S-R, D- type, T-type, J-K and J-K master-slave. Shift registers: Serial in Serial out, Serial in parallel out, Parallel in Parallel out, Parallel in Serial out. Ripple counters: Mod-16, Mod – 12 and Mod- 10. Synchronous counters: Mod-8 and Mod-16.	10

Learning Resources:

1. Operational amplifier with Linear integrated circuits, by William D Staney Fourth Edition, LPE PEARSON Education, 2004, ISBN 81-297-0463-3.
2. Op-Amp and Linear Integrated Circuits, By R. A. Gaykwad 4th. Ed, Prentice Hall of India, 2002, ISBN 81 – 203–2058–1.
3. Operational amplifier & Linear integrated circuits, 6/e Robert F. Coughlin, Frederick F. Driscoll Modern Digital Electronics, by R P Jain, 3'rd Edition, Tata McGraw – Hill Publishing Company Ltd. 2003,ISBN 0-07-049492-4.
4. Digital Electronics, Second Edition, Tokheim, 1985, ISBN 0-07-064980-4.
5. Principles of Electronics, V. K. Mehta, Rohit Mehta, S. Chand and Company Ltd. 2012, ISBN: 81-219-2450-2.
6. Digital Fundamentals, by Thomas L Floyd, 2nd Edition Charles E. Merrill Publishing Company.
7. Electronic Devices, by Thomas L Floyd, Charles E. Merrill Publishing Company.

Course Name: General Condensed Matter Physics

Course Code: PHYT/MJ/501, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. This course deals with crystalline solids and is projected to make available students with the basic physical concept and mathematical tools used to portray solids.
2. The course deals with groups of materials, as in the periodic table, in terms of their structure, electronic, optical, and thermal properties.
3. Specific objectives are: To show how crystal symmetry leads to substantial mathematical simplifications when dealing with solids.
4. Describe basic experimental measurements, to show typical data sets and to compare these with theory.

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

1. The field of General Condensed Matter Physics investigates different classes of materials -metals, ceramics, electronic materials with an emphasis on the relationships between the underlying structure and the processing, properties, and performance of the materials.
2. Research opportunities are offered as scientists and technologists, etc in national and international institutions.
3. Interpret the crystal symmetry leads to substantial mathematical simplifications when dealing with solids.
4. Describe basic experimental measurements, to show typical data sets and to compare these with theories.
5. Calculate charge carriers present in the semiconducting materials.
6. Distinction between semiconductors, insulators and conductors.
7. Apply the knowledge to find energy band gap of the materials.
8. Pursue higher studies at Overseas Universities.

Unit No.	Course Content	Contact Hours
I	**Crystal Structure** Lattice translation vectors and lattices, basis and crystal structure, primitive, non-primitive unit cells, Wigner- Seiz cells, 2d & 3d Bravais lattices, characteristics of cubic lattices, miller indices, symmetry elements, point group and space groups, different crystal structures: hexagonal close packed structure, s.c., b.c.c., f.c.c, sodium chloride, diamond, X-ray diffraction condition and Bragg's law, Experimental method on the basis of Ewald Construction, Electron and Neutron diffraction by crystals, Reciprocal lattice and Brillouin Zone.	12
II	**Lattice Dynamic and Specific Heat** Vibrations of one–dimensional monoatomic lattices: First Brillouin zone, Group velocity, long wavelength and force constant, Diatomic lattices, quantization of lattice vibrations, phonons, inelastic scattering of neutron by phonons, Einstein model, Debye model of lattice heat capacity, electronic heat capacity, anharmonicity, thermal expansion and thermal conductivity: thermal resistivity, density of modes of square lattice.	08

III	**Free electron model of metals and Energy bands in solids** Free electron gas in three dimensions, Fermi – Dirac distribution, heat capacity of electron gas, hall effect, Matthiessen rule, fermi surface, de Hass von Alfen effect, magnetoresistance, tight binding method, pseudopotentials. Origin of energy band gap, Bloch function, Kronig-Penny Model, number of states in a band, distinction between metals, insulators and semiconductors, concept of holes, equation of motion for electron and holes, effective mass of electron and holes.	10

Learning Resources:

1. Solid State Physics: An Introduction- Philip Hofmann, 2nd Edition, Willey-VCH (2015) ISBN: 978-3-527-41282-2, E-Book978-3-527-68206-5.
2. Introduction to solid state physics – C. Kittel, Willey Eastern Pvt. Ltd. (2015) ISBN 10: 8126535180 ISBN 13: 9788126535187.
3. Elementary Solid-State Physics – M. A. Omar, Addition Wesley Pvt. Ltd. ISBN 10: 0201607336 ISBN 13: 9780201607338.
4. Solid State Physics – A. J. Dekker, Published by Macmillan India (2000) ISBN 10: 0333918339/ISBN 13: 9780333918333.
5. Solid State Physics - Aschroft and Mermen, New York, Holt, Rinehart and Winston (1976).
6. Introduction to Solids – L. V. Azaroff McGraw Hill, New York (1960)
7. Solid State Physics – S. O. Pillai, New age International Pvt. Ltd (2015). ISBN 10: 8122436978 ISBN 13: 9788122436976.
8. Solid State Physics – M. A. Wahab (2011). ISBN 10: 8184870566 ISBN 13: 9788184870565.
9. Concept in Solid State Physics – J. P. Shrivastava, Prentice Hall Ltd.
10. Fundamentals of Solid-State Physics – Saxena, Gupta, Saxena, Pragati Prakashan, Publisher: Anu Books (2019) ASIN: B07YCMDBTT.
11. Dynamical stability and low-temperature lattice specific heat of one-dimensional fullerene polymers, Atsushi Shimizu, Shota Ono, Chemical Physics Letters Volume 694, 16 February 2018, Pages 14-17, https://doi.org/10.1016/j.cplett.2018.01.037.
12. Photoswitching mechanism of a fluorescent protein revealed by time-resolved crystallography and transient absorption spectroscopy, Joyce Woodhouse, Gabriela Nass Kovacs, Martin Weik, Nature Communications volume 11, Article number: 741 (2020).
13. Structural, morphological, physical and dielectric properties of Mn doped ZnO nanocrystals synthesized by sol–gel method, VD Mote, Y Purushotham, BN Dole, Materials & Design 96 (2016) 99-105.

Course Name: General Nuclear Physics

Course Code: PHYT/MJ/502, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The themes dealt with in this paper:

1. This course will introduce students to the fundamentals of General Nuclear Physics.
2. It aims to provide a coherent and concise coverage of traditional nuclear physics.
3. Important topics of current research interest will be also discussed, such as radioactivity, radiation detector and accelerators which plays an important role in the realization of this course.
4. A General Nuclear Physics is a foundation course as it is a preparatory course for university-level art and design education.

Course Outcomes: The present unit attempts to achieve the following learning outcomes:

1. On successful completion of the course, students should be able to illustrate general considerations of Nuclear physics to atomic and nuclear system; make general orders of magnitude of estimation of physical effects.
2. Explain how interaction of gamma radiation with matter; the working principle of radiation detector.

Unit No.	Course Content	Contact Hours
I	**General Properties of Nucleus** Nuclear size and its determination, nuclear radii by electron scattering and mirror nuclei methods. Binding energy, mass defect, Packing fraction. Semi-empirical mass formula and its applications. Quantum numbers of nuclei, nuclear angular momentum, nuclear magnetic dipole moment, electric quadrupole moment.	10
II	**Radioactivity (Natural and Artificial)** The basis of the theory of radioactive disintegration, the disintegration constant, half-life and the mean life. Successive radioactive transformation, radioactive equilibrium, the natural radioactive series, units of radioactivity. The discovery of artificial radioactivity, the artificial radio nucleids, electron and positron emission, orbital electron capture, the artificial radio nucleids: alpha emitters.	10
III	**Nuclear Radiation detectors** Types of detectors, ionization chamber, G.M. Counters, proportional counter, semiconductor detector, counting errors, counting efficiency, scintillation counter, energy decapitation in phosphor, photoemission from phosphor.	10

Learning Resources:

1. Introduction to Nuclear Physics; H.A. Enge, Addison- Wesley, 1975.
2. Nuclear Physics; I. Kaplan, 2nd edition, Narosa, 1989.
3. The atomic Nucleus; R.D. Evans, Mc Graw- Hill, New York 1955.
4. Nuclear Physics; R.R. Roy and B.P. Nigam, Wiley – Eastern Ltd, 1983.

5. Basic Nuclear physics; B. N. Shrivastava, Pragati prakashan, Meerut.
6. Theory of Nuclear Structure; M. K. Pal, East – weast press Ltd. 1982.
7. Nuclear Physics; D.C. Tayal, Himalaya Publishing House, Bombay.
8. Experimental Nuclear Physics; E.Serge, John Wiley and sons, New York, 1959.
9. Encyclopaedia of nuclear Physics 3 : M.Chandrabhanu first edition : 2011.
10. Atomic and Nuclear Physics: N Subrahmanyam Brijlal. first edition : 1984.
11. Atomic and Nuclear Physics : Shatendra Sharma 2008.
12. Nuclear Physics An Introduction: S B Patel 2011.
13. Nuclear Physics : Rajkumar First Edition 2010.
14. Fundamentals of Nuclear Physics : Prof Jahan Singh, Pragati Prakashan First Edition 2012.
15. Radiation Physics For Medical Physicists E.B Podgor Second,Enlarged Edition Springer 2009.
16. Physics and Engineering of Radiation Detection Syed Naeem Ahmed Queen's University, Kingston, Ontario Academic Press Inc. Published by Elsevier First edition 2007
17. Radiation, Ionization, and Detection in Nuclear Medicine: Tapan K.Gupta ISBN978-3-642-34076-5(eBook) Springer-Verlag Berlin Heidelberg 2013

Course Name: Atomic and Molecular Physics

Course Code: PHYT/MJ/503, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The themes dealt with in this paper:

1. The atom, the nucleus, the electron and the photon - four necessary steps for the development of quantum physics.
2. The structure of the atom. Atoms in electric and magnetic fields. Fine and hyperfine structure. X-ray spectroscopy. Molecular structure.
3. Rotation-, vibration- and electronic spectra. Chemical bonds. Optical spectroscopy.
4. Applying laser spectroscopic methods as well as other modern tools in atomic and molecular physics, special efforts will be made in laboratory work.

Course Outcomes: The present unit attempts to achieve the following learning outcomes:
At the end of the course the student should be able to:

1. The course is a continuation of the Atomic and Molecular Physics course.
2. Introductory Atomic- and Molecular Physics will be discussed more in detail.
3. A big part of the course will give a view of the modern experimental tools of Atomic- and Molecular Physics job prospects.

Unit No.	Course Content	Contact Hours
I	**Introduction** Stern Gerlach experiment, Quantum states of an electron. Quantum numbers. Spectra of Hydrogen atom. Spin angular momentum, orbital angular momentum. Coupling of spin and orbit. Fine structure, spectroscopic terms, selection rules. Spectra of the alkali elements. Interaction energy in L-S and j-j coupling, Hund's rule and term reversal. Zeeman effect in one valence electron atoms, interaction energy, selection rules, Zeeman patterns. Paschen-Back effect, Pauli principle. Hyper fine structure (Qualitative).	10
II	**Rotational and Vibrational spectroscopy** Classification of molecules, Interaction of radiation with rotating molecule, IR spectra of diatomic molecules, Rigid rotator, energy levels, eigen functions and spectrum of rigid rotator, non-rigid rotator, isotopic substitution, effect of vibration on rotation, Intensities of rotational lines, information derived from rotational spectra. Vibrational course structure, Deslandres table, Diatomic molecule as a harmonic oscillator, energy levels, eigen functions and spectrum of harmonic oscillator, Morse potential, anharmonic oscillator, vibrating rotator with & without Born Oppenheimer approximation.	12
III	**Laser Fundamentals** Masers and lasers, methods of obtaining population inversion, Ammonia maser, Spontaneous and induced emission, Einstein's A and B coefficients, Properties of lasers, Principle & working of He-Ne, Ruby, semiconductor and color center.	10

Learning Resources:

1. Introduction to Atomic Spectra H. E. White McGraw Hill, First Edition ISBN-10: 0070697205 / ISBN-13: 978-0070697201.
2. Atomic Physics by Christopher J. Foot, Oxford University Press 2005. ISBN 10: 0198506961 / ISBN 13: 9780198506966
3. Fundamentals of Molecular Spectroscopy C.N Banwell & Elaine M. McCash. Tata McGraw Hill. ISBN 10: 0077079760 ISBN 13: 9780077079765
4. Spectra of diatomic molecules G. Herzberg, Krieger Malbar Florida (2015). ISBN 10: 5458354060 ISBN 13: 9785458354066.
5. Molecular structure and spectroscopy by G Aruldhas Prentice Hall of India (2009) ISBN 10: 8120332156 ISBN 13: 9788120332157.
6. Spectroscopy volume 2, Edited by B.P. Straughan and S.Walker, London Chapman and Hall. ISBN 10: 0470150319 ISBN 13: 9780470150313.
7. Laser & Non-linear Optics B. B. Laud. Wiley Eastern Limited (2011). ISBN 10: 8122430562 ISBN 13: 9788122430561
8. Laser Spectroscopy, Basic Concepts and Instrumentation by W. Demtroder, Springer. ISBN 10: 0387103430 ISBN 13: 9780387103433
9. Physics of atoms and molecules B. H. Bransden and C. J. Joachain Pearson Education. ISBN 10: 0306410494 ISBN 13: 9780306410499

Course Name: 8086 Microprocessor and Programming

Course Code: PHYT/DSE/504, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Course Objectives:

1. To facilitate the students to understand
   a) The concepts of microprocessor.
   b) The concept of assembly language programming.
2. To provide an opportunity to the students to enter into entrepreneurship.

Course Outcomes: Students will be able to:

1. Understand and explain Microprocessor architecture, physical configuration of memory, logical configuration of memory, and microprocessor programming.
2. Analyze the process of Industrial automation.
3. Start his / her own small scale industry for manufacturing microprocessor based automated devices.
4. Start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well as engineering discipline.

Unit No.	Course Content	Contact Hours
I	**Introduction** Overview of Microcomputer structure and operation, memory, input / output, CPU, address bus, data bus, control bus, 8086 microprocessor family overview, 8086 internal architecture: execution unit, (flag register, general purpose register, ALU), Bus interface unit, segment register, stack pointer register, pointer and index register [Refer Douglas and Hall book for above articles], Pin out and pin functions of 8086 : The pin out, power supply requirements, DC characteristics, input characteristics, output characteristics, pin connections (common pins, maximum mode pins and minimum mode pins) Addressing Modes: Data addressing modes: Register addressing, Immediate addressing, Direct addressing, register indirect addressing, base plus index addressing, register relative addressing, base relative plus index addressing, Programme memory addressing modes: Direct program memory addressing, relative program memory addressing, indirect program memory addressing; stack memory addressing modes.	10
II	**Data Movement, Arithmetic and Logical Instructions** **MOV revised**: machine language, the op code, MOD field, register assignments, R/M memory addressing, special addressing, **PUSH/POP** : PUSH, POP, initializing the stack; **Miscellaneous data transfer instructions**: XCHG, IN and OUT, **Arithmetic and Logic Instructions: Addition, subtraction and comparison: Addition**: Register addition,immediate addition, memory to register addition, array addition, increment addition, addition with carry; **Subtraction**: Register subtraction, immediate subtraction, decrement subtraction, subtraction with barrow; **Comparison, Multiplication and division: Multiplication**: 8 bit multiplication, 16 bit multiplication; **Division**: 8 bit division, 16 bit division; **Basic Logic Instructions**: AND, OR, Ex-OR, TEST, NOT, NEG; **Shift and Rotate: Shift**: left shift, right shift; **Rotate**: Rotate left, rotate right	10

III	**Program Control Instructions and Assembly Language Programming** **The Jump Group**: Unconditional jump: short jump, near jump, far jump, indirect jumps using an index; **Conditional Jumps**: LOOP, conditional LOOPs; **Procedures**: CALL, near CALL, far CALL, indirect memory address, RET; **Machine Control and Miscellaneous Instructions**: Controlling the carry flag bit, wait, HLT, NOP; Assembly Language **Programming**: **Assembler directives**: ASSUME, DB, DD, DQ, DT, DW, END, ENDP, ENDS, EQU, EVEN, EXTRN, GLOBAL, GROUP, INCLUDE, LABEL, LENGTH, NAME, OFFSET, ORG, PROC, PTR, PUBLIC, SEGMENT, SHORT, TYPE [Refer Douglas and Hall book for above articles] **Assembly Language Programming**: Sum of an array, factorial, largest / smallest from given array, sorting of numeric array, square root.	10

Learning Resources:

1. The Intel Microprocessors, Architecture Programming and interfacing, Barry B Brey ; Sixth Edition ; Prentice Hall International, Publications, (2002), ISBN-10: 0130607142, ISBN-13: 978-0130607140
2. The Intel Microprocessors, Architecture Programming and interfacing, Barry B Brey ;Eighth Edition ; Prentice Hall International, Publications (2009), ISBN 0-13-502645-8
3. Microprocessors and Interfacing: Programming and Hardware, Douglas V Hall: II Edition; Tata McGraw-Hill (1990), ISBN-10: 0070257426, ISBN-13: 978-0070257429.
4. Microcomputer Systems: The 8086 / 8088 Family; Architecture, Programming and Design, Yu-Cheng Liu and Glenn A. Gibson, Prentice Hall International, Publications (1986), ISBN-10: 013580499X, ISBN-13: 9780135804995.
5. The 8086/8088 Family: Design, Programming and Interfacing, John, Uffenbeck, Prentice Hall International, Publications (1986), ISBN-10: 0132467526, ISBN-13: 978-0132467520.

Course Name: Atomic Spectroscopy

Course Code: PHYT/DSE/505, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. The concept of the photon, however, emerged from experimentation with thermal radiation, electromagnetic radiation emitted as the result of a source's temperature, which produces a continuous spectrum of energies. More direct evidence was needed to verify the quantized nature of electromagnetic radiation. In this course, we describe how experimentation with visible light provided this evidence.
2. This course addresses various aspects of spectroscopic analysis relevant to research and industry.
3. Seeing that spectroscopy is a set of tools that can put be together in different ways to understand systems and solve chemical problems.
4. Understanding basic concepts of instrumentation, data acquisition and data processing.

Course Outcomes:

After completing this course the student will be able to use spectroscopic methods for qualitative and quantitative analysis.

Unit No.	Course Content	Contact Hours
I	**Relativistic effect on Atomic Spectra** Sommerfeld relativity correction, fine structure and spinning electron, observed hydrogen fine structure, fine structure of ionized helium line $\lambda = 4686$ Å, the Dirac electron in hydrogen atom, Sommerfeld formula from Dirac's theory, Lamb shift (qualitative) [Scope: Introduction to Atomic Spectra by H. E. White,Chapter IX] [Scope: Atomic Physics, Christopher J. Foot, page 40-41].	10
II	**Atoms in magnetic field** Vector model of a one electron system in weak magnetic field, magnetic moment of bound electron, magnetic interaction energy, selection rules, intensity rules, Paschen Back effect, Paschen Back effect of a Principal series doublet, selection rules for Paschen Back effect, The Zeeman and Paschen Back effects for hydrogen, Quantum mechanical model of an atom in a strong magnetic field. The Rydberg Series relationship, Hartley law of constant doublet separation, Displacement law, Law of alternation of multiplicities. Terms in many electron atom, Terms in equivalent electron system, Lande interval rule. Application of Lande Interval rule, Hund's rules, Pauli exclusionprinciple for p2, p3, p4, p5, d2 electrons. [Scope: Introduction to Atomic Spectra by H. E. White,Chapter X]	12
III	**X-ray Spectra** Mosley's law, Absorption spectra, energy levels, selection and intensity rules (Burger - Dorgelo - Ornstein rules), regular and irregular doublet law, predicted structure in x-rays, x-ray satellites, explanation of x-ray absorption spectra. [Scope: Introduction to Atomic Spectra by H. E. White, Chapter XIV]	08

Learning Resources:

1. Introduction to Atomic spectra by H E White McGraw Hill. McGraw-Hill Inc.,New York, US, ISBN-10: 0070697205, ISBN-13: 978-0070697201, (1934 & 1954)
2. Atomic Physics by Christopher J. Foot, ISBN: 9780198506959 Published by Oxford University Press, New York 2005-02-10 (2005) Oxford University Press.
3. Laser Spectroscopy, Volume 1: Basic Principles, Fourth Edition by Wolfgang Demtroder, Springer, ISBN 978-3-540-73415-4 e-ISBN 978-3-540-73418-5, DOI 10.1007/978-3-540-73418-5 Library of Congress Control Number: 2007939486, © 2008, 2003, 1996, 1981 Springer-Verlag Berlin Heidelberg.
4. Atom, laser and spectroscopy by S. N. Thakur and D. K. Rai, ISBN: 9788120339569 Published by A. K. Ghosh Prentice Hall India Learning Private Limited, New Delhi (2010) First Edition. Second Edition ISBN: 9788120348325, Published Prentice Hall India Learning Private Limited, New Delhi (2011).
5. Modern Spectroscopy by J. M. Hollas, ISBN: 9780470844167, Published by John Wiley & Sons Ltd. (2004) Fourth Edition.

Course Name: Radioactivity and Nuclear Decay

Course Code: PHYT/DSE/506, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. Nuclear physics is one of the most important topics of physics.
2. This course is necessary as it gives the idea of important phenomenon of Radioactivity and various nuclear decays.
3. the course will help the student for preparation of NET/SET and other competitive examinations. It should be taught as an Elective.

Course Outcomes:

1. This course is beneficial to students because it can help to understand the uses of radioactivity in determining age of earth, mountains, etc.
2. The understanding of various nuclear decay is beneficial in radio physics / Chemistry and in the field of medical (Treating the cancer patients).
3. The students can get job in medical diagnostic centers as well as they can do research in BARC and other institutions.

Unit No.	**Course Content**	Contact Hours
I	**Radioactivity and Alpha Decay** Introduction, Basic parameters of radioactivity, radioactive series, Induced radioactivity (Artificial radioactivity), radioactivity dating, the age of earth, Units of radioactivity, Radiation dosimetry.- Introduction, Properties of alpha particle, Disintegration energy of alpha decay, Alpha Spectrum, Range of alpha-particles and Geiger–Nuttal law, Long range alpha-particles, Experimental methods for range of alpha-particles (Bragg and Kleeman method, Geiger-Nuttal method), Conservation laws in alpha decay, Gammows theory of alpha decay.	10
II	**Beta Decay** Introduction, Properties of beta-ray, Types of beta decay processes, Energetics of beta decay, Bucherer's method for e/m, Beta ray spectra, Pauli's Neutrino hypothesis, Fermi's theory of beta decay, Selection rules in beta decay, Energy levels and decay schemes.	10
III	**Gamma Decay** Introduction, Properties of gamma-ray, Selection rule, Multipolarity in gamma transitions, Life time of gamma active nuclei, Gamma rays spectra, Conservation laws in gamma emission, Internal conversion, Nuclear isomerism, Mossbauer effect, Interaction of gamma rays with matter.	10

Learning Resources:

1. Nuclear Physics, R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN- EBK0036746).
2. Fundamentals of Nuclear Physics, Jahan Singh, 1st edition, Pragati Prakashan, Meerut- (2012) (ISBN-978-93-5006-593-8)
3. Radioactive Materials, Dr. B. M. Rao, 1st edition, Himalaya Publishing House, Mumbai- (2002).
4. Nuclear Physics, S. B. Patil, 1st edition, New Age International Publishers, New Delhi- (1991) (ISBN-978-81-224-0125-7).
5. Nuclear Physics, D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
6. Basic Nuclear Physics, B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. Nuclear Physics, Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN- 81-7556-915-8).
8. Nuclear Physics, K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-517-3).

Course Name: Electrical Properties of Solid and Superconductivity

Course Code: PHYT/DSE/507, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The course aims at giving the students,

1. In depth knowledge and know-how within the theory of superconductivity in order to understand and describe the principles behind various superconducting applications.
2. Distinguish between perfect conduction and perfect diamagnetism, and give a qualitative description of the Meissner effect, describe different theories of superconductivity and their ranges of validity.
3. Get familiarized with the types of polarization of dielectrics in static and alternating electric fields.
4. Acquiring of knowledge concerning the electrical behavior of dielectric and ferroelectric materials. Will be able to experimentally investigate ferroelectric and dielectric materials.

Course Outcomes: At the end of the course the student will be able to:

1. Describe different theories of superconductivity and basic properties of superconductors.
2. Explain type-I and type-II superconductivity based on thermodynamic calculations of the Gibbs free energy for a superconductor.
3. Will learn to understand the relationship between material structure and electrical properties of materials.
4. Acquire knowledge about different types of dielectric and ferroelectric materials.
5. Develop research/teaching career in the field of Superconductivity/ Dielectrics.

Unit No.	Course Content	Contact Hours
I	**Dielectric Properties of Solids** Fundamental definitions, Local field, Clausius- Mossotti relation, Polarization mechanisms in dielectrics: induced, orientational, electronic, ionic, interfacial and lattice polarizations; combined mechanisms, frequency and temperature effects on polarization, Classical theory of electronic polarizability, dipolar polarizability. Langevin's theory of dipolar polarizability dielectric loss, dielectric breakdown, determination of dielectric constant, properties and different types of insulating materials, Debye theory, Onsager equation, Applications. Ferroelectric properties of Solids: Fundamentals, Curie-Weiss law, Classification of ferroelectric materials, Theory of spontaneous polarization of $BaTiO3$, antiferroelectricity and ferrielectricity, Ferroelectric domains, Piezoelectricity, Pyroelectricity, Applications	12
II	**Basic properties of Superconductors** Some fundamental Phenomena associated with Superconductivity (Zero resistance, persistent currents, superconducting transition temperature Tc, isotope effect, perfect diamagnetism and Meissner effect, penetration depth and critical field, Characteristics Length,). Type-I and Type-II Superconductors, Intermediate states, mixed states, Supercurrents and Critical Currents., Quantization of Magnetic Flux. Thermodynamics of superconducting transition: First order and second order transition, specific heat above and below Tc, thermal conductivity;	10
III	**Theories of Superconductivity** London Equations, BCS theory: Coherence of the BCS Ground State and the Meissner-Ochsenfeld Effect ,Electron -Electron Interaction via Lattice Cooper Pairs, BCS Wave function; Tunneling phenomenon, energy level diagram, ac And dc Josephson Effects, quantum interference. Novel High Temperature superconductors, Applications.	08

Learning Resources:

1. Introduction to Solid State Physics, C. Kittel; 7th Edition; Wiley Eastern Pvt. Ltd. (2011); ISBN-978-81-265-1045-0.
2. Solid State Physics, A.J.Dekker; Macmillan Publishers India Ltd.; (2012); ISBN-10: 0333-91833-9; ISBN-13: 978-0333-91833-3.
3. Introduction to Solids, L.V.Azaroff; TMH Edition; 3rd reprint (2009); TATA McGraw Hill;ISBN-13: 978-0-07-099-219-1; ISBN-10: 0-07-099-219-3
4. Solid State Physics, M.A.Wahab; 2nd Edition; 3rd reprint (2008); Narosa Publishing House Pvt. Ltd; ISBN: 978-81-7319-603-4.
5. Solid state physics, S.O.Pillai; 6th Edition; New Age international Pvt. Ltd.; (2005); ISBN: 81-224-1682-9.
6. Solid State Physics, Vimal Kumar Jain; Ane Books Pvt. Ltc; (2013); ISBN: 978-93-8116-297-2.
7. Modern Physics and Solid State Physics (Problems and Solutions), S.O.Pillai; Revised 3rd Edition; New Age International Publishers; ISBN: 81-224-1704-3.
8. Elementary Solid State Physics, M. Ali Omar; 5th Impression (2009); Pearson Education.inc; ISBN: 978-81-7758-377-9.
9. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena,; 5th Edition; Pragati Prakashan; (2012); ISBN:978-93-5006-539-6.
10. Solid State Physics, Neil W. Ashcroft, N. Devid Mermin; 9th Indian Reprint (2010); CENGAGE Learning India Pvt. Ltd. (India Edition); ISBN-13: 978-81-315-0052-1.

Course Name: Practical Based on PHYT/MJ/500

(Linear and digital Electronics)

Course Code: PHYP/MJ/526, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives: The themes dealt with in this paper:

1. This course deals with the basic foundation to specialization in Electronics and Industrial applications.
2. This course is an advanced which requires the special efforts and training.
3. This course will help the student to elaborate designing the electrical circuits, input and output characteristics and their uses in various electrical devices for various applications.

Course Outcomes: The present unit attempts to achieve the following learning outcomes:

1. After completing this course the student will be prepare to explain the scope and possibilities of electrical circuits designed using OP-AMP, Multivibrators and counters for various applications for research career as well as in industries.
2. The students will be able to design electrical circuits for various industrial applications.

Expt. No.	Title of the Experiments
1.	Determination of characteristics of OP-AMP 741 : CMRR and Slew rate
2.	Determination of characteristics of OP-AMP 741 : input offset voltage and input bias current
3.	Inverting and non-inverting amplifier using OP-AMP 741
4.	Astable multivibrator using OP-AMP 741
5.	Schmidt trigger using OP-AMP 741
6.	Wien bridge Oscillator using IC 741
7.	Monostable multivibrator using IC555
8.	Decimal to BCD converter
9.	Mod 16 counter
10.	Diode Matrix ROM

Course Name: Practical Based on PHYT/MJ/501
(General Condensed Matter Physics)
Course Code: PHYP/MJ/527, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Course Objectives: The themes dealt with in this paper:

1. This course deals with the basic foundation to specialization in Condensed Matter Physics and applications.
2. This course is an advanced which requires the special efforts and training.
3. This course will help the student to elaborate characterization techniques of as prepared materials using XRD and UV-Vis spectra.

Course Outcomes: The present unit attempts to achieve the following learning outcomes:

1. After completing this course the student will be prepare to explain the scope and possibilities of studies in structural properties of synthesized materials for various applications for research career as well as in industry.
2. The students will be able to identify the structure, cell parameters, energy band gaps and optical properties of any given materials.

Expt. No.	Title of the Experiments
1.	Study the cubic structure of given XRD data and determine lattice parameters.
2.	Study the hexagonal structure of given XRD data determine the lattice parameters.
3.	Study the diamond structure using XRD data and determine of lattice parameters.
4.	Study the Hall Effect and determine type and number of charge carriers.
5.	Study the Hall Effect and determine Hall coefficient and Mobility of Carriers.
6.	Study the Hall Effect and determine type and drift mobility.
7.	Study the UV Vis Spectra of ZnO lattice.
8.	Study the UV-Vis spectra of ZnS lattice.
9.	Study the UV-Vis spectra of CdS lattice.
10.	Study of Specific heat of graphite using heat treatment.
11.	Estimate the band gap of a given p-n junction diode.
12.	Determine the Miller indices, lattice parameters and grain size of $Cu_{2-x}Se$, CdS thin films from given XRD data.
13.	Measurement of thermal conductivity of various materials.
14.	Determine the charge carriers of the given semiconducting sample by Hall Effect.
15.	Calculate the Energy band gap of given samples.
16.	Evaluate the resistivity of the given semiconducting sample by Four Point Probe Method.

Course Name: Practical Based on PHYT/MJ/502 (General Nuclear Physics)

Course Code: PHYP/MJ/528, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Course Objectives: The themes dealt with in this paper:

1. This course gives basic foundation to specialization in nuclear physics and Spectroscopy and applications.
2. The course is an advanced course and requires special efforts.
3. The course will help the student to explain characteristics of Geiger Muller counter/tube: Operating voltage, Dead time and counting statistics.

Course Outcomes: The present unit attempts to achieve the following learning outcomes:

1. After completing this course the student will be prepare to explain the scope and possibilities of studies in nuclear physics for research career as well as in industry.
2. The students able to explain the characteristics of Geiger Muller counter/tube: Operating voltage, Dead time and counting statistics.

Expt. No.	Title of the Experiments
1.	Determination of characteristics of Geiger Muller counter/tube: Operating voltage
2.	Determination of dead time of a G. M. counter by double source method.
3.	Determination of dead time of a G. M. counter by variable area method.
4.	Statistical aspects of radioactivity measurements.
5.	Beta backscattering as function atomic number.
6.	Beta energy determination by feather's analysis.
7.	To study the secular equilibrium.
8.	To study the transient equilibrium.

Course Name: Practical based on PHYT/DSE/504

(8086 Microprocessor and Programming)

Course Code: PHYP/DSE/529, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. To facilitate the students to understand
   a) The concepts of microprocessor and assembly language programming.
   b) The concept of interfacing devices at laboratory as well industrial level.
2. To provide an opportunity to the students to enter into entrepreneurship.

Learning Outcomes: Students will be able to learn:

1. Microprocessor architecture, physical configuration of memory, logical configuration of memory, microprocessor programming and interfacing.
2. Students will be capable to perform following job
   a) Industrial automation using 8086 interfacing and programming.
   b) Start his / her own small scale industry for manufacturing microprocessor based automated devices.
3. Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline.

Expt. No.	**Title of the Experiments** **(Experiments using 8086 Kit)**
1.	Data transfer, addition, subtraction, multiplication, division and sum of series
2.	Factorial and square of the number
3.	Sorting of data (ascending / descending), square root of a number
4.	Arithmetic mean of N- numbers and sum of square of Numbers
5.	Interfacing of SPDT switches and 7 segment display as a position encoder / decoder
6.	Interfacing of stepper motor
7.	Interfacing of DC motor
8.	Interfacing of DAC to generate ramp wave, triangular wave and square wave.
9.	Interfacing of 8-bit ADC
10.	Data transfer, addition, subtraction, multiplication, division and sum of series
Expt. No.	**Experiments using 8086 Assembler**
11.	Data transfer, addition, subtraction, multiplication, division and sum of series
12.	Factorial and square of the number
13.	Sorting of data (ascending / descending), square root of a Number.
14.	Arithmetic mean of N- numbers and sum of square of Numbers

Course Name: Practical based on PHYT/DSE/505

(Atomic Spectroscopy)

Course Code: PHYP/DSE/530, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Knowledge of absorption and emission spectra.
2. Study of various types of excitation mechanisms and excitation sources.
   The student will get a training for using state of the art computer interfaced data acquisition system in spectroscopy laboratory for recording the atomic emission spectra.
3. Analysis of recorded atomic spectra.
4. Study the effect of external electromagnetic fields on the atomic spectra.
5. Application of ESR spectroscopy.

Course Outcomes: The student will be able to:

1. perform DC arc excitation of Fe
2. perform DC arc excitation of Cu
3. perform DC arc excitation of Zn
4. perform DC arc excitation Brass
5. record the spectra of elements using HR4000 spectrometer
6. excite the emission spectra using gas discharges
7. excite the inert gases
8. record the absorption spectrum of the Sun
9. arrange the Zeeman effect setup and record the splitting
10. use ESR spectrometer for determining earth's magnetic field

Expt. No.	Title of the Experiments
1.	Record the spectrum of Hydrogen using HR 4000 spectrometer and determine Rydberg constant
2.	Record the spectra of (arc sourcesiron using HR 4000 Spectrometer
3.	Record the spectra of (arc sources) copper using HR 4000spectrometer
4.	Record the spectra of (arc sources) zinc using HR 4000spectrometer
5..	Record the spectra of (arc sources brass using HR 4000spectrometer
6.	Record the spectra of (gas discharge sources) Hg using HR 4000 spectrometer
7.	Record the spectra of (gas discharge sources) Cd using HR 4000 spectrometer
8.	Record the spectra of (inert gases) Ne using HR 4000 spectrometer
9.	Record the spectra of (inert gases) He using HR 4000 spectrometer
10.	To verify the line spectra of calcium and to verify the Landed interval rule
11.	To verify the Landed interval rule for the sharp series lines of Zinc
12.	Record the absorption spectrum of the Sun using HR 4000 spectrometer and identify the elements in the spectrum
13.	Study of hyperfine structure using Zeeman effect
14.	Study of normal Zeeman effect and calculation of e/m.

Course Name: Practical based on PHYT/DSE/506

(Radioactivity and Nuclear Decay)

Course Code: PHYP/DSE/531, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Recording the pulse height spectra using latest gamma ray spectroscopy system.
2. Analysis of recorded pulse height spectra.
3. Study of various types of gamma ray sources.
4. Study the characteristics of Geiger-Muller (G-M) counter.

Course Outcomes:

1. The student will get a training for using state of the art data acquisition system in Nuclear Physics laboratory
2. The student will get a training for analysis of recorded pulse height spectra.
3. The student will be able to perform various kinds of experiments using GM and Scintillation counter.

Expt. No.	**Title of the Experiments**
1.	To study characteristics of Geiger-Muller (G-M) counter.
2.	Determination of dead time of Geiger-Muller G-M) counter (Two source method).
3.	Determination of dead time of Geiger-Muller (G-M) counter (Absorber method).
4.	To study absorption of beta particles in matter.
5.	Verification of the Inverse Square Law.
6.	Window thickness of a Geiger-Muller (G-M) counter.
7.	Window thickness of a Geiger-Muller (G-M) counter (Inverse Square Law).
8.	Shelf ratios of a sample holder.
9.	Determination of Efficiency of a Geiger-Muller (G-M) counter.
10.	Energy dependence of Geiger-Muller (G-M) counter efficiency.
11.	Determination of beta decay energy.
12.	Relationship between thickness of absorber and backscattering
13.	Shielding effect of radiation penetrability
14.	Strength of a beta-source
15.	Determination of Half-Life of unknown sample
16.	Half-life of 40K.
17.	Statistics of radioactive measurements.
18.	Poisson distribution of radioactive measurements.
19.	Gaussian distribution of radioactive measurements.
20.	Chi-Square test of Geiger-Muller (G-M) counter.
21.	Study of Mossbauer spectra of magnetic materials.

22.	Statistical aspects of radioactivity measurements.
23.	Beta backscattering as a function of atomic number.
24.	Determination of the air borne activity.
25.	Secular equilibrium.
26.	Transient equilibrium.

Note: Students should perform any eight experiments.

Course Name: Practical based on PHYT/DSE/507

(Electrical Properties of Solids and Superconductivity)

Course Code: PHYP/DSE/532, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. This activity introduces the fundamental principles of four probe resistivity
2. Identification of ferroelectric materials.
3. Measurement of dielectric constant of different solid samples
4. Determine the resistivity of the given materials.
5. Explain the properties and applications of superconductivity.
6. Describe the structure and uses of Graphite.

Course Outcomes: After completing this course, the students will be able to:

1. Describe what can be detected by four probe resistivity technique
2. Explain the impact of temperature
3. Atom size, and impurities on the tests.
4. Acquisition of the following skills:
5. Ability to explain basic/fundamental dielectric concepts
6. Ability to extort the relevant information from four probe resistivity papers.
7. Pursue higher studies in Overseas universities.

Expt. No.	Title of the Experiments
1.	Resistivity Measurement of a given sample by four probe method.
2.	Measurement of dielectric constant and its variation with temperature.
3.	Determination of bulk density of different materials using immersion technique.
4.	Measurement of dielectric constant of liquids.
5.	Measurement of electrical conductivity of Graphite at room temperature.
6.	Determination of specific heat of Graphite at different temperatures.
7.	Measurement of dielectric constant of solids.
8.	Porosity determination of Superconducting materials.
9.	Determination of Bulk density of ferroelectric materials.
10.	To measure ferroelectric hysteresis curves
11.	Determination of Curie temperature of Ferroelectrics.
12.	Resistivity Measurement of CuS thin film by four point probe method.
13.	Resistivity Measurement of ZnS thin film by four point probe method.

Note: 1) Other experiments may be added as per the availability of instruments.
2) Students should perform any eight experiments.

Course Name: Research Methodology

(Review of Literature for Research Project and Formulation of Topic)

Course Code: PHYT/RM/546, Course Type: RM,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Marks: 50

Learning Objectives:

1. To define research and describe the research process and research methods
2. To understand qualitative research and methods used to execute and validate qualitative research
3. To know how to apply the basic aspects of the research process in order to plan and execute a research project.
4. To provide insight into the processes that lead to the publishing of research.
   To be able to present, review and publish scientific articles.

Course Outcomes: Students will be able to:

1. Understand and explain research process.
2. Do systematic literature survey, formulation of a research topic, study design, analysis and interpretation of data.
3. To design a research approach for a specific research issue of their choice.
4. Select a suitable analytical method for a specific research approach.
5. Demonstrate a good understanding of how to write a research report.
6. critically assess published quantitative research with regard to the statistical methods and approaches adopted
7. Create a research document for implementation research project

Unit No.	Course Content	Contact Hours
I	**Research Fundamentals and Identification of Research Problem** **Research Fundamentals** Introduction: Definition, objectives of the research, characteristics of the research, what makes people to do research, importance of research, Qualitative and Quantitative Research: Qualitative research - Quantitative research - Concept of measurement, causality, generalization, and replication. Merging the two approaches. **Identification of Research Problem** Defining the research problem: Identification of research problems, selection of research problem, facts one should know regarding selection of research problem, the process of research problem definition, some facts involved in defining research problem, Research Design: Concept and Importance in Research - Features of a good research design - Exploratory Research Design - concept, types and uses, Descriptive Research Designs - concept, types and uses. Experimental Design: Concept of Independent & Dependent variables, Case Studies,	10
II	**Formulation of Research Problem** Formulation of the problems: steps involved in defining a problem, formulation of the problems, Formulation of hypothesis: Concept of hypothesis, hypothesis testing, developing the research plan: implementation, interpreting and reporting the findings, Importance of hypothesis in decision making, Case Studies. Interpretation of Data. Measurement: Concept	10

	of measurement- what is measured? Problems in measurement in research- Validity and Reliability. Levels of measurement Nominal, Ordinal, Interval, Ratio.	
III	**Research Report and Proposal Writing** Introduction, research proposal writing: costing, the research proposal, rationale for the study, research objectives, research methodology, target respondents, research Centres, sample size and sample composition, sampling procedures, research project execution, research units; An insight into research report and proposal, research project synopsis, research report writing : types of research reports, guidelines for writing reports; Steps in writing report, report presentation, typing the report, documentation and bibliography, formatting guidelines for writing a good research report / research paper, Paper Writing- Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Case Studies.	10

Course Name: Practical Based on PHYT/RM/546

(Research Methodology)

Course Code: PHYP/RM/547, Course Type: RM

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

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1. Presentations,
2. Case studies,
3. Assignments,
4. Tutorials based on Module I to III

Students are expected to do the Followings

1. Select Broad topic of Research Project (to be implemented from second semester onwards)
2. Read the Basic concepts / fundaments of broad topic
3. Identify 10 SCOPUS / WEB OF SCIENCE Indexed Journals related to broad topic
4. Search and download 20 research articles from above research Journals
5. Do systematic review of above 20 research articles
6. While doing review of each of above mentioned 20 research articles, students are expected prepare notes on following points
   a) What are the objectives of the research article?
   b) What methodology has been adopted?
   c) What are prominent results?
   d) How these results of relevant to the latest development of the subject?
   e) What is novelty of research article?
   f) What are prominent shortcomings of this research a presented in this research article?
   g) What are your plans to address those shortcoming?
7. Draft the fine-tuned title of research project
8. Draft hypothesis
9. Draft Objectives and Methodology
10. Draft expected outcome of the research project

At the end of the assignment, students are expected to prepare a report having following points

1. Fine-tuned title of Research Project
2. Fundamental aspects of the fine-tuned research topic
3. Hypothesis
4. Objectives
5. Methodology
6. Detailed Experimental plan
7. Expected outcome
8. References

Learning Resources:

1. Research Methodology by Dr. S. L. Gupta, Hitesh Gupta; International Book House Pvt Ltd **(2013),** ISBN-10: 8191064278, ISBN-13: 978-8191064278
2. Basic Research Methods-Gerard Guthrie SAGE Publications, India, Pvt Ltd, New Delhi **(2010),** ISBN-10: 8132104579, ISBN-13: 978-8132104575
3. Research Methodology-methods and techniques By C. R. Kothari, New Age International Publishers **(2011)** ISBN 978-81-224-1522-3
4. Principles of Research Methodology- Phyllis G. Supino, Jeffrey S. Borer; Springer, Verlag New York **(2012),** ISBN-ebook: 1461433592, ISBN (Hardcover): 978-1461433590
5. Research Design Qualitative, Quantitative. and Mixed Methods Approaches- John W. Creswell; SAGE Publications Ltd, UK **(2011),** ISBN-9780857023452
6. Research Methodology -A Step-by-Step Guide for Beginners- Ranjit Kumar; Sage Publications Ltd **(2010),** ISBN- 1849203016.
7. Scientific Writing and Communication- Angelika Hofmann; Oxford University Press, US **(2010),** ISBN-13-: 978-0 199947560, ISBN-10: 01 99947562
8. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded- Joshua Schimel, Oxford University Press, **(2011)**, ISBN: 9780199760237
9. Handbook of Scientific Proposal Writing- A.Yavuz Oruc; CRC Press, Taylor & Francis group **(2011)**, ISBN: 9781439869185

AS PER NEP 2020

SEMESTER – II

Course Name: Quantum Mechanics-I

Course Code: PHYT/MJ/550, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Course Objectives:

1. To introduce the Quantum Mechanical postulates for physical systems
2. To introduce the Quantum Mechanical concepts of measurements for physical systems
3. To introduce the role of Quantum Mechanics on evolution of the physical systems in our Universe
4. To introduce the concept of Quantum Mechanics in simple microscopic systems and its connection to actual observable.

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

1. Failure of classical physics at the microscopic level
2. Basic non-relativistic Quantum Mechanics
3. Matrix representation of Quantum Mechanics

They will have skills to do the following:

- Apply principles of Quantum Mechanics to calculate observables for given wave functions
- Solve Schrodinger equation for simple systems like simple harmonic oscillator, hydrogen atom, particle in a box, etc.

Unit No.	Course Content	Contact Hours
I	**Quantum Mechanics in 1-D** Exact Solutions of Schrödinger's equation in one dimension. Free particle, The Potential step and potential barrier (E is less that and greater than V_o) Tunneling. Dirac notation, Harmonic Oscillator using Matrices of p, x, E. The Uncertainly relation in Harmonic oscillator.	10
II	**Quantum Mechanics in 3D** The Hydrogen atom, Spherical polar co-ordinates separation of angular and radial part (Details and Recursion formulae not expected), Calculation of wave function using standard formulae; Degeneracy, angular momentum, various commutation relations. J_+ and J_- operators, Ladder Operators with J and Jz etc. Eigenvalues. Metrics of j=y₂ and j=1. Pauli Spin Matrics.	10
III	**Approximate methods and Scattering** The Variational method-Application to Simpler problem – particle in a box, harmonic oscillator – H_2^+ ion, time independent cases; time dependent perturbation theory; Fermi's rule, Harmonic perturbation, scattering cross section, scattering cross section scattering amplitude, Partial wave analysis; first born approximation.	10

Learning Resources:

1. Quantum Mechanics concept and application by M. Zettili, I K International Publishing.
2. Introduction Quantum Mechanics by Richard Liboff. Peasson Education.
3. Quantum Mechanics theory and application by Ajoy Ghatak and S. Lokhanthan, Mackmillam.
4. Quantum Physics by H. C. Verma, Surya Publication
5. Quantum Mechanics by G. Aruldhas, PHI learrrirs pvt limited.
6. Principle of Quantum Mechanics by R. Shankar Spriger Verlag New York Inc.

Course Name: Mathematical Methods in Physics-I

Course Code: PHYT/MJ/551, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: To facilitate the students to understand

1. The basic elements of complex mathematical analysis, including the integral transform and Laplace transform.
2. To expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
3. To apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
4. To solve partial differential equations of second order by use of series expansion (Fourier series) and integral transforms.

Course Outcomes: After finishing the course the student should be able to:

1. Master the basic elements of complex mathematical analysis, including the integral theorems, obtain the residues of a complex function and to use the residue theorem to evaluate definite integrals
2. Solve ordinary differential equations of second order that are common in the physical sciences.
3. Expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
4. Apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
5. Solve partial differential equations of second order by use of standard methods like separation of variables, series expansion (Fourier series) and integral transforms.
6. Solve some simple classical variational problems.

Unit No.	Course Content	Contact Hours
I	**Fourier series** Definition, Periodic series, Dirichlet's conditions for a Fourier series, Evaluation of coefficient, Function defined in two or more sub ranges,Discontinu8os function, Fourier series representation of even and odd function General properties of Fourier series, simple applications, convergence, integration, differentiation, problems	10
II	**Laplace Transforms** Definition, Important formulae, Properties of Laplace Transform ,Laplace transform of derivatives, LT of derivative of order n, LT of integral of f(t)LT of t(multiplication by t), problems LT of $\frac{1}{t}$ f(t) (division by t), unit step function,, impulse function, Periodic function. Inverse Laplace transforms, important formulae, ILT multiplication by s, ILT division by s, Shifting properties, ILT of derivatives, ILT of Integrals, ILT by partial fraction method.	10
III	**Integrals Transforms** Integral transform, Fourier Integral theorem. Fourier sine and cosine Transform. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Fourier transform of derivatives, Inverse Fourier transform and problems	10

Learning Resources:

1. Advance Engineering Mathematics H. K. Dass/ S. Chand co. / 978-93-52533-83-1/2018
2. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence,3rd ed., **2006,** Cambridge University Press /ISBN9780521679l8/2006
3. Mathematical Physics Fourth edition – B. D. Gupta/ **ISBN** 978-93-5453-506-2/ Vikas Publishing House, New Delhi/2008
4. Mathematical Physics- B.S. Rajput, Pragati Prakashan (Meerut). **ISBN** 10: 8175568712/23 edition/2005
5. Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications/ ISBN-13: 978-0486691930/1996
6. Complex Variables, A.S. Fokas & M.J. Ablowitz, Cambridge University Press, **ISBN**-13: 978-0521534291/2003.
7. Complex Variables and Applications, J.W. Brown & R.V. Churchill, 8th Ed./ (**ISBN**: 978-0-07-333730-2/ 2004, Tata McGraw-Hill
8. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, Jones & Bartlett/ **ISBN**-13: 978-0763757724/2nd edition /1940.

Course Name: Classical Mechanics-I

Course Code: PHYT/MJ/552, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. Impart knowledge of concepts of coordinates.
2. Provide background knowledge and core expertise in Hamiltons's functions.
3. Convey basic knowledge of various Principles Variational.
4. Give knowledge about Cyclic-coordinates.

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

1. Outline basic principles, theorems and integrals of motion.
2. Describe the orbits of artificial satellites.
3. Interpret the vibrations of linear in triatomic molecules.

Course Contents:

Unit No.	Course Content	Contact Hours
I	**Constrained Motion** Constraints: Classification of constraints, Principal of Virtual Work, D'Alembert's principal and its applications, problems. Lagrangian formulation: Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation. Hamiton's formulation: Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles and light rays. Variational Principle: Variational principle, Euler's equation, applications of variational principle, problems.	12
II	**Canonical Transformation and Central Force** Generating function: Conditions for canonical transformation and problem, theory of chaos, Two body central force problem, stability of orbits, condition for closure, integrable power laws, Kepler's problems, orbits of artificial satellites, Virial theorem. Poisson Brackets: Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, invariance of PB under canonical transformation.	10
III	**Rotational and Oscillatory Motion** Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum, small oscillations, Normal co-ordinates and applications to vibrations of linear in triatomic molecules. Liouville's theorem for Hamiltonian mechanics and its implications in chaotic and planetary systems.	08

Learning Resources:

1. Classical Mechanics, by H. Goldstein, 2nd Edition (Published by Narosa Publishing House Pvt. Ltd., New Delhi (2001) ISBN 10:8185015538 / ISBN 13:9788185015538
2. Classical Mechanics, by H. Goldstein, Charles Poole, John Safco, 3 rd Edition (Published by Pearson Education Asia (2014)) ISBN 10:8131758915 / ISBN 13:9788131758915
3. Classical Mechanics, by N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991) ISBN 10: 0074603159 ISBN 13: 9780074603154
4. Mechanics, by A. Sommerfeld (Academic Press, 1952), ISBN 10: 0126546703 ISBN 13: 9780126546705
5. Introduction to Dynamics, by I. Perceival and D Richards (Cambridge Univ. Press. 1982). ISBN-10: 0521281490 / ISBN-13: 978-0521174060
6. Classical Mechanics, P. V. Panat (Narosa Pub. House Pvt. Ltd.) 2008, ISBN: 9788173196317 / 8173196311
7. Classical Mechanics, by Gupta, Kumar and Sharma, Pragati Prakashan, Meerut (2012). ISBN number 9350063808 / 9789350063804
8. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher (2003) ISBN-10: 0534408966 ISBN-13: 978-0534408961
9. Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi. ISBN 10:0070966176 / ISBN 13: 978007096

Course Name: Statistical Mechanics-I

Course Code: PHYT/MJ/553, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To develop strong mathematical and statistical skills, including probability theory, probability distributions, and statistical methods, which are essential for analyzing complex systems.
2. To introduce students to different ensembles (e.g., microcanonical, canonical, grand canonical) and their applications in describing the behavior of systems in different thermodynamic conditions.
3. To study quantum statistical mechanics, including Fermi-Dirac and Bose-Einstein statistics, and their relevance in describing the behavior of particles with quantum properties.
4. To establish a connection between statistical mechanics and classical thermodynamics, showing how macroscopic properties emerge from microscopic interactions.
5. To Study phase transitions and critical phenomena in depth, including critical exponents, universality, and the Ising model, to understand abrupt changes in the properties of matter.

Course Outcomes:

1. After learning this course students analyze transport phenomena such as diffusion, heat conduction, and viscosity using statistical methods.
2. Explore the application of statistical mechanics in various fields such as condensed matter physics, biophysics, and materials science.
3. Encourage research skills and critical thinking, allowing students to apply statistical mechanics principles to solve real-world problems and conduct independent research.
4. Students equip with advanced theoretical and computational tools to analyze and understand the behavior of complex systems at the molecular and atomic level, making it applicable to research, academia, and industries such as materials science and biophysics.

Unit No.	Course Content	Contact Hours
I	**Classical Statistics** Ensembles, types of ensembles, density of distribution in phase space, Liouville's theorem, postulates of equal priori probability, statistical equilibrium, thermal equilibrium, mechanical equilibrium, particle equilibrium, connection between statistical and thermodynamical quantities, microstate and macrostates, Stirlings approximation, general statistical distribution law, most probable distribution law and classical Maxwell-Boltzmann distribution law.	12
II	**Theory of Transport Phenomena** Bose-Einstein statistics, Fermi- Dirac statistics, Maxwell–Boltzmann statistics, thermodynamic interpretation of the parameters α and β, black body radiation and the Planck's radiation law, Grand canonical ensembles and quantum statistics, phase transition in Ferromagnetic material.	08

III	**Theory of Diatomic Molecule** Einstein theory of specific heat of solids, Debye theory of specific heat of solids, Bose-Einstein condensation, Thermal properties of Bose-Einstein condensation , Landau theory, Electron gas, free electron model electronic emission, Pauli's theory of paramagnetism, Boltzmann transport equation for electron and Lorentz solution, Isothermal Hall effect, Phase transition of the second kind(Ising Model), Bragg-Williams approximation, One dimensional Ising Model.	10

Learning Resources:

1. Fundamentals of statistical mechanics-B B Laud New Age International Publishers ISBN 978-81-224-3278-7, 2016.
2. Elementary Statistical mechanics. Gupta & Kumar year: 2019 Publisher: Pragati Prakashan ISBN: 978-93-5006-943-1.
3. Statistical mechanics R. K. Pathria, Second Edition published by Elsevier ISBN 0-7506-2469-8
4. Statistical Mechanics-E Atlee Jackson Publisher Dover Publication ISBN 9780486149394
5. Statistical Mechanics – B. K. Agarwal New Age International Publishers ISBN 978-8122433548
6. Fundamental of Statistical and thermal Physics –Reif, ISBN 9781577666127
7. Statistical Mechanics: The Principle of Statistical Mechanics. By Richard C. Tolman. Oxford University Press, 1939.

Course Name: The 8051 Microcontroller

Course Code: PHYT/DSE/554, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. Provide an overview of difference between microprocessor and microcontroller.
2. Impart knowledge of concepts and architecture of 8051 microcontroller.
3. Provide background knowledge and core expertise in 8 bit microcontroller.
4. Convey basic knowledge of various registers, ports, memory organization and addressing modes in 8051 microcontroller.
5. Give knowledge about arithmetic operations and jump ranges and instructions.
6. Impart knowledge about assembly language programming of 8051 microcontroller.
7. Help understand the importance of various peripheral devices & their interfacing with 8051 microcontroller.

Learning Outcomes:

1. The students would learn the basic difference between the microprocessors and microcontroller.
2. The students will learn the architecture and basic functional blocks from microcontroller.
3. The students will learn the programming tools which is useful for the programming with 8051-microcontroller.
4. The students will learn assembly language programming logic for 8051 microcontroller.
5. The students will learn interfacing with 8051- microcontroller.

Unit No.	Course Content	Contact Hours
I	**8051 Microcontroller** An Introduction: Microprocessors and Microcontrollers, comparing microprocessors and Microcontrollers, a Microcontrollers survey, development system for Microcontrollers, 8051 Microcontroller hardware: Block diagram, Programming model, pin configuration, the 8051 oscillator and clock, program counter and data pointer, A and B CPU registers, flags and program status word, internal memory, internal RAM, the stack and the stack pointer, special function registers, internal ROM; Input / output pins, ports and circuits: port pin circuits, port 0, port 1, port 2, port 3; memory organization, counters and timers, serial data input / outputs, interrupts.	10
II	**Moving data and logical operations** Move Operations: Introduction, addressing modes, external data moves, code memory read only data moves, push and pop op-codes, data exchange, simple programs, Logical operations: Introduction, byte level logical operations, bit level logical operation, rotate and swap operations, examples programs.	10
III	**Arithmetic, Jump and Call Operations** Arithmetic operations: Introduction, flags, instructions affecting flags, incrementing and decrementing, addition: unsigned and signed, multiple byte signed arithmetic, subtraction: Unsigned and signed subtraction, multiplication and division, decimal arithmetic, examples programs. Jump and call operations: Introduction, the jump and call program range, relative range, Short absolute range, long absolute range. Jumps, bit jumps, byte jumps, unconditional jumps, Calls and subroutine, subroutines, Calls and the stacks, Calls and returns, Interrupts and returns, Simple programmes using 8051 Microcontroller and applications.	10

Learning Resources:

1. The 8051 Micorcontroller, Architecture, Programming and applications by Kenneth J Ayala ; Second Edition, ISBN 0-314—20188-2 (hard Copy) 1991; ISBN 0-314-77278-2(Soft) 2014.
2. Microprocessors and Interfacing : Programming and Hardware by Douglas V Hall : II Edition ; Tata McGraw-Hill Edition.
3. The 8051 Microcontroller and embedded Systems by Muhammad Ali Mazidi and Janice Gillspie Mazidi; Pearson Education.

Course Name: Molecular Spectroscopy

Course Code: PHYT/DSE/555, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. Introduction to electronic spectroscopy of diatomic molecules
2. Study of vibrational course structure of electronic spectra of diatomic molecules; analysis of vibrational spectra of diatomic molecules and estimation of vibrational constants, moment of inertia, force constant etc.
3. To understand the electronic structure, course and fine structure of energies of electronic states, of diatomic molecules
4. To understand the vibrational, rotational motions and coupling of these motions by evaluating the vibrational and rotational constants of the electronic states
5. To understand various coupling schemes
6. Determination of term manifold of homonuclear and heteronuclear diatomic molecules
7. To understand the symmetry properties of the electronic wave functions, the selection rules and allowed electronic transitions
8. To understand the basic physics of Raman scattering of diatomic/polyatomic molecules; experimental techniques of Raman spectroscopy; analysis of Raman spectra for investigating the molecular structure

Course Outcomes:

1. arrange the wavenumbers of band heads and band origin in the Deslandres table; identify various sequences and progressions in the band spectrum; analyze the electronic spectra of diatomic molecules, and estimate vibrational constants and vibrational energies; able to calculate: harmonicity and anharmonicity constants of the upper and lower electronic states.
2. explain various coupling schemes and uncoupling phenomena
3. calculate the term manifold of homonuclear and heteronuclear diatomic molecules
4. explain the symmetry properties of rotational levels of upper and lower electronic state
5. explain the symmetry properties of rotational levels of lower electronic state
6. explain the selection rules for electronic transitions; draw the allowed electronic transitions
7. describe the role of various parts of Raman spectrometer, analyze the Raman spectra of molecules, and determine their structure

Unit No.	Course Content	Contact Hours
I	**Electronic Spectra of Diatomic Molecules** Electronic energy and total energy, electronic energy and potential curves; stable and unstable molecular states, Vibrational structure of electronic transitions: general formulae, examples; graphical representation, Deslandres table, progressions and sequences, evaluation of vibrational constants, Rotational structure of electronic bands. Combination relation and evaluation of rotational constant for bands without and with Q branches.	10
II	**Coupling of rotation and electronic motion and determination of term** Classification of electronic states; multiplet structure, orbital angular momentum, spin, total angular momentum of the electrons; multiplets, symmetry properties of the electronic eigen functions, Hund's coupling cases a, b and c. Symmetry	10

	properties of rotational levels. Types of electronic transitions, selection rules, Study of 1 Σ- 1 Σ, 2 Σ - 2 Σ and 1 □- 1 Σ transitions, Determination of term manifold: Separated atoms (like and unlike atoms), Term manifold from electronic configuration, Pauli principle, Molecular configurations of CO, C2, N2, BeO, BeH etc molecules.	
III	**Raman Spectroscopy** Classical theory and quantum theory of Raman Effect, Pure rotational Raman Spectra, Raman spectra of linear, symmetric top and asymmetric top molecules. Raman activity of vibrations, vibrational Raman Spectra, Rotational fine structure, polarization of light and Raman effect, Structure determination from Raman and IR spectra, Instrumentation: Raman spectrometer	10

Learning Resources:

1. Spectra of Diatomic Molecules by G. Herzberg, Krieger Malbar Florida, 1950, ISBN-10: 1406738530, ISBN-13: 978-1406738537.
2. Molecular Structure and Spectroscopy, by Aruldhas, G., Second Edition, 2004; ISBN: 978-81-203-3215-7, PHI Learning

Course Name: Nuclear Reaction and Nuclear Energy

Course Code: PHYT/DSE/556, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The themes dealt with in this paper:

1. This course gives basic foundation to specialization in nuclear physics and applications, including power production through fission and fusion reactors.
2. The course is an advanced course and requires special efforts. So, it can be taught as an elective course only.
3. The course will help the student for preparation of NET/SET and other competitive examinations.

Course Outcomes: The present unit attempts to achieve the following learning outcomes:

1. After completing this course the student will be to prepare to understand the scope and possibilities of studies in nuclear physics for research career as well as in industry.
2. This course is prerequisite to the second elective course.

Unit No.	Course Content	Contact Hours
I	**General Features of Nuclear Reaction and Mechanism** Introduction, Conservation laws in nuclear reactions, Energetics and Q-Value of nuclear reaction, nuclear transmutation, Nuclear reaction cross-section, Partial cross-section, Determination of cross-section, partial wave analysis for reaction cross-section, Breit-Wigner dispersion formula, Level width. Types of nuclear reaction, Compound Nucleus, Theory of nuclear reaction, Direct reaction, Continuum and statistical theories of nuclear reaction.	10
II	**Nuclear Fission** Nuclear fission, Types of fission, Emission of nuclear fission, fission of fertile material, Distribution of mass of fission products, Energy released in fission, Distribution of energy of fragments, Neutrons released in fission, Prompt and delayed neutrons, Spontaneous fission, Liquid drop model, Nuclear chain reaction, Classification of Nuclear Reactor.	10
III	**Nuclear Fusion** Introduction, The plasma, Fusion reaction in the plasma, Conditions for maintain fusion reaction, Stellar energy, Sources of stellar energy, Carbon-Nitrogen cycle, Controlled thermal nuclear reactions, The eight synthesizing processes.	10

Learning Resources:

1. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
2. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN-EBK0036746).
3. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut- (2012)

(ISBN-978-93-5006-593-8)

4. **Nuclear Physics,** S. B. Patil, 1st edition, New Age International Publishers, New Delhi- (1991) (ISBN-978-81-224-0125-7).
5. **Nuclear Measurement Techniques,** K. Sri Ram, 1st edition, Affiliated East-West Press, Madras(1986) (ISBN-81-85095-56-6).
6. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. **Nuclear Physics,** Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN- 81-7556-915-8).
8. **Nuclear Physics,** K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-517-3).
9. **Radioactive Materials,** Dr. B. M. Rao, 1st edition, Himalaya Publishing House, Mumbai- (2002).
10. **Nuclear Energy,** R. K. Taneja, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-516-6).

Course Name: Thin Film and Vacuum Technology

Course Code: PHYT/DSE/557, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. This program will help to the students to work as technocrats in industries that rely on vacuum-based processes to create and manufacture products.
2. Students will be able to elaborate the Physical Vapor Deposition Techniques.
3. Students will be able to apply Chemical and Hybrid Methods for Thin Film Deposition.

Course Outcomes:

1. Employment opportunities span a variety of industries such as semiconductors, microelectromechanical systems (MEMS), glass, optics, light-emitting diodes (LEDs), solar cells, vacuum-based equipment, and other industries that use thin film coating processes.
2. The duties of a technician include building, validating, operating, maintaining, and troubleshooting vacuum-based equipment as well as providing advice on the use of this equipment and processes supported by this technology.
3. The Vacuum and Thin Film Technology program prepares a student to work as a technician in industries that rely on vacuum-based processes to create and manufacture products.
4. Employment opportunities span a variety of industries such as: Semiconductor, Microelectromechanical systems (MEMS), Glass, Optics, Light-emitting diodes (LEDS), Solar cells, Vacuum-based equipment, Other industries which use thin film coating processes.

Unit No.	Course Content	Contact Hours
I	**Thin Film Deposition Mechanics** Thermodynamics and Thin Film Growth, Vacuum Technology: Gas Laws, Kinetic Theory of Gases, Gas Sources in a Vacuum Chamber, Vacuum Pumps.	10
II	**Physical Thin Film Deposition Techniques** Physical Vapor Deposition, Sputtering: DC, rf sputtering, Magnetron sputtering, ECR plasma deposition, Ball Milling, Dr. Blade method, Spin Coating method, Sputtering Mechanisms, and Evaporation.	10
III	**Chemical and Hybrid Methods for Thin Film Deposition** Chemical Vapor Deposition: Mechanisms, Materials, Chemistries, Systems, Chemical Bath Deposition, SILAR, Spray Pyrolysis technique, Electrophoretic technique. Thin Film Characterization: Structural, optical, electrical and magnetic, morphological.	10

Learning Resources:

1. R. K. Waits, Thin Film Deposition and Patterning, American Vacuum Society, 1998. M. Ohring, ISBN 10: 156396872X ISBN 13: 9781563968723.
2. The Materials Science of Thin Films, Academic Press, Boston, 1991. Ludmila Eckertova, Physics of Thin Films, 2nd Plenum Press New York, 1986 (QC 176.83. E2613 1986) ISBN 10: 0123418240 ISBN 13: 9780123418241.
3. Kasturi L. Chopra, Thin Film Phenomena (McGraw-Hill, 1969). ISBN 10: 0070107998 ISBN 13: 9780070107991.
4. Handbook of Thin Film: Maissel and Glang (1970). ISBN 10: 0070397422 ISBN 13: 9780070397422.

Course Name: Practical Based on PHYT/MJ/550

(Quantum Mechanics-I)

Course Code: PHYP/MJ/576, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. To understand and apply experimental techniques used in quantum mechanics, such as measurements, data acquisition and instrumentation.
2. To investigate measurement processes and uncertainties in quantum mechanics, eigen states and the Heisenberg uncertainty principle.
3. To study and demonstrate the phenomenon of quantum entanglement through experiments, emphasizing its implications for quantum information and communication.

Course Outcomes: Students gains hands on experience with experimental setups used in quantum mechanics, including apparatus for measuring quantum phenomena.

1. Students learn techniques for making quantum measurements and grasp the amplification of the measurement process on quantum systems.
2. Outcomes collectively aim to ensure that the students grasp theoretical concept but also acquire practical skill and a deep understanding of how to apply quantum principles in experimental settings.

Expt. No.	Title of the Experiments
1.	Study of Gaussian Type Orbital (GTOs) and Slater type orbital (STOs).
2.	Comparison of Gaussian Type Orbital (GTOs) and Slater type orbital (STOs).
3.	Plotting the hydrogen atom ground state 1s and 2s wave functions.
4.	Plotting the hydrogen atom ground state 2p wave function.
5.	Determination of normalization constant for 1s wave function of hydrogen atom.
6.	Solution of Schrodinger equation for square/harmonic oscillator potential.
7.	Solution of Schrodinger equation for triangular potential.

Course Name: Practical Based on PHYT/MJ/551

(Mathematical Methods In Physics-I)

Course Code: PHYP/MJ/577, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning objectives:

1. To develop problem solving skills by applying mathematical techniques to solve complex physical problems.
2. To acquiring skills in analyzing experimental or simulated data using statistical methods and mathematical techniques.
3. To learn effectively visualize and interpret mathematical results and data through graphical representations and plots.

Course Outcomes:

1. Student can perform numerical simulations effectively, demonstrating an understanding of numerical methods and their application to physical scenarios.
2. Students can analyze experimental or simulated data using statistical methods and mathematical techniques, drawing meaningful conclusions from the results.
3. Students can present results through clear and effective visualization techniques, including graphical representations and plots.

Expt. No.	Title of the Experiments
1.	Determine the roots of Given Equation/ expression by bisection method.
2.	Evaluation of given integrals using Simpson's 1/3 rd rule.
3.	Evaluation of given integrals using Trapezoidal rule.
4.	Find Cube roots of given function.
5.	Determine Fourier series of given function.
6.	To fit curve by Least square fit method.
7.	Curve fitting by graphical method.

Course Name: Practical Based on PHYT/MJ/552 & 553

(Classical Mechanics-I and Statistical Mechanics-I)

Course Code: PHYP/MJ/578, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. To understand and articulate foundational concepts such as ensemble theory, probability distributions and thermodynamic properties.
2. To develop computational skills for simulating and solving statistical mechanics problems.
3. To extend knowledge to quantum statistical mechanics, incorporating principles from quantum mechanics into statistical mechanics.
4. To apply statistical methods to analyze and interpret experimental data using techniques.
5. To explore applications of statistical mechanics in diverse fields including condensed matter physics, chemistry, biology and material science.

Course Outcomes:

1. Students gain proficiency in experimental techniques relevant to statistical mechanics including data collection and analysis.
2. Students apply statistical model to real world systems using acquired theoretical knowledge to interpret and predict experimental results.
3. Students can develop skills in conducting computational simulations using software tools to simulate and analyze statistical mechanical systems.
4. Students can demonstrate the ability to critically to critically analyze experimental data, identifying sources of error and uncertainties in measurements.

Expt. No.	Title of the Experiments
1.	To determine Boltzmann constant.
2.	Determination of Planck's constants.
3.	Determination of thickness of thin wire (Photon as wave).
4.	Study of statistical behavior of gas particle in a box.
5.	To derive and calculate the canonical partition function for a system.
6.	To understand and apply the Boltzmann distribution.
7.	Study of Fermi- Dirac and Bose – Einstein statistics.
8.	Determination of Hall Coefficient(free electron)
9.	Determination of Magnetic Susceptibility (ESR , NMR).

Course Name: Practical Based on PHYT/DSE/554

(The 8051 Microcontroller)

Course Code: PHYP/DSE/579, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning objectives:

1. Provide knowledge and expertise in 8- bit microcontroller.
2. Impart knowledge about assembly and machine language programming.
3. Help to understand the importance of different interfacing to 8051 microcontroller.
4. Impart knowledge of different types of external interfaces.

Course Outcomes:

1. Understand the fundamentals of microcontroller systems, assembly language
2. Programming, interfaces, and have an ability to apply them.
3. Understand and apply the fundamentals of assembly and machine language
4. Programming of 8051-microcontrollers.
5. Design and formulate interfacing experiments for microcontroller.
6. Solve problems by using the concepts of microcontroller systems.

Expt. No.	Title of the Experiments
1.	Assembly language Programs for addition using 8051 microcontroller 8 and 16 bit.
2.	Assembly language Programs for subtraction using 8051 microcontroller 8 and 16 bit.
3.	Assembly language Program for multiplication using 8051 microcontroller.
4.	Assembly language Program for division using 8051 microcontroller.
5.	Assembly language Programs for data transfer.
6.	Assembly language Programs for ones, twos complements of 8 and 16 bits.
7.	Assembly language Program for Ascending and descending numbers using 8051 microcontroller.
8.	Assembly language Program to find square and square root of given number using 8051 microcontroller.
9.	Assembly language Program to find Maximum and minimum numbers form given array using 8051 microcontroller.
10.	Assembly language Program for analog to digital converter (ADC) using 8051 microcontroller.
11.	Assembly language Program to generate ramp, triangular and square waves using DAC through 8255 of 8051 microcontroller.
12.	Assembly language Program for stepper motor interface using 8051 microcontroller.

Note: Students must perform at least <u>eight</u> experiments from above list.

Course Name: Practical Based on PHYT/DSE/555

(Molecular Spectroscopy)

Course Code: PHYP/DSE/580, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Thermal and DC electric field excitation of molecular spectra
2. Recording the molecular spectra using latest computer interfaced instruments
3. Vibrational analysis of the recorded molecular spectra and calculation of vibrational constants of upper and lower electronic states and estimation of force constants
4. Rotational analysis of the recorded molecular spectra and calculation of rotational constants of upper and lower electronic states and estimation of bond lengths
5. Understanding of Morse potentials of diatomic molecules
6. Estimation of dissociation energy of I_2.
7. Understanding the fundamentals and instrumentation of NMR spectrometer; analysis of NMR spectrum

Course Outcomes: The student will be able to:

1. Record the molecular spectrum using HR4000 spectrometer by DC arc excitation
2. Identify various sequences in the band spectrum and arrange the wavenumbers of band heads in the Deslandres table
3. Perform vibrational analysis and calculate vibrational constants of the upper and lower electronic states. Calculate force constants the upper and lower electronic states
4. Perform rotational analysis and calculate rotational constants of the upper and lower electronic states. Estimate bond lengths in upper and lower electronic states.
5. able to explain the role of Morse parameter an to plot Morse potential curve for a given diatomic molecule
6. Able to explain various parts and their role in recording NMR spectrum using NMR spectrometer
7. Able to record and analyze the NMR spectrum

Expt. No.	Title of the Experiments
1.	Record the spectrum of Al arc in air using HR4000 spectrometer. Construct the Deslandre's table by using known wavelengths and calculate the vibrational constants and force constants of upper and lower electronic states
2.	Vibrational analysis C_2 Swan system: Record the spectrum of gas flame (C_2 Swan system) in air using high resolution monochromator. Construct the Deslandre's table by using known wavelengths and calculate vibrational constants and force constants of upper and lower electronic states
3.	Recording the high resolution spectra of BeO using high resolution spectrometer with CCD camera and calculate vibrational constants and force constants of upper and lower electronic states
4.	Rotational analysis of spectra of diatomic molecules (High resolution spectroscopy) for bands with Q-branches
5.	Rotational analysis of spectra of diatomic molecules (High resolution spectroscopy) for bands without Q-branches
6.	Studies of IR spectra of organic molecules (Liquids) containing various functional groups using IR/FTIR spectrometers.

7.	Studies of IR spectra of organic molecules (Solids) containing various functional groups using IR/FTIR spectrometers.
8.	Spectroscopic investigations of molecules using Raman Spectrometer.
9.	Record the spectrum of Iodine and determine dissociation energy of I_2 molecule by Brige-Spooner method
10.	Calculation of Morse potential energy curves for molecular X and B states of AlO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states
11.	Calculation of Morse potential energy curves for molecular states of Swan system of C_2, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states.
12.	Calculation of Morse potential energy curves for molecular states of visible system of BeO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states.

Course Name: Practical Based on PHYT/DSE/556

(Nuclear Reaction and Nuclear Energy)

Course Code: PHYP/DSE/581, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Course Objectives:

1. Recording the pulse height spectra using latest gamma ray spectroscopy system.
2. Analysis of recorded pulse height spectra.
3. Study of various types of gamma ray sources.
4. Study the NaI(Tl) detector..

Course Outcomes:

1. The student will get a training for using state of the art data acquisition system in Nuclear Physics laboratory
2. The student will get training for analysis of recorded pulse height spectra.
3. The student will be able to perform various kinds of experiments using GM and Scintillation counter.

Expt. No.	Title of the Experiments
1.	Study of gamma ray spectrum using scintillation counter using single channel analyzer.
2.	Absorption of gamma rays in lead.
3.	Absorption of gamma rays in aluminum.
4.	Alpha spectroscopy with surface barrier detector- energy analysis of an unknown gamma source.
5.	Determination of range of beta particles in aluminum.
6.	Determination of range of beta particles from unknown source by feather analysis.
7.	Determination of resolution of NaI(Tl) detector.
8.	Determining the activity of gamma a source.
9.	To determine the absorption coefficient as function of gamma ray energy.
10.	Measurements of linier attenuation coefficient of metals.
11.	To determine the half –value layer of various samples.(e.g lead, aluminum)
12.	To determine the tenth –value layer of various samples. .(e.g lead, aluminum)
13.	To determine the Mean free path of various samples. .(e.g lead, aluminum)

Course Name: Practical Based on PHYT/DSE/557

(Thin Film and Vacuum Technology)

Course Code: PHYP/DSE/582, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Course Objectives:

1. Synthesis the thin film by CBD method.
2. Develop thin films of different materials using different substrates by SILAR technique.
3. Estimate the thickness of deposited materials on the substrate.
4. Impart knowledge of thin film synthesis.

Course Outcomes: At the end of this course the students will be able to:

1. Understand the importance of the thin film deposition by CBD.
2. Apply the thin film deposition technique to synthesis the other materials.
3. Verify the electrical properties of the thin films.
4. Design the thickness of the thin films.
5. Demonstrate importance of the Spin Coating Method.
6. Determine the energy band gap of the nanomaterials.

Expt. No.	Title of the Experiments
1.	Deposition of ZnO thin Film by a chemical bath deposition method and calculate the thickness of thin films.
2.	Thin Film deposition of Zinc Oxide
3.	Thin film deposition of CdS by Electrochemical Method/CBD
4.	Deposition of ZnS thin film by Spin Coating method/Electrochemical Method
5.	Deposition of CuS thin film by Hydrothermal Method/SILAR
6.	Estimation of thickness of NiO thin film by Weight Difference Method
7.	Synthesis ZnO thin film using Dr. Blade method.
8.	Deposition of thin films by Spin Coating method.
9.	To study the optical properties of ZnO thin film using UV-Vis spectroscopy.
10.	To study the optical properties of ZnS thin film using UV-Vis spectroscopy.
11.	To study the optical properties of CdS thin film using UV-Vis spectroscopy.
12.	To study the optical properties of CuS thin film using UV-Vis spectroscopy.
13.	To study the Chemical species of ZnO thin film using FT-IR Spectroscopy.
14.	To study the electrical properties of ZnO thin films using I-V characteristics.
15.	Study the electrical properties of ZnS thin films using I-V characteristics.
16.	Determine the thickness of the as prepared ZnS thin film by Weight Difference method.
17.	Evaluate the thickness of the as prepared ZnO thin film by Weight Difference method.
18.	Calculate the thickness of the as prepared CuS thin film by Weight Difference method.

Note: Students must perform at least eight experiments from above list.

Course Name: On-The Job Training/ Field Project

Course Code: PHYP/OJT/FP/596, Course Type: MJ,

Contact Hours: 120, Credits: 04, Hours/Week: 04, Max. Marks: 100

AS PER NEP 2020

SEMESTER – III

Course Name: Quantum Mechanics-II

Course Code: PHYT/MJ/600, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To deepen understanding of advanced quantum mechanical concepts.
2. To apply quantum mechanics to complex and realistic physical systems.
3. To introduce students to the foundational principles of quantum field theory and its applications.
4. To develop the ability to apply WKB approximation to various quantum mechanical problems.

Course Outcomes:

1. Students will understand and apply both time-independent and time-dependent perturbation theories to solve complex quantum systems.
2. Students will explain and apply the principles of quantum statistics to systems of identical particles, including bosons and fermions.
3. Students will understand and apply the principles of the WKB approximation, including the derivation and use of connection formulae.

Unit No.	Course Content	Contact Hours
I	**Introduction to Modern Quantum Mechanics** The problem of black body radiation and its solution using quantum concept; Postulates of quantum mechanics, Ehrenfest theorem, Stern Gerlach experiment, Relativistic Quantum Mechanics, Spin and Magnetic Moment of the Electron, Quantum Entanglement and Bell's Theorem; Introduction to Quantum Field Theory: Second Quantization, Quantum Fields for Bosons and Fermions	10
II	**Applications of Perturbation Theory** Higher order perturbation, non-degenerate and degenerate cases; Applications of time-independent perturbation: Anharmonic oscillator, Zeeman effect, Stark effect; Applications of time-dependent perturbation: Harmonic perturbation; transition to continuum states, absorption and emission of radiation, Einstein's coefficients.	10
III	**WKB Approximation in Quantum Mechanics** Introduction to Semi-Classical Methods: Concept and Importance of Semi-Classical Approximation, Derivation of the WKB Approximation; WKB Wave Function-Asymptotic Analysis and Validity Conditions, Connection Formulae for Matching Solutions; Breakdown of WKB Approximation: Limitations and Breakdown Points of WKB Method, Limitations and Breakdown Points of WKB Method.	10

Learning Resources:

1. Quantum Mechanics by B. H. Bransden and C. J. Joachain, , Pearson Education ltd.
2. Quantum Mechanics by L. I. Schiff, MGH Book Company.
3. Quantum Mechanics by J. D. Powell and B. Crossman, Narosa Pub. House.
4. Quantum Mechanics by S. Gasiorowicz, Wiley International.
5. Quantum Mechanics by G. Aruldhas, PHI Learning Private Limited.
6. Quantum Mechanics Concepts and Applications By Nouredine Zettili, John Wiley & Sons, Ltd

Course Name: Mathematical Methods in Physics-II

Course Code: PHYT/MJ/601, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: To facilitate the students to understand,

1. The basic elements of complex mathematical analysis, including the integral transform and Laplace transform.
2. To expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
3. To apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
4. To solve partial differential equations of second order by use of series expansion (Fourier series) and integral transforms.

Course Outcomes: After finishing the course the student should be able to:

1. Master the basic elements of complex mathematical analysis, including the integral theorems, obtain the residues of a complex function and to use the residue theorem to evaluate definite integrals
2. Solve ordinary differential equations of second order that are common in the physical sciences.
3. Expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion.
4. Apply integral transform (Fourier and Laplace) to solve mathematical problems of interest in physics, use Fourier transforms as an aid for analyzing experimental data.
5. Solve partial differential equations of second order by use of standard methods like separation of variables, series expansion (Fourier series) and integral transforms.
6. Solve some simple classical variational problems.

Unit No.	Course Content	Contact Hours
I	**Complex Analysis** Brief Revision of Complex Numbers and their Graphical Representation. Addition ,subtraction, multiplication, division of complex number. Euler's formula, De Moivre's theorem, Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Integral theorem,. Cauchy's Integral formula, Cauchy integral formula for the derivative of an analytic function. Cauchy's residue theorem, Evaluation of real definite integrals by contour integration. Taylor series, Laurent series, calculus of residues, problems.	12
II	**Vector Analyses** Introduction, representation of vectors, addition, subtraction of vectors, scalar multiplication of vectors, coplanar and non coplanar vectors, differentiation of vectors, differentiation rules, Partial differentiation, scalar and vector field, gradient of scalar field, divergence of vector field, curl of vector field, vector relationship, vector integration, Gauss	10

	divergence theorem, stokes theorem, Greens theorem, Gauss formula of electrostatics from Gauss divergence theorem, Classification of vector fields.	
III	**Ordinary Differential Equations** Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Partial differential equations: Laplace, Poisson's, wave, Helmholtz and heat equations in two and three dimensions.	08

Learning Resources:

1 Advance Engineering Mathematics H. K. Dass/ S. Chand co. / 978-93-52533-83-1/2018.

2 Mathematical Physics- B.S. Rajput, Pragati Prakashan (Meerut). **ISBN** 10: 8175568712/23 edition/2005.

3 Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence,3rd ed., **2006,** Cambridge University Press /ISBN978052167918/2006.

4 Mathematical Physics Fourth edition – B. D. Gupta/ **ISBN** 978-93-5453-506-2/ Vikas Publishing House, New Delhi/2008.

5 Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications/ ISBN-13: 978-0486691930/1996.

6 Complex Variables, A.S. Fokas & M.J. Ablowitz, Cambridge University Press, **ISBN**-13: 978-0521534291/2003.

7 Complex Variables and Applications, J.W. Brown & R.V. Churchill, 8th Ed./ (**ISBN**: 978-0-07-333730-2/ 2004, Tata McGraw-Hill.

8 First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, Jones & Bartlett/ **ISBN**-13: 978-0763757724/2nd edition /1940.

Course Name: Classical Mechanics-II

Course Code: PHYT/MJ/602, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To distinguish between 'inertia frame of reference' and 'non-inertial frame of reference.
2. To know how to impose constraints on a system in order to simplify the methods to be used in solving physics problems.
3. To know what central, conservative and central-conservative forces mathematically understand the conservative theorems of energy, linear momentum and angular momentum.
4. To know the importance of concepts such as generalized coordinates and constrained Motion.
5. Understand Poisson brackets, understand canonical transformations
6. To establish that Kepler's laws are just consequences Newton's laws of gravitation and that of motion.

Course Outcomes: Upon successful completion of this course it is intended that a student will be able to:

1. Students learn about Lagrangian and Hamiltonian formulation of Classical Mechanics.
2. State the conservation principles involving momentum, angular momentum and energy and understand that they follow from the fundamental equations of motion
3. Have a deep understanding of Newton's laws.
4. Students learn about motion of a particle under central force field.

Unit No.	Course Content	Contact Hours
I	**Hamiltonian Formulation of Mechanics** View point of the development, phase space and the motion of the system, Hamiltonian, Physical significance of H, Advantage of Hamiltonian approach, Deduction of canonical equations from a variational principle, Applications of Hamilton's equation of motion, simple pendulum, compound pendulum, two dimensional isotopic harmonic oscillator, Linear harmonic oscillator, principle of least action, Features of Δ variation, application for Δ, proof of principle of least action.	10
II	**Canonical Transformations** Transformation, Point transformation, Canonical transformation, Generation function, First form, Second form, Third form and Forth form, Advantage of Canonical transformations, examples of Canonical transformation, Condition for a transformation to be canonical, an exact differential equation, examples, Hamilton- Jacobi equation for Hamilton's characteristics function, Conservative systems, physical significance of Hamilton's characteristics function W, Type of Canonical transformation generated by W. Poisson's brackets, Definition, Properties, Invariance of Poisson's brackets with respect to canonical transformations, Jacobi's identity.	10
III	**Two Body Problem** Equivalent one body problem, general features of central force motion, Conservation of energy and momentum, Lagrange's equation of motion, expression for r(t) and Θ (t), equation of path (orbit), Equivalent one dimensional problem, orbits under inverse square law of force, motion with different values of k, Motion under inverse square force: Kepler's problem, To explore the shape of orbit in a given case, case of elliptical orbit, Kepler's laws, Deviation of Kepler's second law, Deviation of Kepler's first law, Deviation of Kepler's third law, Examples.	10

Learning Resources:

1. Classical Mechanics, by Gupta, Kumar and Sharma, Pragati Prakashan, Meerut (2012). ISBN : 978-93-5006-380-4.
2. Classical Mechanics, by H. Goldstein, 2nd Edition (Published by Narosa Publishing House Pvt. Ltd., New Delhi (2001) ISBN 10:8185015538 / ISBN 13:9788185015538 .
3. Classical Mechanics, by H. Goldstein, Charles Poole, John Safco, 3 rd Edition (Published by Pearson Education Asia (2014)) ISBN 10:8131758915 / ISBN 13:9788131758915.
4. Classical Mechanics, by N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991) ISBN 10: 0074603159 ISBN 13: 9780074603154.
5. Classical Mechanics, P. V. Panat (Narosa Pub. House Pvt. Ltd.) 2008 ISBN: 9788173196317 / 8173196311.

Course Name: Statistical Mechanics-II

Course Code: PHYT/MJ/603, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To learn and to understand stochastic processes predictive approach.
2. To develop an ability to analyze and apply some basic stochastic processes for solving real life situations.
3. To learn and to understand stochastic processes predictive approach.
4. To develop an ability to analyze and apply some basic stochastic processes for solving real life situations.
5. To understand the uncertain occurrence situations with logical manner.

Course Outcomes:

1. After learning this course students analyze transport phenomena.
2. Formulate and solve problems which involve setting up stochastic models.
3. Understand renewal theory and branching processes with applications.
4. Recognize common probability distributions for discrete and continuous variables.
5. Apply methods from algebra and calculus to derive the mean and variance for a range of probability distributions.

Unit No.	Course Content	Contact Hours
I	**Transport Properties** Introduction, Boltzmann transport equation, Drift variation, collisions or scattering interaction, Boltzmann transport equation for electron and Lorentz solution, Chambeer's equation, Sommerfield's theory of electrical conductivity, thermal conductivity of metals, Magnetoresistance ,Viscosity of Boltzmann equation, Isothermal Hall effect. Onsager relations, Proof of Onsager Reciprocal relations, application of Onsager relation,	10
II	**Fluctuations in Thermodynamic Quantities** Introduction, Fluctuation in Energy, Fluctuation in Pressure, Fluctuations in volume, Probability of one dimensional Random walk, Motion due to fluctuating force(Fokker Planck Equation), Solution on Fokker- Planck Equation, Fourier analysis of Random function(Wiener- Khintchine Theorem), Electrical Noise(Nyquist's Theorem), Yang and Lee Theory, Measurement of low temperature.	10
III	**Methods of Ensembles and Measurement of Low Temperature** Canonical ensemble as an approximation to Microcanonical ensemble: Probability density for canonical ensemble, Nature of Probability function, particle function for canonical ensemble, thermodynamic functions for canonical ensemble, partition function and properties, Perfect monatomic gas in canonical ensembles, perfect gas in grand canonical ensemble, Production of low temperature, approach to absolute zero by adiabatic demagnetization, Measurement of low temperature.	10

Learning Resources:

1. Elementary Statistical mechanics. Gupta & Kumar year: 2019 Publisher: Pragati Prakashan ISBN: 978-93-5006-943-1.
2. Fundamentals of statistical mechanics-B B Laud New Age International Publishers ISBN 978-81-224-3278-7, 2016.
3. Statistical mechanics R. K. Pathria second Edition published by Elsevier ISBN 0-7506-2469-8
4. Statistical Mechanics-E Atlee Jackson Publisher Dover Publication ISBN 9780486149394
5. Statistical Mechanics – B. K. Agrawal New Age International Publishers ISBN 978-8122433548
6. Fundamental of Statistical and thermal Physics -Reif ISBN 9781577666127
7. Statistical Mechanics: The Principle of Statistical Mechanics. By Richard C. Tolman. Oxford University Press, 1939.

Course Name: Microwaves

Course Code: PHYT/DSE/604, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The themes with this paper are:

1. Gain knowledge of microwaves, its features, applications and various bands.
2. Analyze transmission line theory, their associated problems and applications. Also use of smith chart to solve various transmission line problems.
3. Gain knowledge of microwave generators like tube and solid state, their designing and practical use.
4. Gain knowledge of microwave components and their construction and applications.
5. Gain knowledge of different microwave measurements.

Course Outcomes: At the end of course the student should be able to:

1. Design transmission line for any microwave frequency.
2. Able to analyze limitations and applications of microwave tube and solid state generators.
3. Able to discriminate different microwave components and find their applications and use it in supporting systems.
4. Able to conduct experiments by use of microwave components and interpret the data accordingly.
5. Able to apply theory and practical knowledge of microwaves in respective fields.
6. Design transmission line for any microwave frequency.

Unit No.	Course Content	Contact Hours
I	**Introduction of Microwaves and Transmission Line Theory** Microwaves: Definition, characteristic features, applications and bands. Transmission Line Theory: Distributed parameters, Basic transmission line equations and solution, Determination of alpha and beta for a transmission line. Distortion on a transmission line, conditions for distortion less line. Standing waves, standing waves ratio, Properties of lines of various lengths.	10
II	**Microwaves Generators** Microwave Tubes: Reflex klystron, operation, transit time, Modes, Applications. Two cavity Klystron, velocity modulation, Multi cavity klystron, performance and applications. Microwave solid state devices: MESFET configuration, Transfer electron oscillator, Modes: Transit time mode, Quenched and delayed domain modes, LSA mode, Gunn oscillator circuits: coaxial cavity and waveguide cavity circuits.	10
III	**Microwave components and Measurements** Waveguide tees: E, H and Magic tee, directional coupler, Isolator: Faraday's rotational principle, ferrite, construction and working of isolator, applications, Circulator. Microwave network representations: S- matrix theory of directional coupler and magic tee. Microwave measurements: Bolometers, NTC and PTC, microwave power measurements by bridge method using bolometer, VSWR measurement, Detector diodes	10

	and detector mounts, Detector output indicator, Impedance measurement by slotted line and probe and Network analyzer, Measurement of scattering parameters, Frequency measurement: wave meter, Electronics techniques of frequency measurement by transfer oscillator and direct reading microwave counters.	

Learning Resources:

1. Microwave Devices and Circuits, by Samuel, Liao, Fourteenth impression PHI. ISBN 81-978-81-7758 (2012)
2. Microwaves, by K.C. Gupta, Wiley Estern Ltd. ISBN 0 85226 346 5
3. Microwave Engineering, by Sanjeev Gupta, Khanna Publishers.
4. Electronics Communications, by Sanjeeva Gupta, Khanna Publishers Delhi- 6. (For Chap. 3 and 5)
5. Electronics Communication systems By George Kennedy third Edn
6. Networks Lines and Filters by John D. Ryder, PHI second Edn.
7. Microwave Engineering by Annapurna Das & Sisir K. Das (TMH Publication) 2000.
8. Introduction to Microwaves, by G. I Wheelers, PHI
9. Microwave and Radar Engineering, by M. Kulkarni, 3rd Edition , Umesh Publications Delhi 110006
10. Microwave Engineering, by Monojit Mitra, II Edition,

Course Name: Modern Trends in Spectroscopy

Course Code: PHYT/DSE/605, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. Acquiring of knowledge concerning the electrical behavior of dielectric materials.
2. The students become accustomed with the Electrons Spin Resonance Spectroscopy (ESR), Fourier Transform Infrared Spectroscopy (FTIR) and Raman Spectroscopy methods.
3. The objective of this chapter is to make the student acquainted with paramagnetic species such as free radicals, transition metal ions, ions and molecules having odd number of electrons and their identification using the technique of electron spin resonance spectroscopy.
4. The student will develop their abilities to investigate polyatomic molecules by ESR, FTIR and Raman spectroscopy.
5. Imparting knowledge based on fundamentals of physical principles and measurement methods used for characterization.

Course Outcomes:

1. The student will be able to analyse the molecular spectra.
2. The student will be able to get the information about a particular substance using ESR, FTIR and Raman spectroscopy.
3. The student will be able to analyse the FTIR spectra of thin film and molecules and determine their structure.
4. Will be able to interpret/analyse ESR, IR and Raman spectra of molecules, and determine their structure.
5. Explain basic principles of ESR and IR spectroscopy
6. Arrange components of ESR, IR and Raman spectroscopy device
7. Explain working principles and taking spectrum of ESR, IR spectroscopy device
8. Know about pure rotational, vibrational and vibrational-rotational Raman spectra.
9. Know about selection rules in Raman spectroscopy.
10. Discuss Mutual exclusion Principle with suitable examples.
11. The student will be able to analyse the molecular spectra.

Unit No.	Course Content	Contact Hours
I	**Electrons Spin Resonance Spectroscopy** Principle of ESR, ESR Spectrometer, Total Hamiltonian, Hyperfine Structure, ESR Spectrum of Hydrogen Atom, ESR Spectra of Free Radicals in Solution- Energies of Radicals with One Unpaired Electron, CH_3 Radical, Benzene Anion (C_6H_6-), etc. **Scope:** Molecular structure and spectroscopy by G Aruldhas, Prentice Hall of India, Chapter 11.	10

II	**Fourier Transform Infrared Spectroscopy** Introduction, Historical Background, FT-IR Spectroscopy, Basic Integral Equation, Attenuated Total Reflectance, Experimental Setup, Advantages, Other Aspects, Applications, Surface Studies, Characterization of Optical Fibers, Vibrational Analysis of Molecules, Study of Biological Molecules, Study of Polymers. **Scope**: Handbook of Applied Solid State Spectroscopy, by D. R. Vij, Springer, chapter 9.	10
III	**Nonlinear Spectroscopy Phenomena** Nonlinear Raman Phenomena (Preliminaries), Hyper Raman Effect, Stimulated Raman Scattering, Inverse Raman Effect, Coherent Anti-Stokes Taman Scattering, Photo-acoustic Raman Scattering, Multi-photon Spectroscopy. **Scope:** Molecular structure and spectroscopy by G Aruldhas, Prentice Hall of India, Chapter 15.	10

Learning Resources:

1. Handbook of Applied Solid State Spectroscopy, by D. R. Vij, ISBN: 978-0-387-32497-5 (Print) 978-0-387-37590-8 (Online) **DOI** 10.1007/0-387-37590-2, 2006 Springer.
2. Molecular Structure and Spectroscopy, by Aruldhas, G., Second Edition ,2004. ISBN: 978-81-203-3215-7, PHI Learning.

Course Name: Reactor Physics

Course Code: PHYT/DSE/606, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The themes dealt with in this paper:

1. Outline and brief description, including fundamentals of the different reactors like swimming pool (Apsara) type reactor, Zerlina type reactor etc.
2. To enable the students to study the basic and advance concepts of Reactor Physics

Course Outcomes: The present unit attempts to achieve the following learning outcomes:

1. To explain the basic properties of neutrons and their sources.
2. Able to define the different types of reactors.
3. To describe Neutron Diffraction.
4. Students will be able to study the basic and advance concepts of Reactor Physics will be able have job opportunities in BARC.

Unit No.	Course Content	Contact Hours
I	**The Neutron and Detections** Discovery of neutron, neutron sources, basic properties of neutrons, wavelength of neutrons, high energy neutrons, measurements of energy of neutrons, time of flight method. Detection of neutrons, detection of slow neutrons- foil- activation method, ionization chambers and counter tubes for the detection of slow neutrons, Scintillators for the detection of slow neutrons, fission chambers for detection of thermal neutrons, detection of fast neutrons.	10
II	**Neutron Diffraction** Neutron diffraction from crystal, reflection for slow neutrons from mirrors, mechanical velocity selectors, measurement of neutron cross-section as a function of energy, cold neutrons and their isolations, neutron electron interaction, decay of neutrons.	10
III	**Physics of Nuclear Reactors** Thermalization of neutrons, dynamics of elastic scattering of neutrons, angular distribution of neutrons, Fermi age equation, condition of criticality of a reactor, critical equation of a reactor, rectangular parallelepiped reactor. Types of Nuclear reactors: Spherical reactor, reactor in the shape of a cylinder, some important reactors, Swimming pool (Apsara) type reactor, Zerlina type reactor.	10

Learning Resources:

1. Nuclear Physics, R. C. Sharma.
2. Nuclear Physics, I. Kaplan, 2nd edition, Narosa, 1989.
3. Basic Nuclear physics, B. N. Shrivastava, Pragati prakashan, Meerut.
4. Nuclear Physics, D.C. Tayal, Himalaya Publishing House, Bombay.
5. The elements of nuclear reactor theory, Glastone and Edund.
6. Introduction to Nuclear Engineering, Murry.

Course Name: Crystallography

Course Code: PHYT/DSE/607, Course Type: DSE,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The objective of this course is to present the basic concepts needed to understand the crystal binding, crystallography and crystal physics.

1. Learn the fundamental concepts including crystal binding, Madelung constant.
2. Describe the principle of powder diffraction method.
3. Outline the application of X-ray diffraction.
4. Identify and describe various types of defects in materials, such as point defects and line defects.
5. Describe what can be detected with X-ray crystallography

Course Outcomes: Upon successfully completion this course, the students will be able to:

1. Explain basic/fundamental crystallographic concepts
2. Extort the relevant information from a crystallographic paper
3. Find specific tools for solution of a given crystallographic problems.
4. Relate their broad tutoring toward the understanding of the impact of engineering solutions in a global and societal context.
5. Apply knowledge of defects and alloys to solve real-world engineering and manufacturing challenges.

Unit No.	Course Content	Contact Hours
I	**Crystal Binding** Crystal of inert gases, Van der Waals – London interaction, repulsive interaction, cohesive energy, ionic crystals, Madelung energy, Born-Mayer model, evaluation of Madelung constant for an infinite line of ions, binding in covalent, metal and Hydrogen bonded crystals and Atomic radii.	08
II	**Crystallography and Crystal Physics** Principle of powder diffraction method, interpretation of powder photographs, indexing of powder patterns, accurate determination of lattice parameters, least square method, Synchrotron X-ray diffraction (SCXRD), applications of powder method, Diffraction by an ideal crystal, The Debye – Waller factor. External symmetry elements of crystals, point group, space group, Symmetry operations, influence of symmetry on physical properties, derivation of equivalent point position, experimental determination of space groups.	12
III	**Defects and Alloys** Classification of defects, Point defects: Vacancy, Schottky, Frenkel Defects, Color Centres, Line Defects: Edge Dislocation, Screw Dislocation, Burger Vector, Alloys: diffusion, magnetic alloys and Kondo effect, Dislocation in Crystals: slip and plastic deformation, shear strength of single crystals, stress fields of dislocations, dislocation multiplication and slip, short and low range order in liquids and solids, liquid crystals, quasi crystals and glasses, low angle grain boundaries, dislocation densities, dislocation and crystal growth, whiskers.	10

Learning Resources:

1. Introduction to Solid State Physics, Charles Kittel, Willey India Edition, (8th Edition), ISBN – 978-0-471-41526-8, 1 January 2019.
2. Elementary Solid State Physics – M. A. Omar, Addition Wesley Publishing Company 1993, Digitized21/11/2007, ISBN: 0201607336.
3. Solid State Physics – A. J. Dekker, Published by Macmillan India (2000) ISBN 10: 0333918339 /ISBN 13: 9780333918333.
4. Solid State Physics – N. W. Aschroft and N. D. Mermin, Publisher Cengage Learning, 2011, ISBN: 8131500527.
5. Introduction to Solids – L. V. Azaroff, McGraw Hill, New York, 2001, ISBN: 10:0070992193.
6. Solid State Physics – S. O. Pillai, Publisher Kent: New Age Science, 2010
7. Solid State Physics – M. A. Wahab, Narosa Publishinng House, ISBN: 81-7319-266-9.
8. Concept in Solid State Physics – J. P. Shrivastava, Prentice Hall Ltd.
9. Solid State Physics – Saxena, Gupta, Saxena, Pragati Prakashan Eleventh Edition, 2007, ISBN: 818398-135-6.
10. Crystallography of Quasicrystals- Walter Steurer; Sofa Deloudi, Springer 2009, e-Book.
11. Crystallography- E.J.W. Whittaker, Elsevier Science 2013, e-Book.
12. Point Defects in Solids- James H.Crawford; Lawrence M. Slifkin, Springer US 2012, e-Book
13. Alloy Physics- Wolfgang Pfeiler, Wiley 2008, e-Book
14. Dislocations in Solids-John P. Hirth, Elsevier Science 2011, e-Book.
15. Recent Advances in Crystallography, Academic Editor: Jason B. Benedict, 2012, Intechopen, e-Book (Link: https://www.intechopen.com/books/2334).
16. Defect engineering using crystal symmetry, Ramamoorthy Ramesh, | PNAS | September 18, 2018 | vol. 115 | no. 38, pp 9344–9346.
17. Interstitial Point Defect Scattering Contributing to High Thermoelectric Performance in SnTe, Pei, Y. et al., Adv. Electron. Mater. 2, (2016) 1600019.
18. Irradiation responses and defect behavior of single-phase concentrated solid solution alloys, T. Yang et al., J. Mater. Res., 2018, pp1-15.
19. A study of the 160 MeV Ni 7+ swift heavy ion irradiation effect of defect creation and shifting of the phonon modes on MnxZn1–xO thin films, H A Khawal, **B N Dole**, RSC Advances 7 (55), (2017) 34736-34745.
20. Native Point Defect Measurement and Manipulation in ZnO Nanostructures, Leonard Brillson, Jonathan Cox, Hantian Gao, Geoffrey Foster, William Ruane, Alexander Aarjour, Martin Allen, David Look, Holger von Wenckstern and Marius Grundmann, Materials (2019), 12, pp 2242.
21. Designing reduced graphene oxide decorated Ni doped δ-MnO2 nanocomposites for supercapacitor applications, ND Raskar, DV Dake, VA Mane, RB Sonpir, M Vasundhara, K Asokan, U Deshpande, R Venkatesh, VD Mote, BN Dole, Materials Science in Semiconductor Processing 178 (2024) 108451.
22. Nanoengineered reduced graphene oxide-Fe doped α-MnO2: A multifunctional smart material for energy storage and environmental remediation, ND Raskar, DV Dake, VA Mane, RB Sonpir, HA Khawal, VD Mote, M Vasundhara, K Asokan, KP Gattu, BN Dole, Journal of Energy Storage 86 (2024) 111206.

Course Name: Practical Based on PHYT/MJ/600

(Quantum Mechanics-II)

Course Code: PHYP/MJ/626, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Expand the students' knowledge about basic quantum theories.
2. Explore the various terms of advanced quantum physics.
3. Inculcate the approximations in quantum mechanics.

Course Outcomes: Upon successful completion this course, the students will be able to:

1. Obtain correct Energy equation for Hydrogen atom, 1-D potential Well.
2. Find out corrections in energy levels.
3. Get knowledge about blackbody radiation.

Expt. No.	Title of the Experiments
1.	Energy equation for 1-D potential Well, when the particle is inside the well.
2.	Relationship between wave function and change in energy states for 1-D potential well.
3.	Temperature-dependent blackbody radiation.
4.	Calculation of De-Broglie wavelength.
5.	Calculation of degenerated states of the Hydrogen atom.
6.	Relationship between change in energy states and degeneracy of the 2D harmonic oscillator.
7.	Calculation of Rydberg constant.
8.	Energy equation for Simple harmonic oscillator.

Course Name: Practical Based on PHYT/MJ/601

(Mathematical Methods in Physics-II)

Course Code: PHYP/MJ/627, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. The primary objective is to teach the students to measure physical quantity and to measure physical quantity which are not measureable.
2. The purpose of the course is to introduce students to the methods of mathematical physics and to develop required mathematical skills to solve advanced problems in physics.
3. To develop problem solving skills by applying mathematical techniques to solve complex physical problems.
4. To acquiring skills in analyzing experimental or simulated data using statistical methods and mathematical techniques.
5. To learn effectively visualize and interpret mathematical results and data through graphical representations and plots.

Course Outcomes:

1. Student can perform numerical simulations effectively, demonstrating an understanding of numerical methods and their application to physical scenarios.
2. Students can analyze experimental or simulated data using statistical methods and mathematical techniques, drawing meaningful conclusions from the results.
3. Students can present results through clear and effective visualization techniques, including graphical representations and plots.

Expt. No.	Title of the Experiments
1.	Integration round the rectangular Contours.
2.	Evaluation of integral round indented Semicircle
3.	Evaluation of integral round an infinite Semicircle.
4.	Evaluation of Integration round Unit circle.
5.	Evaluation of residue by all possible method.
6.	Using the integral representation of $f^n(a)$, prove that $\left(\frac{x^n}{n!}\right)^2 = \frac{1}{2\pi i}\int_c \frac{x^n}{n!}\frac{e^{xz}}{z^{n+1}}$ where c is any closed contour surrounding the origin. Hence prove that $\sum_{n=0}^{\infty}\left(\frac{x^n}{n!}\right)^2 = \frac{1}{2\pi}\int_0^{2\pi} e^{2x\cos\theta}\, d\theta$.
7.	Evaluation of integral $\int_c \frac{z\,dz}{(9-z^2)(z-i)}$ using Cauchy integral formula (where c is circle, $\lvert z\rvert = 2$ described in the +ve sense.
8.	Evaluation of the integral $\bar{z}$ along (a) upper half of the circle $\lvert z\rvert = 1$ from $z = -1$ to $z = 1$. (b) Lower half circle $\lvert z\rvert = 1$.
9.	Estimation of thermal Storage method for given sample for storing solar energy.
10.	Measure the resistance of copper wires of different gauge and estimate their resistivity.

11.	To measure the intensity of sanity at different Hours.
12.	Estimate the efficiently of Lithium- Ion battery.
13.	Determine the Series solution of y''-yy'+ 2y = 0
14.	Solve the differential Equation $x(x+1)\, y'' + (3x+1)\, y' + y = 0$ by series integration method.
15.	Find the general Solution of the Equation $\frac{d_x^2}{d+2} + y' + k^2\, x = \phi(t)$.
16.	Find a power series solution of given equation.
17.	Derive Laplace integral by alternative method I= $\int_0^{\pi} \frac{d\theta}{a \pm b\cos\theta}$.
18.	Derive the Rodrigue formula for Legendre polynomials.
19.	To determine second solution of Bessel's equation $Cy'' + \frac{1}{x}y' + y = 0$.

Note: Students are advised to perform at least Six Experiments.

Course Name: Practical Based on PHYT/MJ/602 and PHYT/MJ/603

(Classical Mechanics-II and Statistical Mechanics-II)

Course Code: PHYP/MJ/628, Course Type: MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. To develop an ability to analyze and apply some basic stochastic processes for solving real life situations.
2. To learn and to understand stochastic processes predictive approach.
3. To understand the uncertain occurrence situations with logical manner.

Course Outcomes:

1. After learning this course students analyze transport phenomena.
2. Formulate and solve problems which involve setting up stochastic models.
3. Understand renewal theory and branching processes with applications.
4. Recognize common probability distributions for discrete and continuous variables.
5. Apply methods from algebra and calculus to derive the mean and variance for a range of probability distributions.

Expt. No.	Title of the Experiments
1.	Study of variation of resistivity of given specimen using 4-probe method and determination of its energy band gap.
2.	Study of variation of dielectric constant as a function of temperature and verification of the Curie law and determination of the Curie temperature.
3.	Accidental discovery: Franck Hertz Experiment
4.	Determination of e/m by Thomson method
5.	Determination of magnetic susceptibility of diamagnetic and paramagnetic samples using Guoy balance method.
6.	Study of variation of photoconductivity using polarized light.
7.	Michelson Interferometer.
8.	Study the temperature dependence of resistivity of a semiconductor (Ge) by four-probe method and determine band gap of the material.

Note: Students are advised to perform at least Six Experiments.

Course Name: Practical Based on PHYT/DSE/604

(Microwaves)

Course Code: PHYP/DSE/629, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Gain knowledge of microwaves for applications using various bands.
2. Analyze different bands and their applications.
3. Gain knowledge of microwave generators for practical use.
4. Gain knowledge of microwave components and use it in various experiments.
5. Gain knowledge of different microwave measurements.

Course Outcomes: At the end of course the student should be able to:

1. Learn to use transmission line or waveguide for microwave frequency.
2. Able to use microwave tube and solid state generators in actual set up..
3. Able to discriminate microwave components and use it in different experiments.
4. Able to assemble microwave bench for any experiment and interpret the data accordingly.
5. Able to apply theory and practical knowledge of microwaves in respective fields.

Expt. No.	Title of the Experiments
1.	Demonstrate relationship between frequency (f), wavelength (λ_0) in free space and wavelength in waveguide (λ_g).
2.	Reflex Klystron Characteristics – Mode diagrams, ETR and ETS.
3.	Gunn Diode Characteristics; V- I and V - P characteristics.
4.	Microwave Horn Antenna E-H Plane pattern and Beam width.
5.	Study of square law behavior of microwave crystal detector and hence to determine Operating range and detection frequency
6.	Study of high and low VSWR and impedance measurements using Smith chart.
7.	Measurement of S- parameters of a) E-Tee b) Magic Tee c) Directional coupler.
8.	Determination of dielectric constant of solids – Two point method
9.	Determination of dielectric constant of liquids – Robert-Von Hipple method
10.	Study of standing wave pattern using wave propagation kit.
11.	Refraction in microwaves using wave propagation kit
12.	Reflection in microwaves using wave propagation kit
13.	Other experiments using wave propagation kit

Note: Students must perform at least **eight** experiments from above list.

Course Name: Practical Based on PHYT/DSE/605

(Modern Trends in Spectroscopy)

Course Code: PHYP/DSE/630, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Knowledge about the experimental investigation methods of spectroscopy.
2. Understanding the theoretical knowledge by experiments.
3. Capacities development for establishing measurement methods.

Course Outcomes:

1. After completing this course, the student will be able to determine the vibrations for a polyatomic molecule and identify whether they are infrared-active.
2. On the basis of ESR, FTIR, and Raman spectra student will able to identify the material.
3. On the basis of ESR, FTIR, and Raman spectra student will able to identify the types of material.

Expt. No.	Title of the Experiments
1.	Determination of Lande's factor of DPPH using ESR spectrometer.
2.	To study the Electron Spin Resonance and to determine Lande's g-factor
3.	To study the Electron Spin Resonance and to determine magnetic field
4.	To study the Electron Spin Resonance in iron-based compounds.
5.	Determination of absorptivity of bromobenzene vibrational band by FTIR.
6.	Determination of absorptivity of dimethylsulphoxide, dimethylacetamide and acetone vibrational band by FTIR.
7.	Analysis of caffeine in tea and coffee using Fourier transform Infrared (FTIR) spectroscopy.
8.	Characterization of ZnO nanoparticles using FTIR spectroscopy
9.	Characterization of ZnO nanoparticles using Raman spectroscopy.
10.	To analyze FTIR spectra and to identify the functional groups of unknown materials.
11.	Finding type of molecules and vibration levels using FTIR Spectra.
12.	Finding type of molecules and vibration levels using Raman Spectra.
13.	To study the effect of carbon chain in primary alcohols on FTIR spectra

Course Name: Practical Based on PHYT/DSE/606

(Reactor Physics)

Course Code: PHYP/DSE/631, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. To record the pulse height spectra using latest gamma ray Scintillation counter.
2. Analysis of recorded pulse height spectra and calculate FWHM and resolution.
3. Study of various types of gamma ray sources in the energy range 10-1500keV.
4. Study the NaI(Tl) Scintillation detector.

Course Outcomes:

1. The student will get training for using state of the art data acquisition system in Nuclear Physics laboratory and calculate FWHM and resolution for a Scintillation counter.
2. The student will get training for analysis of recorded pulse height spectra and able to verify inverse square law.
3. The student will be able to perform various kinds of experiments using Scintillation counter.

Expt. No.	Title of the Experiments
1.	Location of photo peak using signal channel analyzer.
2.	Mass absorption coefficient of Pb foil using SCA.
3.	Mass absorption coefficient of Al foil using SCA
4.	Energy calibration of unknown source.
5.	Determination of range of beta particles in aluminum.
6.	Study of Cs-137 spectrum and calculation of FWHM and resolution for a given Scintillation detector.
7.	Study of Co-60 spectrum and calculation of FWHM and resolution for a given Scintillation detector.
8.	Spectrum analysis of Ba-133 and Na-22.
9.	Design, fabrication and study of Linear pulse amplifier.
10.	Kinematics of Compton scattering. Compton scattering process.
11.	Variation of gamma intensity as a function of distance (Verification of Inverse Square Law)
12.	Excitation of K-X-rays in different material by beta radiation (verification of Mosley's law).

Note: Students should perform any **eight** experiments.

Course Name: Practical Based on PHYT/DSE/607

(Crystallography)

Course Code: PHYP/DSE/632, Course Type: DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Acquire expertize in depositing uniform and tailored thin films through SILAR.
2. Develop proficiency in synthesizing thin films with controlled morphology using CBD Technique.
3. Deposit thin films of various materials on substrates namely, oxides, semiconductors, metals, and composites by spray pyrolysis technique.
4. Determine crystal structure and crystallographic properties of materials by XRD.
5. Evaluate and characterize the mechanical properties of the materials using AFM.
6. Skilled XRD, AFM and UV-Vis spectrometer users play a pivotal role in pushing forward the boundaries of knowledge and capabilities, leading to the development of new materials, technologies and methodologies.

Course Outcomes: Upon successful completion this course, Students will be able to:

1. Analyse crystal structure of the materials using XRD.
2. Synthesis of the thin films of various materials for technological applications.
3. Identification of Functional groups using FI-IR.
4. Determination of grain size and thickness of the materials.
5. Interpretation of defects, texture and surface morphology of the materials.
6. Pursue advanced education at esteemed universities abroad.

Expt. No.	Title of the Experiments
1.	Study the structural parameters of ZnO thin films deposited by Spin Coating technique and analyze crystal structure using X-Ray Diffraction.
2.	Synthesis the CdS thin film deposited on given substrate by SILAR method (for 20 cycles) and analyze the surface morphology by AFM.
3.	Study the structural parameters of ZnO thin films deposited by Spin Coating technique and Evaluate thickness using weight difference method.
4.	Deposition of ZnO thin films by Spray Pyrolysis or CBD technique and calculate E_g using UV-Vis Spectrometer.
5.	Synthesis the Bi_2S_3 thin film deposited on given substrate by SILAR method (for 20 cycles) and determine the thickness of Bi_2S_3 thin film by weight difference method.
6.	Investigation of Luminescence Properties of TiO_2 using Photoluminescence Spectroscopy.
7.	Synthesis ZnS thin films by SILAR technique and analyze functional groups by FT-IR.
8.	Synthesis ZnS thin films by SILAR technique and calculate thickness by weight difference method.
9.	Study the surface roughness of GO based ZnO nanoparticles by AFM.
10.	Synthesis the CdS thin film deposited on given substrate by SILAR method (for 20 cycles) and determine the thickness of CdS thin film using SEM.
11.	Synthesis of Bi_2S_3 thin film deposited on given substrate by CBD techniques and determine energy band gap using UV-Vis Spectrometer.

12.	Characterization of Crystal Structure by Powder X-Ray Diffraction: Front and Back Reflection Methods.
13.	Study the crystallographic symmetries using optical techniques and analyze their manifestations in crystal structures.
14.	Determine the Miller indices, lattice parameters and grain size of CuSe, $Cu_{2-x}Se$ and Cu2Se thin films from given data.
15.	Determination of orientation of crystal by back reflection Laue method.
16.	Rotation / Oscillation photograph and their interpretation
17.	Determination of particle size using X-ray powder method
18.	Study the crystal structure of a given film by powder method.
19.	Interpretation of transmission Laue photograph.
20.	To determine the coefficient of thermal conductivity
21.	Determination of velocity and wavelength of ultrasonic waves.
22.	Determine the specific heat of graphite using heat treatment.
23.	Porosity determination of semiconducting material.
24.	To measure the ionic conductivity of ionic solids and to determine activation energy
25.	Study the dispersion relation for monoatomic Lattice.
26.	Study the dispersion relation for diatomic Lattice.

Course Name: Research Project/Field Project

Course Code: PHYP/RP/FP/646, Course Type: RP/FP,

Contact Hours: 120, Credits: 04, Hours/Week: 04, Max. Marks: 100

AS PER NEP 2020

SEMESTER – IV

Course Name: Computational Methods in Physics

Course Code: PHYT/MJ/650, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To provide a high quality education which prepares students for further study and research in physics and for a wide range of career opportunities in industry .
2. To provide a high quality mathematical models and abstractions of physical objects and systems to rationalize, explain and predict natural phenomena.
3. To find approximate solutions to complex problems using only the simplest operation of arithmetic's.

Course Outcomes:

1. Enhanced ability to address appropriate physical problems using theoretical analysis and computational skills.
2. To provide opportunities for scientific study and creativity within a global context that will stimulate and challenges students.
3. To develop an ability to analyze, evaluate and synthesize scientific information.

Unit No.	Course Content	Contact Hours
I	**Methods for obtaining solutions of linear and nonlinear equations and their convergence:** Graphical method, interval bisection method, Newton Raphson method, secant method, method of false position **Curve fitting:** Linear regression, polynomial regression, nonlinear regression using exponential functions. Fitting curve of the form $y = ae^{bx}$. Numerical integration: Newton-Cotes formulae, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule.	10
II	**Finite differences:** Forward Difference, backward difference, central difference, Interpolation with equally spaced point: Newton forward interpolation, Newton backward Interpolation, central difference interpolation, Gauss forward interpolation, Numerical differentiation: using derivative of Newton forward, backward and central difference interpolation formulae.	10
III	**Numerical solution by ordinary differential equations:** Preliminaries and classification: General form of ordinary differential equation(ODE), solution of an ODE, Order and degree of ODE, linear and nonlinear differential equation, Initial value problem, boundary value problem, Euler method, Runge-Kutta second order method, Runge-Kutta fourth order method, Predictor –Corrector method: Adams-Moulton's method, Milnes method.	10

Learning Resources:

1. Numerical Methods in Engineering & Science (with Programs in C, C^{++} &MATLAB) by B.S. Grewal ISBN: 978-81-7409-248-9.
2. Numerical methods; E. Balguruswamy, Tata McGrow Hill. ISBN13 9780074633113.
3. Introductory methods of numerical analysis; S.S. Shastry, Prentice Hall of India. ISBN-13: 978-8120327610.
4. Application of Numerical methods; Jain M.K. Iyengar S R K and Jain R. K. Addison-Wesley.
5. Numerical methods with programs in BASIC, FORTRAN, Pascal and C^{++}; S Bhalchandra Rao, C K Shantha, Universities Press (India) pvt Ltd. ISBN-13: 978-0863113703.
6. Theory and problems of numerical analysis; Scield F. Schaum's outlines Tata Mc Graw Hill publishing company limited New Delhi ,ISBN-13: 978- 0070552210.

Course Name: Electrodynamics

Course Code: PHYT/MJ/651, Course Type: MJ,

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To study and be able to apply the conceptual structure of Electrodynamics.
2. To provide an introduction to electrodynamics and a wide range of applications including communications, superconductors, novel materials.

Learning Outcomes: After completing this course students should be able to:

1. Explain classical electrodynamics based on Maxwell's equations including its formulation in covariant form.
2. Solve problems involving the calculation of fields, the motion of charged particles and the production of electromagnetic waves.
3. Analyze the solution of these problems in the context of a range of applications.

Unit No.	Course Content	Contact Hours
I	**Maxwell's Field equation and Propagation of Electromagnetic waves** Review of Maxwell's equations, Displacement Current, Derivation of Maxwell's equation, Maxwell's equation in free space, Propagation of plane electromagnetic waves in free space, Energy flow due to plane electromagnetic wave (poynting vector for free space),Relative orientation of E and H vectors in a plane wave, Polarization of electromagnetic waves, Lienard -wiechart potentials, Problems.	10
II	**Reflection and transmission of Electromagnetic waves** Boundary conditions for the electromagnetic field vectors at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two non-conducting media. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law, total internal reflection, Reflection & Refraction at the boundary of a conducting and non-conducting media for E vector incidence parallel and perpendicular to plane, problems.	10
III	**Guided wave, wave guide and cavities** Basic concept of waveguide, Transverse electric and transverse magnetic mode (TE & TM), Rectangular wave guide-TE and TM mode. Circular waveguide (TE and TM waves), cylindrical cavity resonator, rectangular cavity resonator(TE and TM waves), radiating system, radiation due to an oscillating electric dipole, problems.	10

Learning Resources:

1. Introduction to Electrodynamics, D.J. Griffiths/**ISBN**-13: 978-81-203-1601-0/Edition: **3rd**, 2008, Prentice-Hall of India private limited New Delhi.
2. Classical Electrodynamics- J. D Jackson (John Wiley and sons)/ **ISBN**-13: 978-0471309321/Edition: 3rd

3. Classical Electromagnetic Radiation-J.B. Marion (Academic press)/ **ISBN**-13: 978-0124722576/Edition: 2nd.
4. Electrodynamics-Gupta, Kumar, Singh, Pragati Prakashan (Meerut). Edition 21 st , **ISBN** 978-93-5006-724-6
5. Elements of Electromagnetic, M.N.O. Sadiku, 2001, Oxford University Press/ **ISBN**-13: 978-0195315196 Edition: 8th.
6. Introduction to Electromagnetic Theory, T.L. Chow, 2006, / **Jones** and Bartlett Publishers. **ISBN**-13: 978-0-7637-3827-3
7. Fundamentals of Electromagnetic, M.A.W. Miah, Tata McGraw Hill/ **ISBN** 9780226220871/1982.
8. Electromagnetic field Theory, R.S. Kshetrimayun, Cengage Learning/ **ISBN** : 9788131516584; 2012,
9. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer/ **ISBN** 978-3-540-76306-2
10. Electromagnetic Fields & Waves, P. Lorrain & D. Corson, ISBN-10: 0716703319/ W. H. Freeman & Co. /1970,
11. Electromagnetic- B. B. Laud / **ISBN**: 9788122430554. New Age International (P) Ltd. , 2011
12. Electromagnetic waves and Fields- R. N. Singh/ **ISBN**: 0074603477.

Course Name: Renewable Energy

Course Code: PHYT/MJ/652, Course Type: MJ

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives: The objectives of the Renewable Energy Course shall be as follows:

1. To create several self-employment opportunities in renewable energy and energy efficiency.
2. Sectors for modestly-trained and self-trained human resources exist in all geographic locations of the country.
3. To create several self-employment opportunities in renewable energy and energy efficiency.
4. It will help to develop the skills required in renewable energy.
5. To develop proficiencies and skills for becoming successful scientist, technicians in RE sector.
6. To develop the expertise for the innovation of different skills and its implementation in RE Sector.
7. To explore the different techniques in RE sector.
8. To create several self-employment opportunities in renewable energy and energy efficiency.

Course Outcomes: Upon successful completion of this course, students will be able to:

1. Apply knowledge of mathematics, science, and Technologies to solve real life problems.
2. Design and conduct experiments, as well as to analyse and interpret data.
3. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, Manufacturability, and sustainability.
4. Function on multidisciplinary teams.
5. Identify, formulate, and solve engineering problems.
6. Understanding of professional and ethical responsibility.
7. Understand the impact of technological solutions in a Global, environmental, and societal context.
8. Engage in independent learning and recognize the need for continual professional progress.
9. Use the techniques, skills, and modern technological tools necessary for Technological practice.

Unit No.	Course Content	Contact Hours
I	**Introduction** An introduction to energy sources, present energy consumption and need, world energy futures, energy sources and their availability commercial or conventional energy sources and new energy technologies. Renewable energy sources and prospects.	08
II	**Solar Energy** Solar Radiation and its measurements, Solar Radiation at the earth surface, Solar Radiation Geometry, Measurements, data, and average solar radiation. Solar energy collectors, transmissive flat-plate collectors, concentrating collectors: focusing type and principle of the conversion of solar radiation into heat. Solar energy storage, solar energy storage system, solar pond, principle of operation and description of non-convective solar pond, extraction of thermal energy and application of solar ponds. Application of solar energy, solar water heating, Space heating/cooling (solar heating/cooling of buildings), solar thermal electric conversion, solar electric power generation: solar photo – voltaic, solar distillation, pumping, furnace, cooking, green houses and production of hydrogen.	12

III	**Biomass and Hydrogen Energy** Biomass conversion technologies (Wet & Dry processes), Photosynthesis, Biogas generation and factors affecting. Materials used for bio-gas generation, site selection, design, problems and maintaining biogas production. Properties of biogas, utilization of biogas and biomass as a source of energy. Energy plantation, plants proposed and advantages of energy plantation, methods for obtaining energy from biomass. Thermal, chemical and bio gasification of biomass. Hydrogen energy and production, Electrolysis, Thermochemical methods, Fossil fuel methods and solar energy methods. Hydrogen storage, transportation, utilization as an alternative fuel for motor vehicles. Hydrogen technology development in India, its safety and management.	10

Learning Resources:

1. Non-Conventional Energy Sources by G. D. Rai, 4th Edn., Khanna Publishers, Delhi (2009).
2. Solar Energy by Radu D. Rugescu, InTech Publisher, Croatia, 1st Edn. (2010).
3. Renewable Energy by T. J. Hammons, InTech Publishers, Croatia, 1st Edn. (2010).
4. Solar energy : renewable energy and the environment by Robert Foster, Majid Ghassemi, Alma Cota, CRC Press, Boca Raton, FL 1st edn. (2010).
5. Biofuel Technology Handbook by Dominik Rutz and Rainer Janssen, WIP, Germany, 2nd Edn. (2008).
6. Renewable Energy (2nd edition) : Boyle, Godfray. Oxford University Press, 450 pages (ISBN No.: 0-19-926178-4)].
7. Energy Systems and Sustainability: Power for a Sustainable future: Boyle, Godfray, Bob Everett, and Janet Ramage (eds.) 2004. (ISBN NO: 0-19-926179-2),101.
8. "Large –Scale Offshore Wind Power in the United States,": W.Musial and B.Ram U.S. National Renewable Energy Laboratory, NREL/TP-500-40745, September 2010.
9. Wind Energy: Advantages and disadvantages: Dallas Lioyd, December 11,2014.
10. Pathways for Solar Photovoltaic, Journal of Energy and Environmental Science: Joel Jean, Patrick R. Brown, Robert L. Jaffe, Tonio Buonassisi and Vladimir Bulovic, 4, 2015.
11. Renewable Energy Technology and Market Overview: David Mooney, September 7, 2016.

Course Name: Advanced Sensor Technology

Course Code: PHYT/DSE/653, Course Type: DSE

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To introduce materials and their requisite in the perspectives of sensor.
2. To make understand the operation of principles of various sensors.
3. To make students facilitate manufacturing techniques for sensors.
4. To enable students to fabricate sensors through various technologies.

Course Outcomes:

1. Classify sensor materials and technologies.
2. Analyze the system based on sensor and actuators.
3. Design experiments for sensor calibration.
4. Develop sensor devices and sensor networks.

Unit No.	**Course Content**	Contact Hours
I	**Sensor Materials and Sensor Matrix** Materials: Material selection criteria, fulfillment of ideal sensor requisite, importance of 1-D materials in sensors, importance of surface area enhancement and enhancement in surface activity, Importance of size dependent Properties for sensing applications; Promising sensing materials: Carbon Nanotubes, Organic Conducting Polymers, Porphyrins and metal nanoparticles, Sensor Fabrication Technologies: AC Dielectrophoretic alignment of SWNTs and surface modification of SWNTs by OCP by charge controlled potentiostatic deposition and porphyrins by solid casting, for SWNTs, confirmation of coating by I-V measurements and electrochemical measurements.	10
II	**Chemical Sensors** Chemical Sensor Characteristics; Specific Difficulties; Classification of Chemical-Sensing Mechanisms; Direct Sensors: Metal-Oxide Chemical Sensors, Chemiresistive and ChemFET sensors, Electrochemical Sensors, Potentiometric Sensors, Conductometric Sensors, Amperometric Sensors, Complex Sensors: Optical Chemical Sensors Biosensor, Multisensor Arrays, Electronic Noses (Olfactory Sensors).	10
III	**Sensors Technology (Techniques for Sensor Fabrication)** Chemical Methods for preparation of sensor matrix: Chemical bath deposition, SILAR, Physical vapor deposition: Evaporation, Sputtering, Molecular beam epitaxy, Laser ablation deposition; Chemical vapor deposition: APCVD and LP CVD, PE CVD, Spray pyrolysis; Electrodeposition and electroless deposition: Electroless deposition, Electrodeposition, Potentiostatic, Galvanostatic, Cyclic voltammetry: Chemical sensor fabrication technology: screen printing, spin coating, dip coating, and casting.	10

Learning Resources:

1. Modern Sensors Handbook, Editedby Pavel Ripka and AloisTipek; ISTE Ltd, USA **(2007)**, ISBN 978-1-905209-66-8.
2. Handbook of Chemical and Biological Sensors; Edited by Richard F Taylor, Arthur D Little Inc., Jerome S Schultz, University of Pittsburgh ; Institute of Physics Publishing Bristol and Philadelphia; **(1996)** ISBN 0 7503 0323 9
3. Hand Book of Modern Sensors : Physics, Designs and Applications By Jacob Fraden Third Edition (Springer-Verlag New York, Inc.) **(2004)**, ISBN 0-387-00750-4.
4. Understanding Smart Sensors By Randy Frank; Second Edition; Artech House Boston. London **(2000),** ISBN 1-58053-398-1.
5. Sensors and Transducers, Third Edition By Ian R. Sinclair; Butterworth-Heinemann publication, Woburn **(2001),** ISBN 0 7506 4932 1
6. Chemical Sensors: An Introduction for Scientists and Engineers: Grundler, Peter; Springer Berlin Heidelberg New York **(2007),** ISBN 978-3-540-45742-8
7. Principles of Chemical Sensors : Janata, Jiri 2nd Edition ; Springer Dordrecht Heidelberg London, New York **(2009),** ISBN 978-0-387-69930-1 e-ISBN 978-0-387-69931-8
8. Optoelectronics Devices and System SECOND EDITION by S. C. Gupta; Prentice Hall International**(2011)** ISBN: 978-81-203-5065-6
9. Optical Fibers and fiber optic communication Systems by Subir Kumar Sarkar; S Chand & Company Ltd **(2000),** ISBN:9788121914598
10. Lasers and Optical Fiber Communications by P Sarah; I.K. International Publishing House Pvt Ltd, New Delhi **(2008),** ISBN : 9788189866587 / 8189866583
11. Optoelectronics by R. A. Barapate (Tech-Max Publication) **(2003)**

Course Name: Applied Spectroscopy

Course Code: PHYT/DSE/654, Course Type: DSE

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. Describe the basic principles of physics as related to the field of photonics.
2. Integrate the concepts of light, geometric and wave optics and their practical applications in photonics.
3. Theory and practice of instrumental methods for the separation, identification and quantitative analysis of chemical substances.
4. To understand how structure and bonding influence the physical properties and reactivity of molecules.
5. To be able to use symmetry to predict molecular orbital diagrams and explain electronic spectra
6. The course will explore the role of symmetry in
   a. Determining molecular properties (e.g. optical activity, dipole moment),
   b. Classifying and assigning nomenclature to molecules, molecular states and molecular Motions
   c. Bringing about simplifications in the application of quantum mechanics to molecules,
   d. Determining spectroscopic selection rules based on molecular symmetry. Group theory applied to the study of molecular symmetry has far reached consequences in chemistry and the course will provide an in-depth appreciation of this.

Course Outcomes: After completing this course, the student will be able to:

1. Use spectroscopic methods for qualitative and quantitative analysis.
2. Describe the interactions of electromagnetic radiations with matter
3. Explain the fundamentals of instrumental analysis
4. Discuss the basic components common to most spectroscopic instruments
5. Discuss how spectroscopic methods are used for qualitative and quantitative analyses
6. Develop advanced hands-on experience in the operation of spectroscopic instruments
7. Analyse instrumental responses to generate valid hypotheses and results
8. Hypothesise on theoretical concepts and predict instrumental responses
9. Will be able to interpret fluorescence spectroscopy
10. Explain basic principles of fluorescence spectroscopy
11. Explain working principles, taking spectrum and outline of fluorescence spectroscopy device
12. Gain a significant knowledge on formal group theory, including representations
13. Familiar with its applications to molecular symmetry, and can apply this know-how to problems in computational chemistry and molecular spectroscopy.

Unit No.	Course Content	Contact Hours
I	**Spectroscopic Instrumentation and Detection of Light** Spectrographs and Monochromators, Prism Spectrometer, Basic Considerations, Dispersive power and Spectral Resolving Power, Grating Spectrometers: Basic Considerations, Dispersive power and Spectral Resolving Power, Multiple Beam Interferometry. Thermal Detectors, Photodiodes, Photoconductive Diodes, Photovoltaic Detectors, Photoresistors, Photo emissive Detectors, Photocathodes, Photomultipliers,	10

	Scope: Laser spectroscopy by W. Demtroder, Springer, chapter 4. Spectroscopic Instrumentation.	
II	**Luminescence Spectroscopy** Introduction, Joblanski Diagram, Phosphorescence, Fluorescence, Resonance Fluorescence, Normal Fluorescence, Delayed Fluorescence. Intensity of Transitions. Non-Radiative Decay of Fluorescent Molecules, Effects of Medium on Fluorescence Spectra. Population of Triplet States, Phosphorescence Intensity, Solvent Effect, Excitation Spectra, Emission spectra, Experimental Methods, Emission Life Time Measurement. Application of Fluorescence and Phosphorescence. **Scope:** Spectroscopy Vol. 3 by B. P. Straughan and S. Walkar, London Chapman and Hall, Chapter 5.	10
III	**Molecular Symmetry and Group Theory** The Defining Properties of a Group, Some Examples of Groups, Subgroups, Classes, Symmetry Operations, Symmetry Elements, Algebra of Symmetry Operations, Multiplication Table. Molecular Point Groups, Matrix Representation of Symmetry Operations, Reducible and Irreducible Representations, Character Table for C2v and C3v Point Groups, Symmetry Species of Point Groups, Complete Character Table for Point Group, Distribution of Fundamentals among the Symmetry Species, Infrared Activity, Raman Activity. **Scope: 1.** Molecular Structure and Spectroscopy, by G. Aruldhas, Prentice Hall of India pvt, chapter 5. **2.** Chemical Applications of Group Theory (Third Edition), by F. Albert Cotton, John Wiley & Sons, Chapter 2,3 & 4]	10

Learning Resources:

1. Laser Spectroscopy, Volume 1: Basic Principles, Fourth Edition by Wolfgang Demtroder, Springer, ISBN: 978-3-540-73415-4 e-ISBN 978-3-540-73418-5, DOI 10.1007/978-3-540-73418-5 Library of Congress Control Number: 2007939486, © 2008, 2003, 1996, 1981 Springer-Verlag Berlin Heidelberg.
2. Modern Spectroscopy by J. M. Hollas, ISBN: 9780470844167, Published by John Wiley & Sons Ltd. (2004) Fourth Edition.
3. Spectroscopy by B. P. Straughan& S. Walker, ISBN: 0470150319 (v.1, Halsted Press), ISBN: 0470150327 (v.2), ISBN: 0412133806 (v.3, Cased Ed.) London: Chapman & Hall, New York, Vol. 1,2 & 3 (1976).
4. Molecular Structure and Spectroscopy, by Aruldhas, G., Second Edition, 2004. ISBN: 978-81-203-3215-7, PHI Learning.
5. Chemical Applications of Group Theory by F. Albert Cotton, ISBN: 9780471510949, John wiley & Sons (Wiley - Interscience) (1990) Third Edition.
6. Elements of Group Theory for Physicists by A. W. Joshi, ISBN: 812240975X, New Age International Private Limited publishers, New Delhi, (1997) Revised Fourth Edition.
7. Group Theory and Quantum Mechanics by M. Tinkham, ISBN: 9780486432472, Mc-Graw Hill Book Company, New Delhi (1964).

Course Name: Elementary Particle Physics

Course Code: PHYT/DSE/655, Course Type: DSE

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. This course is necessary for the students to make aware to various elementary particles apart from proton, neutron and electron.
2. The knowledge of elementary particles is helpful to classify the nuclear structure, their interactions,
3. The course should be taught as an elective and it should be taught at Semester-IV as it requires understanding of interactions of those particles with other particles (elementary particles) which is a very involved topic and requires knowledge of other aspects of nuclear physics covered in IV semester.
4. The course will help the student for preparation of NET/SET and other competitive examinations.

Course Outcomes: The course is useful to students as it provides knowledge of various elementary particles; their properties etc and the nature of strongest force i.e. Nuclear force.

1. The students can get job and opportunity of research in nuclear energy sector and accelerator center.
2. The course is extremely important for carrying out theoretical research leading to more and more elementary particles and ultimately vision of universe.
3. The origin of universe is a hot topic these days, for which studies in cosmic rays in also necessary.
4. In short, the course is the basis for front-line research in physics in present times.

Unit No.	Course Content	Contact Hours
I	**Elementary Particles Physics-I** Fundamental properties of elementary particles, Classification of elementary particles, Quantum numbers of elementary particles, Conservation laws of elementary particles, Relationship between particle and antiparticle.	10
II	**Elementary Particle Physics-II** Properties of massless and Lepton Particles, Properties of mesons (Pions, Neutral π-meson, K-mesons, □-meson), Properties of Baryons (Nucleons, Hyperons, resonant particle), Description of strange particles (K-mesons and Hyperons, Violation of parity, Strangeness and hypercharge, Properties of strange particles), Quarks and Gluons, Inversions in elementary particles (Time-reversal, Parity, Charge conjugation), Elementary particle symmetries (SU (3)-symmetry, Gell-Mann-Okubo mass formula).	10
III	**Nuclear Forces** Introduction, Characteristics of nuclear forces, The deuteron, The ground state of deuteron, Radius of deuteron, n-n and n-p scattering, p-p scattering below 10MeV, Distinction between p-p and n-p scattering, Similarity between n-n and p-p forces, Meson theory of nuclear forces.	10

Learning Resources:

1. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut- (2012) (ISBN-978-93-5006-593-8)
2. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
3. **Nuclear Physics,** Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN-81-7556-915-8).
4. **Nuclear Physics,** S. B. Patil, 1st edition, New Age International Publishers, New Delhi- (1991) (ISBN-978-81-224-0125-7).
5. **Nuclear Measurement Techniques,** K. Sri Ram, 1st edition, Affiliated East-West Press, Madras(1986) (ISBN-81-85095-56-6).
6. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN-EBK0036746).
8. **Nuclear Physics,** K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-517-3).
9. **Radioactive Materials,** Dr. B. M. Rao, 1st edition, Himalaya Publishing House, Mumbai- (2002).
10. **Nuclear Energy,** R. K. Taneja, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-516-6).

Course Name: Advances in Magnetic Materials

Course Code: PHYT/DSE/656, Course Type: DSE

Contact Hours: 30, Credits: 02, Hours/Week: 02, Max. Marks: 50

Learning Objectives:

1. To introduce students to advanced topics in Magnetic Materials.
2. To enable students to analyse the magnetic properties of magnetic materials.
3. To explore the diverse applications of magnetic materials in technology.
4. To develop students critical thinking skill through problem solving exercises, discussions of scientific literature.
5. To create awareness and encourage students to analyse experimental data.
6. To provide opportunities for students to enhance their communication skills through presentations, written assignments, and class discussions.
7. By achieving these objectives, students will gain deep understanding of Magnetic Materials, its theories, experimental techniques and practical applications for technology and scientific research.

Course Outcomes: Upon successful completion of the course, students will be able to:

1. Describe the physical origin of diamagnetism in solids.
2. Explain the physical origin of paramagnetism in solids.
3. Group the materials according to their magnetic susceptibilities.
4. Analyse the strong magnetization in ferromagnetic materials.
5. Determine the differences between ferromagnetic substances
6. Compute the experimental results by theoretical calculations.
7. Argue the magnetic dipole and spin concepts in detail.
8. An ability to apply their broad education toward the understanding of the impact of engineering solutions in a global and societal context.

Unit No.	Course Content	Contact Hours
I	**Diamagnetism and Paramagnetism** Langevin theory of diamagnetism, Langevin theory of Para magnetism, Curie law, quantum theory of paramagnetism, Curie law, magnetism of rare earth ions, iron group ions, crystal field splitting, quenching of orbital angular momentum, paramagnetic susceptibility of conduction electrons, Problems.	08
II	**Ferromagnetism** Ferromagnetic ordering, mean field theory, Curie – Weiss law, Heisenberg's exchange interaction, origin of domains, domain walls, motion of domain walls, thickness and energy of Bloch wall, coercive force, hysteresis, anisotropy energy, magnon and dispersion relation for magnons, experimental techniques-measurement of magnetic properties by VSM and SQUID Magnetometry, Applications-MRI Machines, Magnetic Levitation Trains, Spintronics, Magnetic Sensors, Electric Motors and Generators, Magnetic Data Storage, Problems.	12

III	**Antiferromagnetism and Ferrimagnetism** Antiferromagnetic ordering, two sublattice model, susceptibility below the Neel temperature, the dispersion relation for magnons in an antiferromagnet, super exchange interaction. Applications of Antiferromagnetic- Magnetic data Storage and Spintronics, Quantum Computing, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Spinel, Garnets, ferrimagnetic compounds, Properties: High Temperature Susceptibilities, Specific Heat, structure of ferrites, the saturation magnetization, Neel's theory. Applications of Ferrimagnetic Materials- Magnetic recording, Magnetic sensors, Magnetic refrigeration, Spin filters, Magnetostrictive Transducers	10

Learning Resources:

1.	Introduction to Solid State Physics, Charles Kittel, Willey India Edition, (8th Edition), ISBN – 978-0-471-41526-8, 1 January 2019.
2.	Solid State Physics, S. O. Pillai, New Age International Pvt. Ltd., 6th Edition, ISBN 8122416829, 9th January 2018.
3.	Solid State Physics – M. A. Wahab, Narosa Publishing House, 3rd Edition, ISBN: 81-7319-266-9, 1 January 2015
4.	Concepts of Solid State Physics- J. N. Mandal, Pragati Second Revised Edition 2011, ISBN: 978-93-5006-456-9.
5.	Solid State Physics-Vimal Kumar Jain, Ane Books Pvt. Ltd., 2013, ISBN: 978-93-8116-297-2, Website:www.anebooks.com.
6.	Structure and Properties of Solids- B. A. Mattoo, A Pragati Edition, First Edition 2008, ISBN: 978-81-8398-495-9.
7.	Materials Science- S. L. Kakani and Amit Kakani, A New Age International Publishers, 2004, ISBN: 81-224-1528-8.
8.	Introduction to Solids – L. V. Azaroff, McGraw Hill, New York, 2001, ISBN: 10:0070992193.
9.	Solid State Physics – A. J. Dekker, Published by Macmillan India (2000), ISBN 10: 0333918339 / ISBN 13: 9780333918333.
10.	Introduction to Magnetic Materials- B. D. Cullity and C. D. Graham, Second Edition, Willey Online Library, Published Online: 29 FEB 2008 DOI: 10.1002/9780470386323, e-Book.
11.	The Physics of Ferromagnetism- Terunobu Miyazaki, Jin Hanmin, Springer 2012, ISBN: 9783642255830 e-Book 489 pages.
12.	Hanbook of Magnetic Materials- K. H. J. Buschow (ed.), Elsevier Science 2013, ISBN: 9780444595959, e-Book 394 pages.
13.	Physics of Ferromagnetism- Soshin Chilazumi, Oxford University Press 2009, ISBN: 9780191569852, e-Book 668 pages.
14.	The Faraday effect in diamagnetic glasses, Jianrong Qiu and Kazuyuki Hirao, Journal of Materials, Research / Volume 13 / Issue 05 / 1998, pp 1358-1362, Materials Research Society 1998, Published online: 31 January 2011.
15.	Ferromagnetic ordering in NpAl2: Magnetic susceptibility and 27Al nuclear magnetic resonance, L. Martel, , J.-C. Griveau, R. Eloirdi, C. Selfslag, E. Colineau, R. Caciuffo, Journal of Magnetism and Magnetic Materials, Volume 387, 1 August 2015, Pages 72–76.
16.	Carbon-Induced Ferromagnetism in the Antiferromagnetic Metallic Host Material Mn3ZnN, Ying Sun, Yanfeng Guo, Yoshihiro Tsujimoto, Jiajia Yang, Bin Shen, Wei Yi Yoshitaka Matsushita, Cong Wang, Xia Wang, Jun Li, Clastin. Sathish, and Kazunari Yamaura, *Inorg. Chem.*, 2013, 52 (2), pp 800–806, **DOI:** 10.1021/ic3019265 Publication Date (Web): January 7, 2013.
17.	Antiferromagnetic behavior in Y–Ba–(Cu1−xScx)–O, A. Chakraborty, X. D. Chen, F. Zuo, B. R. Patton, J. R. Gaines and A. J. Epstein, Journal of Materials Research Journal of Materials Research Volume 4 / Issue 03 / 1989, pp 467-469, Materials Research Society 1989, Published online: 31 January 2011, DOI: http://dx.doi.org/10.1557/JMR.1989.0467 (About DOI)

18.	Surface driven effects on magnetic properties of antiferromagnetic LaFeO3 nanocrystalline ferrite, A. Sendil Kumar, M. Manivel Raja, and Anil K. Bhatnagar, J. Appl. Phys. 116, 113912 (2014); https://doi.org/10.1063/1.4896191.
19.	Calculation of losses in ferro- and ferrimagnetic materials based on the modified Steinmetz equation, J. Reinert A. Brockmeyer, A. Brockmeyer, Rik W. De Doncker, Rik W. De Doncker, Emotron AB, Helsingborg, IEEE Transactions on Industry Applications (Impact Factor: 2.05). 08/2001; DOI: 10.1109/28.936396, Source: IEEE Xplore.
20.	Structural and magnetic properties of cobalt ferrite nanoparticles synthesized by co-precipitation at Increasing temperatures, C. R. Stein, M. T. S. Bezerra , G. H. A. Holanda, J. André-Filho, and P. C. Morais, AIP Advances 8, 056303 (2018); https://doi.org/10.1063/1.5006321.
21.	Structural studies of Mn doped ZnO nanoparticles, **BN Dole**, VD Mote, VR Huse, Y Purushotham, MK Lande, KM Jadhav, Current Applied Physics 11 (3), (2011) 762-766
22.	Intriguing physicochemical properties and impact of co-dopants on N-doped graphene oxide based ZnS nanowires for photocatalytic application, DV Dake, ND Raskar, VA Mane, RB Sonpir, E Stathatos, M Vasundhara, R Meena, K Asokan, BN Dole, Scientific Reports 13 (1), (2023) 7595 (Publisher: Nature Publishing Group UK).

Course Name: Practical Based on PHYT/MJ/650

(Computational Methods In Physics)

Course Code: PHYP/MJ/676, **Course Type:** MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. As Computational physics is the study of scientific problems using computational methods, so it combines computer science, physics and applied mathematics to develop scientific solutions to complex problems.
2. To find approximate solutions to complex problems using only the simplest operation of arithmetic's.

Course Outcomes: After this course students can do:

1. Computational physics complements the areas of theory and experimentation in traditional scientific investigation.
2. Computer-based methods used to numerically solve mathematical models that describe physical phenomena.

Expt. No.	Title of the Experiments
1.	Root finding and solving nonlinear equations.
2.	Numerical differentiation and integration.
3.	Solving ordinary and partial differential equations.
4.	Solving linear systems of equations.
5.	Eigen value problems.
6.	Problems based on above theory.

Course Name: Practical Based on PHYT/MJ/651

(Electrodynamics)

Course Code: PHYP/MJ/677, **Course Type:** MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. To study and be able to apply the conceptual structure of Electrodynamics.
2. To provide an introduction to electrodynamics and a wide range of applications
3. Study the origin of pseudo forces in rotating frame.

Course Outcomes:

1. Understand the physical interpretation of gradient, divergence and curl.
2. Comprehend the difference and connection between Cartesian, spherical and cylindrical coordinate systems.
3. Study the response of the classical systems to external forces and their elastic deformation.
4. Understand the dynamics of planetary motion and the working of Global Positioning System (GPS).

Expt. No.	Title of the Experiments
1.	Measurement of magnetic field using magnetic compass and determination of e/m by magnetic focusing method.
2.	Measurement of resistivity by the four probe method.
3.	Measurement of dielectric constant of thin sheets and liquid.
4.	Hall effect in doped semiconductors and determination of charge density, velocity of charge carriers in the lattice.
5.	Determination of Brewster's angle.
6.	Newton's Rings: Wavelength of light.
7.	Newton's Rings: Refractive index of liquid.
8.	Deflection and Vibration Magnetometer: Magnetic moment of a magnet and horizontal component of earth's magnetic field.
9.	Carey Foster Bridge: Resistance per unit length and low resistance
10.	Study the fundamental physics behind reflection and refraction of light (electromagnetic waves).
11.	Study the working and applications of Michelson and Fabry-Perot interferometers.
12.	Comprehend the use of polarimeters.
13.	Study the characteristics and uses of lasers.
14.	Variation of magnetic field along the axis of Helmholtz coil

Course Name: Practical Based on PHYT/MJ/652

(Renewable Energy)

Course Code: PHYP/MJ/678, **Course Type:** MJ,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Measure solar cell efficiency under varying conditions.
2. Understand principles of solar energy conversion.
3. Investigate factors affecting solar cell performance.
4. Explain electrolysis of water for hydrogen gas production.
5. Gain a deeper understanding of fundamental algorithmic concepts.

Course Outcomes: Upon the completion of this course, students will be able to:

1. Mastery of solar cell operation and performance evaluation.
2. Proficiency in experimental design and data analysis.
3. Enhancement in problem solving abilities for optimizing solar energy conversion.
4. Development of skills for efficient hydrogen generation.
5. Performance of the solar PV module and its applications.
6. Pursue higher education in Overseas Universities can lead to specialized expertise and career advancement in the renewable energy.

Expt. No.	Title of the Experiments
1.	Study the characteristics of solar cell.
2.	Measure and analyse solar radiation levels at different times of the day.
3.	Estimate the efficiency of Lithium-ion Battery.
4.	Determine the efficiency of Lead-Acid Battery.
5.	Measure the charging efficiency of supercapacitor.
6.	Solar cell dark and illuminated characteristics.
7.	Solar cells in series and parallel-effect of series and shunt resistance.
8.	Study the effect of temperature and light intensity on solar cell characteristics
9.	Measurement of Fill Factor of a Solar Cell.
10.	Solar PV system (with/without charge controller)
11.	Effect of sun tracking on solar PV module efficiency
12.	Fabrication of Free Energy Generator Self Running by Magnet With Light Bulb 220V, Measure the Intensity by varying distance
13.	Fabrication of Free energy device with light bulbs, salty water, magnets and study the inverse square law using different filters.
14.	Determination of Solar Cell Efficiency.
15.	Electrolysis of Water for Hydrogen Production.
16.	Production of Bio-gas from organic waste and measure the gas production rate.
17.	Study the heat absorption of different materials (black paint, Al foil) for Solar cooker's surface.
18.	Determine the efficiency of Battery Storage systems for Storing Solar Energy.
19.	Study the Thermal Storage method for Storing Solar Energy.

Course Name: Practical Based on PHYT/DSE/653

(Advanced Sensor Technology)

Course Code: PHYP/DSE/679, **Course Type:** DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. To facilitate the students to understand
   a) the concepts of sensor science and technology from different principles of sensing viz. Optical fibre-based chemical, displacement, pressure sensors, Potentiometric sensors and gas sensors based on conducting polymers and single-walled carbon nanotubes.
   b) properties of optical fibre (viz. Numerical aperture, losses in optical fibre and optical to electrical and electrical–optical characteristics of fibre optic converter)
   c) the concept of Sensor materials and different principles of sensing technology which are used in laboratory as well as industrial level
2. To provide an opportunity for the students to enter into sensor research and develop smart sensor devices.
3. To create enthusiasm among the students to undertake research in sensors.

Course Outcomes:

1. Students will be able to -
   a) learn Sensors, characteristics of sensors, sensor materials and technologies, optical fibre and optical sensors, and various methods of detection.
   b) develop sensor devices and sensor networks based on optical, thermal, optical fibre and chemical sensors.
2. Students will be capable of undertaking jobs in optical fibre industries and sensor industries.
3. Students will have the option to start his / her teaching career either in science or engineering colleges/institutes as this course is included in science as well engineering discipline OR do research in sensor science.

Expt. No.	Title of the Experiments
1.	Determination of Numerical Aperture of PMMA optical fibre
2.	Losses in Optical Fiber.
3.	Study of Optical to Electrical (O-E) characteristics of fibre optic Phototransistor converter.
4.	Study of Electrical to Optical (E-O) characteristics of fibre optic 660nm and 850nm converter.
5.	Optical fibre chemical sensor.
6.	Study of Displacement sensor
7.	Study of Potentiometric sensor.
8.	Gas sensor based on OCP (organic Conducting Polymers)
9.	Gas Sensors based on Single-Walled carbon nanotubes (SWNTs)
10.	Study of characteristics of photovoltaic cell
11.	Study of characteristics of phototransistors.
12.	Study of characteristics of Photoconductive cell
13.	Study of characteristics of PIN Photodiode
14.	Study of characteristics of IC temperature sensor (LM 335)

15.	Study of K (chromel – alumel) type Thermocouple
16.	Characteristics of Platinum RTD (Resistance – Temperature Detector)
17.	Characteristics of NTC (negative Temperature Coefficient) Thermistor
18.	Study of Optical fibre Pressure sensor

Note: Students should perform at least **six** experiments

Course Name: Practical Based on PHYT/DSE/654

(Applied Spectroscopy)

Course Code: PHYP/DSE/680, **Course Type:** DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Basic knowledge of optical phenomena such as interference, interference between parallel plates, polarization, birefringence, absorption in optical media, total internal reflection, etc.
2. Applications of these phenomena in determining splitting of spectral lines (high resolution spectroscopy).
3. Behavior of optical media in external electric and magnetic fields.
4. Estimation of parameters of optical media and applications of lasers in investigating these phenomena.
5. To understand how structure and bonding influence the physical properties and reactivity of molecules.
6. Practice of instrumental methods for the separation, identification and quantitative analysis of photoluminescence substances.
7. Computer interfacing of these experiments and analysis of observations.

Course Outcomes: At the end of the course the student will be able to:

1. get basic training in optics.
2. analyse the optical patterns and other observations.
3. use spectrophotometric techniques for obtaining unknown concentrations of solutions.
4. hypothesise on theoretical concepts and predict instrumental responses.
5. able to setup magneto optic Faraday effect experiment.
6. verify Gaussian propagation of lasers and find laser spot size.
7. understand and explain the basic physics of optical fibres.
8. able to arrange various setups for investigation of interference of light and obtain fundamental parameter of media like refractive index.

Expt. No.	Title of the Experiments
1.	Determine the thickness of Fabry-Perot interferometer by exact fraction using CCD camera setup.
2.	To determine the unknown concentration of solute using Uv/Vis spectrophotometer.
3.	Measure the refractive index of a liquid (Water) using hollow prism.
4.	Measure the grating element of transmission grating
5.	To verify Beer and Lamberts law using spectrophotometer.
6.	To determine the wavelength of He-Ne LASER by using Michelson's Interferometer apparatus.
7.	To determine wavelength of He-Ne laser using grating element.
8.	Study of fluorescence properties of fluorophore using Photo luminance spectrophotometer.
9.	Study the Luminance material using Photo-Luminance (PL) spectroscopy

10.	Study of phosphorescence properties of fluorophore using Photo luminescence spectrophotometer.
11.	Experimental and theoretical investigation of excited g-symmetry states of Cu_2
12.	To identify the symmetry operations and assign the point group for given molecules (model).
13.	Measure the divergence of a LASER beam using detector.
14.	Measure the numerical aperture of an optical fibre using detector.
15.	Setup and study the electro-optic Kerr effect.
16.	Fabry-Perot Interferometer
17.	Twyman-Green Interferometer

Course Name: Practical Based on PHYT/DSE/655

(Elementary Particle Physics)

Course Code: PHYP/DSE/681, **Course Type:** DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives: To facilitate the students to understand,

1. The concepts of nuclear physics from different principles viz. Pulse height gamma-ray spectrum of 137Cs,with MCA, Energy calibration of scintillation spectrometer with SCA and MCA,Least square fitting of a straight line, Inverse Square law, Absorption of Gamma-rays in an absorber,Compton scattering from a lead target, Scattering cross section measurements from plastic targets.
2. Properties of nuclear materials (Viz, Backscattering from different targets, Relative efficiency calibration of a scintillation detector, Absolute efficiency calibration of a NaI(Tl) detector,Activity of Gamma-ray source (Area ratio method),Absolute activity of Gamma-ray source by sum peak method,
3. Verification of Moseley's Law, Determination of radioactivity in surface soil, cement and fly ash ,Determination of (Half-Life of 137mBa.

Course Outcomes: Students will be able to:

1. Learn the concepts of nuclear physics from different principles.
2. To understand the properties of nuclear materials.
3. Students will be capable to undertake job in BARC and industries
4. Students will have option to start his / her teaching career in science OR do research in gamma ray interaction studies.

Expt. No.	**Title of the Experiments**
1.	Pulse height gamma-ray spectrum of ^{137}Cs.
2.	Pulse height gamma-ray spectrum of ^{60}Co.
3.	Pulse height gamma-ray spectrum with multichannel analyzer.
4.	Energy calibration of scintillation spectrometer with SCA.
5.	Energy calibration of scintillation spectrometer with MCA.
6.	Least square fitting of a straight line.
7.	Inverse Square law.
8.	Absorption of Gamma-rays in an absorber in lead.
9.	Absorption of Gamma-rays in an absorber in aluminum.
10.	Compton scattering from a lead target.
11.	Scattering cross section measurements from plastic targets.
12.	Backscattering from different targets.
13.	Relative efficiency calibration of a scintillation detector.
14.	Absolute efficiency calibration of a NaI(Tl) detector.
15.	Activity of Gamma-ray source (Area ratio method).
16.	Absolute activity of Gamma-ray source.
17.	Absolute activity of a Gamma source by sum peak method.

18.	Verification of Moseley's Law.
19.	Determination of radioactivity in surface soil, cement and fly ash.
20.	Half-Life determination of 137m Ba.

Note: Students should perform at least four experiments.

Course Name: Practical Based on PHYT/DSE/656

(Advances in Magnetic Materials)

Course Code: PHYP/DSE/682, **Course Type:** DSE,

Contact Hours: 60, Credits: 02, Hours/Week: 04, Max. Marks: 50

Learning Objectives:

1. Students will explore diamagnetic response of materials and learn to measure and analyze the magnetic susceptibility of diamagnetic substances using experimental techniques.
2. Students will verify the Curie-Weiss law by measuring the temperature dependence of magnetic susceptibility in paramagnetic materials and analyzing experimental data.
3. Students will measure and analyze hysteresis loops of ferromagnetic materials.
4. Students will determine the Neel temperature of ferrimagnetic materials through experiments.

Course Outcomes: After completing this course successfully students will be able to:

1. Recognize and classify materials diamagnetic properties based on their response to external field.
2. Acquire the skills to measure the magnetic susceptibility of diamagnetic materials using experimental techniques.
3. Develop ability to analyze the temperature dependence of magnetic susceptibility in paramagnetic materials.
4. Characterization of hysteresis behavior in ferromagnetic materials.
5. Analyze the factors affecting the magnetic properties of magnetic materials.
6. Determine the Neel Temperature of ferrimagnetic materials through experimental measurements.
7. Apply theoretical models such as Weiss molecular field theory to describe ferromagnetic phenomenon.

Expt. No.	**Title of the Experiments**
1.	Measure the diamagnetic susceptibility of wood and ebonite samples.
2.	Estimate the magnetic susceptibilities of Bismuth and Platinum materials and classify the materials.
3.	Determine the magnetic susceptibilities of Glass and Copper samples.
4.	Measure the magnetic susceptibilities of Aluminium and Graphite materials and classify the materials based on their magnetic properties.
5.	Determine the magnetic susceptibility of Aluminium and Copper samples as a function of temperature and classify their magnetic properties.
6.	Measure the paramagnetic susceptibility of Al and Gd as a function of Temperature and verify Curie-Weiss Law and determine Curie temperature of the samples.
7.	Estimation of core loss and coercive force for a ferromagnetic core material of a transformer.
8.	Study the Paramagnetic susceptibility of Magnesium and Manganese as a function of temperature.
9.	To determine the magneto resistance of Bismuth crystal / Bismuth compound thin film as a function of Magnetic field.
10.	Determine the Neel temperature of a ferrimagnetic materials viz. ferrites or Garnets.
11.	Measurement of Curie temperature of a given ferromagnetic material.
12.	Magnetic susceptibility of solids by Guoy's method.

13.	Study of magnetic susceptibility in liquids.
14.	Variation of residual magnetization of carbon steel rod as a function of temperature.
15.	Study the magnetic field shielding effect of diamagnetic sample viz. wood.
16.	Demonstrate paramagnetic cooling using Gd-based paramagnetic material.
17.	Study the magnetic properties and energy losses of given material by B-H curve tracer.

Note: Students are advised to perform at least six experiments.

Course Name: Research Project/Field Project

Course Code: PHYP/RP/FP/696, **Course Type:** RP/FP,

Contact Hours: 180, Credits: 06, Hours/Week: 12, Max. Marks: 100