ALAGAPPA UNIVERSITY

(A State University Established in 1985)

Karaikudi - 630003, Tamil Nadu, India

Padma bhushan Vallal Dr. RM. ALAGAPPA CHETTIAR

2017	2018	2018	2019	2019
Accredited with A+ Grade by NAAC (CGPA : 3.64)	MHRD Govt. of India, UGC University Grants Commission — Graded as Category - 1 & Granted Autonomy	MHRD Government of India — Swachh Campus Rank : 4	NIRF National Institutional Ranking Framework — Rank : 28	QS — India Rank : 20, BRICS Rank : 104, Asia Rank : 216

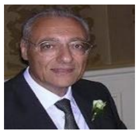
DEPARTMENT OF BIOELECTRONICS AND BIOSENSORS

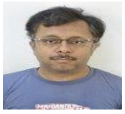
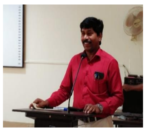
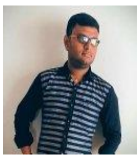
M.Sc., MATERIAL SCIENCE

[Choice Based Credit System (CBCS)]

[For the candidates admitted from the academic year 2019 -2020]

Panel of Members-Broad Based Board of Studies

Chairperson Dr. C. Sekar, Professor And Head, Department of Bioelectronics and Biosensors, Alagappa University, Karaikudi. AreasofExpertise Materials Science: Metal Oxide Semiconductors, Carbon Nanostructures, Biomaterials, Low DimensionalCuprates Sensors: Chemical Sensors, Biosensors for Medical, Food, Agricultural and EnvironmentalApplications	
Foreign Experts Dr. Giovanni Neri, Professor, Department of Engineering, University of Messina. Italy. Areas of Expertise Catalysis, Gas Sensors, Biosensors.	
Dr. Subramainan Tamil Selvan, Professor, Translational Neuroscience Laboratory, Lee Kong Chian School of Medicine, Nanyang Technological University, 59 Nanyang Drive, Singapore 636921. Email:subra.selvan@ntu.edu.sg. Areas ofExpertise:Nanomedicine, Bioimaging, Nanoparticle, Quantum Dots, Energy.	
Dr. Nanda Gunawardhana, Professor, Sri Lanka Technological Campus, New Kandy Rd, Malabe 10115, Sri Lanka. Email: nandhag@sltc.ac.ik. Areas ofExpertise:Capacitors, Gas Sensors, Nanomaterials, LIBs.	
Indian Experts Dr. P. Ravindran, Professor, Department of Physics, School of Basic and Applied Sciences, Central University of Tamil Nadu, Thiruvarur-610 101. Areas of Expertise: Nanophase Materials, Mofsandother Nano/Micro/Measo-Porous Materials, Hydrogen Storage & Battery Materials, Solar Energy Materials Including Transparent Conducting Oxides, Defects in Semiconductors, Linear, Nonlinear Optical Properties andother Excited State Properties, Magneto-Optical and Magneto-Caloric Materials., Magnetic Properties, Magnetic Anisotropy, Spin, Charge and Orbital Ordering, Multi-Ferroicandother Multifunctional Materials, Structural Phase Stability and High Pressure Studies.	
Dr. K. Chinnakali, Professor, Plot No.28, Ram Nagar First Street - North Extn, Velachery Chennai 600042. Areas ofExpertise:X-Ray Crystallography, Materials Science.	
Dr. S. Arumugam,, Professor, Centre For High Pressure Research, Bharathidasan University, Palkalaiperur Campus, Tiruchirappalli - 620 024, Tamil Nadu, India. Areas ofExpertise: X-Ray Crystallography, Magnetism.	
National Laboratories Experts Dr. Pratima R. Solanki, Assistant Professor, Special Centre For Nanoscience, Jawaharlal Nehru University,New Delhi, 110 067. Areas ofExpertise:Nano Biosensors, Nano Bio-Interface.	
Dr. N. Lakshminarasimhan, Scientist, Functional Materials Division, CSIR-Central Electrochemical Research, Institute, India. Email:laksnarasimhan@cecri.res.in. Areas of Expertise : Solid State Chemistry and Materials Science, Photo functional Materials - Phosphors, Photocatalysts, Transparent Conductors, Materials for Energy Conversion and Storage, Structure-Morphology-Property Correlations in Nanomaterials and Photofunctional Materials	

Dr. J. Mathiyarasu, Principal Scientist, Biosensors Division, CSIR-Central Electrochemical Research Institute, India. Email:almathi@cecri.res.in. Areas ofExpertise: Electrochemical Biosensors.	
Special Invitee Dr. J. Jeyakanthan, Professor and Head, Department of Bioinformatics, Alagappa University Karaikudi – 630 003, Tamil Nadu, India. Email:jjkanthan@gmail.Com. Areas ofExpertise: Structural Biology and Bio-Computing, Small and Macro Molecule X-Ray Crystallography.	
Dr.K.Gurunathan, Professor and Head, Department of Nanoscience and Technology, Alagappa University, Karaikudi – 630 003, Tamil Nadu, India. Email: kgnathan27@Rediffmail.Com. Areas of Expertise : Hydrogen Energy, Photo catalysisandPhoto electrochemistry, Nano (Quantum Dots &Core-Shell Solar Cells), Flexible (Plastic) Solar Cells, Nanomaterials for Electronics and Power Sources, Conducting Polymers and Their R-GO-MO-Nanocomposites, Nano Magnetism (Core-Shell Magnetic Materials For MRI), Nano Toxicology & Phytochemical Synthesis of Nanomaterials	
Dr. Jitendra Kumar, Scientific Officer, Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Mumbai. Email:jkumar@barc.gov.in. Areas ofExpertise: Biosensors.	
Members Dr. G. Ravi, Professor andHead, Department of Physics, Alagappa University, Karaikudi – 630003, Tamil Nadu,India. Email:raviganesa@rediffmail.com. Areas ofExpertise: Crystal Growth of Organic & InorganicMaterials, Nano Materials Synthesis and Thin Films Preparation for Supercapacitors, Photocatalytic and SensorApplications, Opto-Electronics and E-O Modulator–Devices.	
Dr. K.Sankaranarayanan, Professor, Department of Physics, Alagappa University, Karaikudi – 630003, Tamil Nadu,India. Email:hhrsankar@yahoo.com. Areas ofExpertise: MaterialsScience, Crystallization Kinetics of Organic and InorganicMaterials. Unidirectional Growth of Bulk Organic and InorganicCrystals. III-V Semiconductor Materials – Synthesis AndGrowth.	
Dr. V. Dharuman, Assistant Professor, Department ofBioelectronicsand Biosensors, Alagappa University, Karaikudi – 630003, Tamil Nadu,India.Email:dharumanudhay@yahoo.com. Areas of Expertise: Chemistry/Electrochemistry/ Diabetic, Cancer Biosensors Development using, DNA, Antibody (Immunosensors) and Neurological Disorder Sensors.	
Dr. J. Wilson, Assistant Professor, Department OfBioelectronics& Biosensors, Alagappa University, Karaikudi – 630003, Tamil Nadu,India.Email:wilson.J2008@yahoo.com.Areas of Expertise: Conducting Polymers, Metal Oxides, Carbon Based Materials, Biosensors, and Lithium Batteries.	
Alumni Dr. N. Sudhan, Assistant Professor, Department of Chemistry, Thiyagarajar College Madurai, India. Email:sudhamadhu@gmail.com. Areas of Expertise: Chemo-Biosensors, DNA Microarray, Gold Nanorods.	

CONTENTS

I. Introduction
II. Objectives of the Programme
III. Eligibility for Admission
IV. Programme outcomes
V. Programme Specific Outcomes (psos)
VI. Duration of the Programme
VII. Courses of Study
VIII. Semesters
IX. Teaching Methodologies
X. Examinations
XI. Scheme of Examinations
XII. Condonation
XIII. Question Paper Pattern
XIV. Evaluation
XV. Village Placement Programme
XVI. Passing Minimum
XVII. Classification of Successful Candidates
XVIII. Maximum Duration for the Completion of Programme
XIX. Commencement of this Regulation
XX. Code and Grading

I. Introduction

M.Sc**. Materials Science**

Physics – the study of matter, energy and their interactions - is an exciting intellectual adventure that inspires young people and expands the frontiers of our knowledge about nature. Physics is the most basic of the physical sciences from and geology and chemistry to biology and cosmology. We understand science in terms of the concepts developed in physics. The interests and concerns of physicists have always formed the basis of future technology. Physics can play an important role in developing strategies to combat climate change, in the development of cleaner energies, and in the development of technological advancement. Physics and technology must work together to resolve the need for new technologies that will decrease the damage to our planet, the need for solutions to deadly diseases that remain a threat, and need for solutions to the increasing demands we place on our resources before they are depleted.

The role of physics in our modern world is more important than in any other time in history. Physics extends and enhances our understanding of other disciplines, such as the earth, agricultural, chemical, Biological and environmental sciences, plus astrophysics and cosmology – subjects of substantial importance to all peoples of the world. Physics contributes to the technological infrastructure and provides trained personnel needed to take advantage of interdisciplinary subjects like nanotechnology, biotechnology, bioelectronics andbiosensors.

Biosensor is an interdisciplinary area currently makes revolution in all fields of science and technology. Application of fundamentals of physics and chemistry together to correlate biological behavior at nanoscale is essential to understandand prevent the biological system damage and to control of progressive diseases. Students need to understand the principles and applications of biosensing technology for the development of nanoscale sensor devices to monitor the disease state. Hence, courses pertaining to the biosensing technology is introduced in the first semester. During this period, students will learn about materials being used in fabricating nanoscale sensing devices with special attention to semiconductor technology. Further knowledge on types of biosensors, molecule based electronic devices and nanodevice applications for monitoring electrical properties of system biology. In the second semester, a spectrum of bioanalytical techniques available for biosensing will be taught. Third semester imparts basic and applied knowledge of electrical and optical based biosensing techniques as a core course. In the fourth semester, students will learn recent advancements in nanoelectronics based on molecular transducers and their applications in biosensing and other areas of nanoelectronics.

VISION

Department of Bioelectronics and Biosensors at Alagappa University shall strive towards the world class centre by producing students with higher technical knowledge, professional skills and other values. The Department shall provide an outstanding experience in teaching, research and consultancy. The Department shall perform frontier research and create knowledge base in physics, materials science, bioelectronics, biosensors and other relevant areas of technological importance.

MISSION

Department Bioelectronics and Biosensors at Alagappa University shall provide high quality physics education, producing well prepared students who are intellectually and technically equipped in their abilities and understanding of physics and in particular materials science and its application in the areas ofbiosensors. The Department of Bioelectronics and Biosensors promotes high quality academic and research programmes and providing extension services in cutting edge technologies in materials science and biosensors. The Department of Bioelectronics and Biosensors ensures the conducive campus climate in academic and research activities by meeting the need of the students, faculty and staff.

II. Objectives of the Programme

The major objectives of M.Sc. Materials Science are set as follows:

- To provide thorough theoretical and experimental courses in various branches of Physics and to make the students aware of the applied aspects of physics in the area of bioelectronics and biosensors.
- To develop abilities and skills that are relevant to the study and practice of physics, materials science and sensors, useful in everyday life
- To develop attitudes relevant to science such as concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness.

III. Eligibility for Admission

A candidate who has passed B.Sc., Degree Examination with Physics or Applied Physics or Applied Science as main course of study of any University accepted by the syndicate as equivalent thereto, subject to such condition as may be prescribed there for shall be permitted to appear and qualify for the M.Sc. Degree in Materials Science of this University after a course of study for two academic years.

IV.Programme outcomes

After going through the two years of study, our Materials Science Post-Graduates will exhibit ability to:

S.No.	Graduate	Programme Outcome
1.	Research aptitude	An ability to independently carry out research/ investigation and development work to solve practical problems
2.	Technical documentation	An ability to write and present a substantial technical report/document
3.	Technical competence	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the Program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4.	Modern Tool Usage	Students will develop and demonstrate an ability to work in laboratory, conduct experiments, visualize data and Interpret the results.
5.	Impact in society	Students will show the understanding of impact of materials in the society and also will be aware of Contemporary issues.
6.	Ethical responsibilities	Students will demonstrate knowledge of professional and Ethical responsibilities.

V. Program Specific Outcomes (Psos):

By the completion of the Materials Science program the student will have following Program specific outcomes.

1. To select materials as per needs and specifications and process them.
2. To develop new materials for specific applications and characterize them.
3. To develop new materials with required physical properties.
4. To analyze the functioning of devices made with novel materials.

VI. Duration of the Programme

The Master of Science in Materials Science shall consist of two academic years divided into four semesters. Each semester consistsof 90 working days.

VII. Courses of Study: M.Sc. Materials Science (2019-20 onwards)-CBCS - Structure of the Programme

No.	Course Code	Title of the Course	No. of Credits	Hours/ Week	Marks		
I SEMESTER					**I**	**E**	**Total**
1	542101	Mathematical Physics	4	4	25	75	100
2	542102	Classical Mechanics and Statistical Thermodynamics	4	4	25	75	100
3	542103	Electronics and Instrumentation	4	4	25	75	100
4	542104	Electromagnetic Theory and Optics	4	4	25	75	100
5		Program Elective I	3	3	25	75	100
6	542105	Lab-I Materials Science	3	6	25	75	100
		Library/Yoga/ Counseling/ Soft Skill		5			
			22	**30**	**150**	**450**	**600**
II SEMESTER							
7	542201	Numerical Methods for Materials Science	4	4	25	75	100
8	542202	Characterization of Materials	4	4	25	75	100
9	542203	Quantum Mechanics	4	4	25	75	100
10	542204	Physics of Materials	4	4	25	75	100
11		Program Elective II	3	3	25	75	100
12	542205	Lab-II Bio-Materials Science	3	6	25	75	100
13		Non-Major Elective course - I	2	3	25	75	100
14		Self-learning course (SLC) –MOOCs	Extra credits				
		Library/Yoga/ Counseling/ Soft Skill/Seminar		2			
			24	**30**	**175**	**525**	**700**
III SEMESTER							
15	542301	Fundamentals of Nanoscience & Technology	4	4	25	75	100
16	542302	Polymer and Composite Materials	4	4	25	75	100
17	542303	Solid State Physics	4	4	25	75	100
18		Program Elective II	3	3	25	75	100
19	542304	Lab-III Nano Materials; Mini Project	3	6	25	75	100
20		Non-Major Elective course -II	2	3	25	75	100
21		Self-learning course (SLC) –MOOCs	Extra credits				
		Library/Yoga/ Counseling/ Soft Skill/Seminar		6			
			20	**30**	**150**	**450**	**600**
IV SEMESTER							
22	542401	Molecular Spectroscopy	3	3	25	75	100
23		Program Elective IV	3	3	25	75	100
24		Program Elective V	3	3	25	75	100
25		Open Elective	3	3	25	75	100
26	542999	Dissertation	12	18	25	75	100
		Library/Yoga/ Counseling/ Soft Skill					
			24	**30**	125	375	500
TOTAL CREDIT			**90**	**120**			

Non-Major Elective-Courses offered to the other Department to other Departments

Sl. No	Paper Code	Semester	Title of the paper	Crédits	Hours/ Week	Marks		
						I	E	T
1	542701	II	Electronics for Daily Life	2	3	25	75	100
2	542702	II	Food Chemistry	2	3	25	75	100
3	542703	III	Nanobiosensors	2	3	25	75	100
4	542704	III	Green Chemistry	2	3	25	75	100

ELECTIVE COURSES

No.	Code	Title of the Course	No. of Credits	Contact Hours
I SEMESTER				
1	542501	Biomaterials	3	3
2	542502	Molecular Electronics	3	3
3	542503	Non-Destructive Testing	3	3
4	542504	Nonlinear Optics and Materials	3	3
5	542505	Laser and Applications	3	3
6	542506	Python Programming	3	3
II SEMESTER				
7	542507	Semiconductor Materials and Devices	3	3
8	542508	Advances in Crystal Growth	3	3
9	542509	Materials Processing	3	3
10	542510	Nanoelectronics and Photonics	3	3
11	542511	Corrosion Science and Engineering	3	3
12	542512	Solid State Ionics	3	3
III SEMESTER				
13	542513	Bioelectronics	3	3
14	542514	Chemical Sensors	3	3
15	542515	Thin Film Science and Technology	3	3
16	542516	Nanomaterials Preparation and Characterization	3	3
17	542517	Ceramic Materials	3	3
18	542518	Physical Metallurgy	3	3
19	542519	Superconducting Materials and Applications	3	3
IV SEMESTER				
20	542520	Nanobioelectronics	3	3
21	542521	High Pressure Science and Technology	3	3
22	542522	Optical Materials	3	3
23	542523	Biosensors	3	3
24	542524	Composite Materials and Structures	3	3
25	542525	Nuclear Physics and Reactor Materials	3	3
26	542526	Smart Materials and Structures	3	3

VIII. Semesters

An academic year is divided into two semesters. In each semester, courses are offered in 18 teaching weeks including the duration of conduct of internal examination. Each week has 30 working hours spread over 5 days a week.

IX. Teaching Methodologies

The classroom teaching shall be through conventional lectures and use of Power Point and YouTube presentations. The lecture shall be such that the student should participate actively in the discussion. Student seminars would be conducted and scientific discussions would be arranged to improve their communicative skill. In the laboratory, instruction shall be given for the experiments followed by demonstration and finally the students have to do the experiments individually. Periodic tests would be conducted and special attention shall be given to the slow learning students.

X. Examinations

The examination shall be three hours duration to each course at the end of each semester. The candidate failing in any course(s) will be permitted to appear for each failed course(s) in the subsequent examination. Practical examinations for M.Sc. programme in Materials Science shall be conducted at second and third semesters. At the end of fourth semester viva-voce will be conducted on the basis of the Project report submitted by the student. One internal and one external examiner will conduct the viva-voce jointly.

XI. Scheme of Examinations

No.	Course Code	Title of the Course	No. of Credits	Contact Hours	Marks		
I SEMESTER					I	E	T
1		Mathematical Physics	4	4	25	75	100
2		Classical Mechanics and Statistical Thermodynamics	4	4	25	75	100
3		Electronics and Instrumentation	3	4	25	75	100
4		Electromagnetic Theory and Optics	4	4	25	75	100
5		Program Elective I	3	3	25	75	100
6		Lab-I Materials Science	3	6	25	75	100
		Library/Yoga/ Counseling/ Soft Skill		5			
			22	**30**	**150**	**450**	**600**
II SEMESTER							
7		Numerical Methods for Materials Science	4	4	25	75	100
8		Characterization of Materials	4	4	25	75	100
9		Quantum Mechanics	4	4	25	75	100
10		Physics of Materials	4	4	25	75	100
11		Program Elective II	3	3	25	75	100
12		Lab-II Biomaterials Science	3	6	25	75	100
13		Non-Major Elective course - I	2	3	25	75	100

		Library/Yoga/ Counseling/ Soft Skill		2			
			24	**30**	**175**	**525**	**700**
III SEMESTER							
14		Fundamentals of Nanoscience &Technology	4	4	25	75	100
15		Polymer and Composite Materials	4	4	25	75	100
16		Solid State Physics	4	4	25	75	100
17		Program Elective III	3	3	25	75	100
18		Lab-III Nanomaterials; Mini Project	4	6	25	75	100
19		Inter-Departmental Course	3	3	25	75	100
		Library/Yoga/ Counseling/ Soft Skill		6			
			20	30	150	450	600
IV SEMESTER							
20		Molecular Spectroscopy	3	3	25	75	100
21		Program Elective IV	3	3	25	75	100
22		Program Elective V	3	3	25	75	100
23		Open Elective	3	3	25	75	100
24		Dissertation	12	18	25	75	100
		Library/Yoga/ Counseling/ Soft Skill					
			24	**30**	**125**	**375**	**500**
TOTAL CREDIT			**90**	**120**			

XII. Condonation

Student must have earned 75% of attendance in each course for appearing for the examination. Students who have earned 74% to 70% of attendance have to apply for condonation in the prescribed form with prescribed fee. Students who have earned 69% to 60% of attendance should apply for condonation in the prescribed form with the prescribed fee along with the Medical Certificate. Students who have attended below 60% are not eligible to appear for the examination and they shall re-do the semester after completion of the programme, with the prior permission of the Registrar of the University.

XIII. Question Paper Pattern

M.Sc. Materials Science(2020-21 onwards)

XXX: Course title
Time: 3 Hours Max. Marks - 75

PART A: Answer all questions. All questions carry equal marks. (10 × 2 = 20 marks)
Two questions should be problem oriented.

There will be 10 Questions covering the entire syllabus viz. 2 from each Unit (I to V)

PART B: Answer all questions either (a) or (b). (5 × 5 = 25 marks)
One either or question should be problem oriented.

11. (a) or (b) from UNIT I

12. (a) or (b) from UNIT II
13. (a) or (b) from UNIT III
14. (a) or (b) from UNIT IV
15. (a) or (b) from UNIT V

PART C: Answer any three questions. ($3 \times 10 = 30$ marks)
16. from UNIT I
17. from UNIT II
18. from UNIT III
19. from UNIT IV
20. from UNIT V

XIV. Evaluation

The performance of a student in each course is evaluated in terms of percentage of marks with a provision for conversion to grade points. Evaluation for each course shall be done by continuous internal assessment (CIA) by the concerned course Teacher as well as by an end semester examination (ESE) and will be consolidated at the end of the course. The components for continuous internal assessment are:

Two tests	- 15 marks (Third /repeat test for genuine absentees)
Seminar/Quiz	- 05 marks
Assignment / field trip report /case study report.	- 05 marks
	25 marks

Attendance need not be taken as a component for continuous assessment, although the student should put in a minimum of 75% attendance in each course. In addition to continuous evaluation component, the end semester examination, which will be a written examination of at least 3 hours duration, would also form an integral component of the evaluation.

The ratio of marks to be allotted to continuous internal assessment and to end semester examination is 25:75. The evaluation of laboratory component, wherever applicable, will also be based on continuous internal assessment for 25 marks and an end-semester practical examination for 75 marks.

Distribution of marks for practical examinations (CIA marks 25 + ESE 75 marks)

CIA	**Marks**
Two Model Practical exams	25

ESE	**Marks**
Circuit Diagram / Diagram / Formula / Tables	10
Observation	20
Results	20
Viva – voce in practical	15
Record Note	10
Total	75

XIII. Project Work

Project Work: 100 marks

Periodic Presentation of Learning	25 marks
Concise Project	50 marks
Viva-voce	25 marks

Total 100 marks

(a) Plan of Work:

The student should prepare plan of work for the project, get the approval of the guide and should be submitted to the University during the fourth semester of their study. In case the student wants to avail the facility from other University/laboratory, they will undertake the work with the permission of the guide and HOD and acknowledge the alien facilities utilized by them. The duration of the project research shall be a minimum of three months in the fourth semester.

(b) Project Work outside the Department:

In case the student stays away for work from the Department for more than one month, specific approval of the HOD should be obtained.

(c) No. of copies/distribution of project work:

The students should prepare three copies of project work in bound volume and submit the same for the evaluation by Examiners. After evaluation one copy is to be retained in the Department library and one copy for guide and one copy for the student.

(d)Format to be followed:

The format/certificate for project to be submitted by the student is given below:

Format for the preparation of project work:

(a) Title page
(b) Bonafide Certificate
(c) Acknowledgement
(d) Table of contents

CONTENTS

Chapter No.	TITLE	Page No.
1.	Introduction	
2.	Review of Literature	
3.	Materials and Methods	
4.	Results and Discussion	
5.	Summary	
6.	References	

Format of the Title Page:

TITLE OF THE PROJECT

Project Submitted in partial fulfillment of the requirement for the Degree of Master of Science in MATERIALS SCIENCE to the Alagappa University, Karaikudi -630 003.

By

Students Name:
Register Number:
Under the Guidance of

(Faculty Name)
University Emblem
Department of Bioelectronics & Biosensors
Alagappa University
Month and Year

Format of Declaration of the Candidate:

Name and class of the student

DECLARATION

I hereby declare that the Project entitled ________________________________ submitted to ALAGAPPA UNIVERSITY for the award of the degree of MASTER OF SCIENCE is my original work and that it has not previously formed the basis for the award of any degree, diploma/associate-ship or any other similar title of any other University or Institution.

Signature of the Student

Signature of HOD

Format of the Certificate:

CERTIFICATE

This is to certify that the project entitled --submitted in partial fulfillment of the requirement of the degree of Master of Science in Materials Science to the Alagappa University, Karaikudi is a record of bonafide research work carried out by -------------------------under my supervision and guidance and that no part of the project has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date: Signature of the Guide

Place:

Guidelines for approval of M.Sc. Materials Science guides for guiding students in their research for submitting project work:

1. A person seeking for recognition as guide should have Ph.D. Degree in Science discipline (or) M.Phil., / M.Sc. degree in Science with first class/second class should have 3 years of active teaching/research experience. They should have published at least one research paper in a National/International Journal authored solely or jointly.

1. Procedure for submitting application for approval as guides:
   - (i) The University shall on request give prescribed application form.
   - (ii) The filled in applications should be submitted before the close of said date by the University.
   - (iii) All such applications should be routed through the HOD with specific recommendations.
   - (iv) All relevant proofs should be submitted along with the applications. The committee constituted for the purpose will scrutinize the applications and recommend for

approval/rejection. Orders will then be passed by the authority of the University and communicated to each member individually through the HOD.

XV. Village Placement Programme (VPP)

The SivagangaandRamnad districts are backward districts, where a majority of the people lives in poverty. The rural mass is economically and educationally backward. Thus the aim of the introduction of this Village Placement Programme (VPP) is to extend outreach programs in environmental awareness, hygiene and health to the rural masses of this region. The students in their third semester have to visit any one of the villages within the jurisdiction of Alagappa University and can arrange various programmes to educate the rural masses in the following areas for three days.

1. Environmental awareness 2. Hygiene and health

A minimum of two faculty members can accompany the students and guide them. This course is a compulsory one for all the students of the Department of Bioelectronics and Biosensors, Alagappa University.

XVI. Passing Minimum

The candidate shall be declared to have passed the examination if the candidate secures a minimum of 50 % in the University external examination and 50% of the total (Int+Ext) marks.

For the project work and viva-voce, a candidate should secure 50% of the marks for pass. The candidate should compulsorily attend viva-voce examination to secure pass in that course.

Candidate who does not obtain the required minimum marks for a pass in a course/Project Report shall be required to reappear and pass the same at a subsequent appearance.

XVII. Classification of Successful Candidates

Candidates who secure not less than 60% of the aggregate marks in the whole examination shall be declared to have passed the examination in First class. All other successful candidates shall be declared to have passed in the Second class.

Candidates who obtain 75% of the marks in the aggregate shall be deemed to have passed the examination in First class with Distinction provided they pass all the examinations prescribed for the course at the first appearance.

Candidates who pass all the examinations prescribed for the programme in the first instance and within a period of two academic years from the year of admission to the programme only are eligible for University Ranking.

A candidate is deemed to have secured first rank provided he/she

(i) should have passed all the courses in first attempt itself

(ii) should have secured the highest overall grade point average (OGPA)

XVIII. Maximum Duration for the Completion of the Programme

The maximum duration for completion of M.Sc. Degree in Materials Science Programme shall not exceed FOUR semesters.

XIX. Commencement of this Regulation

These regulations shall take effect from the academic year 2020-2021 i.e., for students who are to be admitted to the first year of the programme during the academic year 2020-2021and thereafter.

XX. Code and Grading

Legend

M.Sc. Materials Science

Once the marks of the CIA and end-semester examination for each of the courses are available, they will be added. The marks, thus obtained will then be graded as per the scheme provided in Table 1.

Table 1: Grading of the Courses

Marks	**Grade Point**	**Letter Grade**
96 and above	10	S+
91 – 95	9.5	S
86 – 90	9.0	D++
81 – 85	8.5	D+
76 – 80	8.0	D
71 – 75	7.5	A++
66 – 70	7.0	A+
61 – 65	6.5	A
56 – 60	6.0	B
50 – 55	5.5	C
Below 50	0	F

From the second semester onwards the total performance within a semester continuous performance starting from the first semester is indicated respectively **Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA).**

These two are calculated by the following formula.

$$GPA = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$$

Where 'Ci' is the Credit earned for the course 'i' in any semester; 'Gi' is the Grade Point obtained by the student for the course 'i' and 'n' is the number of courses **passed** in that semester. **CGPA** (Cumulative Grade Point Average) = Average Grade Point of all the Courses starting from the first semester to the current semester.

M.Sc. Materials Science

(Regular Programme)
Curriculum (2020-2021 onwards)
under
Choice Based Credit System

<table>
<tr><th colspan="5">I Semester</th></tr>
<tr><td>Course code</td><td></td><td>MATHEMATICAL PHYSICS</td><td>Credits: 4</td><td>Hours: 4</td></tr>
<tr><td>Objectives</td><td colspan="4">- To introduce the students to understand the vector calculus and matrices.
- To make the students to understand the special functions.
- To make the student to study the complex variables.
- To involve the student to learn the integral transform.
- To educate the students to develop the understanding partial differential equation and group theory.</td></tr>
<tr><td>Unit -I</td><td colspan="4">VECTOR CALCULUS AND MATRICES - Introduction to vectors and Product of vectors – Gradient, Divergence, Curl - Vector operators in curvilinear coordinates Gauss, Green and Stokes theorems - Applications - Introduction to Matrix – properties of Matrix – Rank of Matrix - Eigenvalue problem - Diagonalization - solving differential equations.</td></tr>
<tr><td>Unit-II</td><td colspan="4">SPECIAL FUNCTIONS - Beta and Gamma functions - Bessel, Legendre andHermite, functions and their properties-Series solutions - Recurrence relations - Rodrigue's formulae, Orthogonality, Generating functions – Applications - Dirac delta function.</td></tr>
<tr><td>Unit III</td><td colspan="4">THEORY OF COMPLEX VARIABLES - Functions of complex variables - Cauchy Riemann conditions-Analytic functions -Conformal mapping - Cauchy's Integral Theorem and Integral Formula -Taylor's and Laurent's series - Singularities - Zeros, Poles and Residues-Residue theorem - Contour integration.</td></tr>
<tr><td>Unit IV</td><td colspan="4">INTEGRAL TRANSFORMS - Fourier transform-properties-transforms of simple functions and derivatives-Convolution theorems – Applications - Laplace's transform – properties -Transform of simple functions and derivatives-periodic functions-Convolution theorem-Application to solve differential equation.</td></tr>
<tr><td>Unit V</td><td colspan="4">PARTIAL DIFFERENTIAL EQUATIONS AND GROUP THEORY - Transverse vibration of a string - Wave equation - One dimensional heat conduction - Diffusion equation - Two dimensional heat flow - Laplace's equation - Method of separation of variables - Definition of group - symmetry elements - Reducible and irreducible representation - Orthogonality theorem – Physical applications of group theory.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Gupta. B.D. (2019). Mathematical Physics. Vikas Publishing House Pvt. Ltd.
Sathya Prakash. (2019). Mathematical Physics. Sultan Chand& Sons.
Butkov. (1973).Mathematical Physics. Addison Wesley, New York.
Grewal B.S. (2015). Higher Engineering Mathematics, Khanna Publishers.
Kreyszig. E (2015). Advanced Engineering Mathematics. Wiley.
Pipes L.A. andHarvillL.R. (2014). Applied Mathematics for Engineers and Physicists. Dover Publications Inc.</td></tr>
<tr><td>Outcomes</td><td colspan="4">At the end of the course, the student should be able to
- Apply ideas of vector calculus and matrices to physics problems.
- Crack the physics problems with special formula.
- Make use of complex variable to solve integrals.
- Use integral transform in physics and optics.
- Utilize the partial differential equation to boundary value problems.</td></tr>
</table>

<table>
<tr><td colspan="5">I Semester</td></tr>
<tr><td>Course code</td><td></td><td>CLASSICAL MECHANICS AND STATISTICAL THERMODYNAMICS</td><td>Credits: 4</td><td>Hours: 4</td></tr>
<tr><td>Objectives</td><td colspan="4">□ To develop familiarity with mechanical aspects of systems and mathematical methods of Classical Mechanics.
□ To make the students understand the concepts laws of thermodynamics its applications and phase equilibria.
□ To make the students understand the statistical mechanics of systems, probability distribution laws.
□ To enable the students to understand the applications of statistical thermo dynamical methods in solid state physics.
□ To make the students understand the basic concepts of heat and mass transfer and its application in hydrodynamics.</td></tr>
<tr><td>Unit -I</td><td colspan="4">LAGRANGIAN AND HAMILTONIAN DYNAMICS-Mechanics of single and system of particles - Conservation laws – Constraints - Generalised coordinates -Virtual work - D’Alembert’s principle – Lagranges equation of motion– Cyclic co-ordinates - Hamilton’s equations of motion -Euler Lagrange equation - Principle of least action.</td></tr>
<tr><td>Unit-II</td><td colspan="4">CANONICAL TRANSFORMATION, BRACKETS AND RIGID BODY- Canonical transformation – Generating functions - Poisson brackets - Lagrange brackets - Relation between Lagrange and Poisson brackets-Jacobi Idendity. Rigid body dynamics: Euler’s angles- -Angular velocity – Principal moment of inertia -Kinetic energy.</td></tr>
<tr><td>Unit III</td><td colspan="4">THERMODYNAMICS- Laws of thermodynamics- internal energy- Enthalpy- Entropy- Helmholtz and Gibbs free energies – Thermodynamic relations – Euler equation – Maxwell’s relations and applications – Chemical Potential- Gibbs phase rule – phase equilibria (single and multicomponent systems) - Clausius – Clayperon equation – law of mass action – first order phase transition in single component systems – Second order phase transition.</td></tr>
<tr><td>Unit IV</td><td colspan="4">CLASSICAL AND QUANTUM STATISTICS - Micro and Macro States - Ensembles - Microcanonical, canonical and grand canonical ensembles – Maxwell – Boltzmann, Bose- Einstein and Fermi-Dirac statistics – Comparison of MB, BE and FD statistics.</td></tr>
<tr><td>Unit V</td><td colspan="4">APPLICATION OF STATISTICS - Planck’s Radiation law – Stefan-Boltzmann law – Einstein model of a solid – Bose condensation – Classical partition function and classical ideal gas – Equipartition theorem – Semiconductor statistics – Statistical equilibrium of electrons in semiconductors.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Callen.H.B. (1966).Thermodynamics. John Wiley and Sons.
Engel. T. and Reid.P. (2007). Thermodynamics, Statistical Thermodynamics & Kinetics, Pearson Edu.
Goldstein. H. PooleC.P. andSafko.J. (2017). Classical Mechanics. Pearson Education, Inc.
Gupta.M.C. (1993). Statistical Thermodynamics. Wiley Eastern Ltd.
Holman.J.P. (2008). Heat transfer. Tata McGraw Hill.
RanaN.C. andJoag.P.S. (2017). Classical Mechanics. McGraw Hill Education.
Reif.F. (2010). Fundamentals of Statistical and Thermal Physics. Waveland Press.
UpadhyayaJ. C.. (2005).Classical Mechanics. Himalaya Publishing House.</td></tr>
<tr><td>Outcomes</td><td colspan="4">□ Students have gained knowledge in mathematical methods of classical mechanics, namely Newtonian mechanics, Lagrangianand Hamiltonian dynamics.
□ Students have learned the laws of thermodynamics, thermodynamic relations, its applications, phase equilibria and phase transitions.
□ Students have understood the concepts of ensembles and learned to derive the statistical distribution laws.
□ Students have learned to apply the statistical distribution laws to problems in solid state physics.
□ Students have understood the basic concepts of heat and mass transfer, the equations governing them and its application in hydrodynamics.</td></tr>
</table>

I Semester				
Course code		**ELECTRONICS AND INSTRUMENTATION**	**Credits: 4**	**Hours: 4**
Objectives	To make the students to understand the concept of analog electronics. To introduce the advanced concepts of digital electronics. To educate the students on the concepts of optoelectronics. To equip the students for designing electronic instruments. To introduce the concepts of nanoelectronics and physics aspects to the students.			
Unit -I	**ANALOG ELECTRONICS -**Operational amplifiers: Introduction –op-amp parameters–feedback– differential amplifier –comparators – mathematical operations – active filters – instrumentation amplifiers – isolation amplifiers – OTAs –Voltage regulators: Principles and operations.			
Unit-II	**DIGITAL ELECTRONICS-** Introduction – overview of logic functions and logic gates – combinational logic – flip-flops and related circuits – sequential logic – registers, counters, shift-registers and memory – microprocessor architecture – A/D and D/A conversion.			
Unit III	**OPTOELECTRONICS-** LEDs – semiconductor lasers – photodiodes – solar cells – photodetectors – optical fibers – communication – optoelectronic modulation and switching devices – optocoupler– optical data storage devices.			
Unit IV	**ELECTRONIC INSTRUMENTATION -** Basics of instrumentation system – transducers – types of transducers – strain gauges – RTDs – LVDT – piezoelectric transducers – load cell – flow meters – signal conditioning – data acquisition andconversion – data transmission.			
Unit V	**NANOELECTRONICS -** MOSFETs - `electron transport in nanostructures - resonant tunneling diodes – single electron transfer devices – molecular switches and memory storage – nano-electromechanical systems - quantum dot cellular automata.			
Reference and Text Books: - Bhattacharya P. (2019). *Semiconductor Optoelectronic Devices*. Pearson Education. Chua L.O,.DesoerC.A andKuh E.S. (1997).*Linear and Nonlinear Circuits*. McGraw-Hill. Cooper W.D.(1991).*Electronic Instrumentation and Measurement Techniques*. Prentice Hall of India. Floyd.T.L. (2015).*Electronic devices*. Pearson Education. Hanson G.W. (2009). *Fundamentals of Nanoelectronics*. Pearson Education Inc. HorowitzP andHill W. (2006). *Art of electronics*. Cambridge Univ.Press. Kalsi H.S. (2017). *Electronic Instrumentation*. McGraw Hill Education. Lakshmanan MandMurali K. (1996). *Chaos in Nonlinear Oscillators*. World Scientific. Malvino A.P. (2011). *Electronic principles*. Tata McGraw-Hill.				
Outcomes	After completing this course, the students should able to To design analog electronic circuits. To design digital electronic circuits. To design optoelectronic circuits. To design electronic instruments. To gain knowledge on nanoelectronic devices.			

I Semester				
Course code		**ELECTROMAGNETIC THEORY AND OPTICS**	**Credits: 4**	**Hours: 4**
Objectives	• Fundamentals of Maxwell's equations are their applications in different situations. • Insight on fundamental laws of optics and how they can be derived from Maxwell's Equations. • Introduction to novel calculus of tensors and illustrate their usage in different Material properties. • An overview on various optical activities and their applications in material characterization. • Basics of non-linear optical effects and non-linear optical materials.			
Unit -I	**MAXWELL'S EQUATIONS -**Review of Gauss's law in electrostatics and magnetism - Ampere's law- Faraday'slaw -displacement current - Maxwell's equations - differential and integral forms - scalar and vector potentials and applications Potential due to a uniformly charged sphere - magnetic inductiondue to a current carrying wire.			
Unit-II	**ELECTROMAGNETIC WAVE PROPAGATION -** Plane electromagnetic waves in free surface - Poynting vector - characteristic impedance - wave equation in an isotropic medium - wave equation in insulators and conductors - reflection by a perfect conductor - normal and oblique incidence - Fresnel equations for parallel and perpendicular polarization.			
Unit III	**CRYSTAL OPTICS -** Crystal symmetry-Light propagation in anisotropic media – Maxwell's equations: the constitutiverelation -Index ellipsoid – wave plates – Biaxial media: Optic axes – positive and negative crystals - Electrical conductivity tensor- - stress optic tensors - third rank tensors – Linear Electro-optic effect - Fourth rank tensors: third order susceptibility tensor.			
Unit IV	**OPTICAL ACTIVITY-** Optical Polarization – Magneto-optical effects – Magneto-optical Kerr and Faraday effect - Kerr andPockel effect - applications - Harmonics and sum & frequency generation - stimulated Brillouin scattering (SBS) - stimulated Raman scattering (SRS) – applications of SBS and SRS for material characterization – examples.			
Unit V	**NONLINEAR OPTICS -** Theory and applications of non-linear effects - frequency conversion - optical switching - phase conjugation - optical bistability - nonlinear optical materials - NLO crystals, properties and applications.			

Reference and Text Books: -

CorsonD. andLorrain P. (2013).*Introduction to Electromagnetic Fields and Waves*, Literary Licensing, LLC.

FleischD. (2008). *A student's Guide to Maxwell's Equations*. Cambridge University Press.

GriffithsD.J. (2015). *Introduction to Electrodynamics*. Pearson Education.

Jordan E.Cand Balmain K.G (2015). *Electromagnetic Waves and Radiating Systems*. Pearson Education.

New G. (2014). *Introduction to Nonlinear Optics*, Cambridge University Press.

Nye J.F. (1997) *Physical Properties of Crystals*. Oxford University Press.

YarivA. andYehP. (2007). *Photonics*. Oxford University Press.

Outcomes	After completion of this paper the students will understand the effect of light propagation in materials and how materials change the nature of electromagnetic wave. Specifically they will be able to: • Derive Maxwell's equations and apply them to study the electrostatics andmagneto statics. • Understand boundary conditions between different materials and reflection and refraction of light based on Maxwell's equations. • Appreciate the use of tensors in determining crystal symmetry and in explaining advanced properties of materials like elastic properties, piezoelectric effect, eletro-optic effect etc. • Elucidate how optical activities occur in materials and how they can be used to further characterize materials. • Apprehend the fundamentals of Non-linear optical effects, the nature of materials exhibiting such properties, and their applications.

Course Code	LAB – I MATERIALS SCIENCE	L T P	C
		0 0 6	3

LIST OF EXPERIMENTS
Any Fifteen experiments

1. Band gap determination.
2. Determination of elastic constants – Hyperbolic fringes.
3. Determination of elastic constants – Elliptical fringes.
4. Determination of dielectric constant.
5. Ultrasonic diffractometer - Ultrasonic velocity in liquids.
6. Magnetostriction measurements.
7. Study of crystal lattices.
8. Strain gauge meter – Determination of Young’s modulus of a metallic wire.
9. Conductivity of ionic crystals.
10. Instrumentation Amplifier.
11. Regulated power supply.
12. 555 Timer – Astablemulti-vibrator.
13. Operational amplifier - characteristics and applications.
14. Active filter.
15. RC Phase Shift Oscillator (FET).
16. AD/DA convertor.
17. Viscosity of liquid - Meyer's disc.

TOTAL: 90 PERIODS

LABORATORY EQUIPMENTS REQUIREMENTS:

1. X-Y translation microscope.
2. Thermostats.
3. Ultrasonic generator.
4. Multimeters.
5. IC’s transistors and resistors.

II Semester				
Course code		**NUMERICAL METHODS FOR MATERIALS SCIENCE**	**Credits: 4**	**Hours: 4**

Objectives	To improve and enhance the analytical ability in problem solving skills of students using numerical methods. - To demonstrate the understanding of numerical methods using Mat Lab. - To solve the large system of linear equations and find the roots of non-linear equations. - To familiarize interpretation and curve fitting using numerical methods. - To understandand use the appropriate method of numerical differentiation and integration when the function is too complicated and difficult to solve. - To demonstrate the use of different methods to find the solution of ordinary differential equation and get exposed to basic statistics.
Unit -I	**MATLAB/SCILAB PROGRAMMING -** Overview ofMatlab – data types and variables – operators – flow control – functions – input-output– array manipulation – writing and running programs – plotting – overview ofsimulink environment.
Unit-II	**SYSTEM OF EQUATIONS -** Linear equations: Introduction – linear systems – Gaussian elimination – singular systems – Jacobiiteration - Gauss-Seidel iteration. Nonlinear equations: Introduction – bisection method – rule of false position – Secant method – Newton-Raphson method – Comparison of methods for a single equation – Seidel and Newton’s methods for systems of nonlinear equations.
Unit III	**INTERPOLATION & CURVE FITTING AND ERROR ANALYSIS -** Polynomial interpolation theory - Newton's forward and backward interpolation formulae - Lagrange's method - Lagrange's inverse interpolation – piecewise linear interpolation – interpolation with cubic spline – least-squares line - curve fitting – Fourier seriesand trigonometric polynomials.
Unit IV	**NUMERICAL DIFFERENTIATION AND INTEGRATION -** Numerical differentiation: Finite difference approximations – Richardson extrapolation – derivatives by interpolation. Numerical integration: introduction to quadrature – composite Trapezoidal and Simpson’s rule – recursive rules and Romberg integration – Gaussian integration.
Unit V	**DIFFERENTIAL EQUATIONS SOLVING AND STATISTICS -** Initial value problems: Euler method - Taylor series method – Runge-Kutta methods – stability and stiffness – adaptive Runge-Kutta method – Predictor - corrector method – system of differential equations – phase-plane analysis: chaotic differential equations. Boundary value problems:finite-difference method. Statistics: random variable – frequency distribution – expected value, average and mean – variance and standard deviation – covariance and correlation. Generating random numbers – Monte Carlo integration.

Reference and Text Books: -

Kharab A.andGuenther R.B. (2019). *An Introduction to Numerical Methods: A MATLAB Approach*. CRC Press.

MathewsJ. H. and FinkK. D. (2015). *Numerical Methods using MATLAB*. Pearson Education India.

SastryS.S (2012). *Introductory Methods of Numerical Analysis*. Prentice Hall India Learning Private Limited.

Venkatraman M.K. (1997). *Numerical Methods in Science and Engineering*. National Publishing Company, Madras.

Woodford C. andPhillips C. (2014). *Numerical Methods with worked examples: MATLAB edition*. Springer.

Outcomes	At the end of each unit the students will be able to - Write efficient mat lab code, analyze and interpret numerical results. - Solve large system of linear equation and find the roots of non-linear equations. - Construct approximate polynomial of given data and also apply numerical methods for curve fitting. - Numerically differentiate and evaluate complicated integrals. - Understand the basic concepts in numerical methods to estimate the solutions to ordinary differential equations and also get expose to use of statistics.

II Semester				
Course code		**CHARACTERISATON OF MATERIALS**	**Credits: 4**	**Hours: 4**

Objectives	To introduce the important characterization techniques to the students • To make the students understand some important thermal analysis techniques. • To make the students familiarize with image formation in an optical microscope and learn other specialized microscopic techniques. • To make the students learn the principle of working of electron microscopes and scanning probe microscopes. • To make the students understand some important semiconductor characterization techniques. • To introduce the students the basics of some important spectroscopic techniques.
Unit -I	**THERMAL ANALYSIS -**Introduction – thermogravimetric analysis (TGA) – instrumentation – determination ofweightlossand decomposition products – differential thermal analysis (DTA)- cooling curves - differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements – determination of thermomechanical parameters .
Unit-II	**MICROSCOPIC METHODS -** Optical Microscopy: optical microscopy techniques – Bright field – Dark field optical microscopy – phase contrast microscopy -differential interference contrast microscopy - fluorescence microscopy - confocal microscopy - Metallurgical microscope.
Unit III	**ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY-** SEM-FESEM- EDAX,- HRTEM: working principle and Instrumentation – sample preparation – scanning probe microscopy - STM – AFM - working principle, Instrumentation and modes of operation.
Unit IV	**ELECTRICAL METHODS AND OPTICAL CHARACTERISATION-** Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V, I-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations - Photoluminescence – light – matter interaction – instrumentation – Applications.
Unit V	**SPECTROSCOPY-** Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, ESR, NMR, NQR, mass spectroscopy – Bain bridge-Jordan Mass spectroscope – application.

Reference and Text Books: -

Banwell C.N.andMcCashE.M. (2017). *Fundamentals of Molecular Spectroscopy*. McGraw-Hill Education.

Belk J.A. (1979). *Electron Microscopy and Microanalysis of Crystalline Materials*. Applied Science Publishers, London.

KealeyD.and Haines P.J. (2002). *Analytical Chemistry*. Viva Books Private Limited, New Delhi.

MurrL.E. (1991). *Electron and Ion microscopy and Microanalysis principles and Applications*. Marcel Dekker Inc., New York.

StradlingR.A. andKlipstainP.C. (1990). *Growth and Characterization of semiconductors*. Adam Hilger, Bristol.

Outcomes	• Students will be able to describe TGA, DTA, DSC and TMA, its applications and interpretation of results. • Students have understood the concept of image formation in Optical microscope and other specialized microscopes. • Students have learned the working principle and operation of SEM, TEM, STM and AFM. • Students have understood the necessary theory of Hall measurement, four –probe resistivity measurement, C-V, I-V, Electrochemical, Photoluminescence and electroluminescence techniques. • Students have learned basics and necessary theory of some important spectroscopic techniques and its applications.

II Semester				
Course code		**QUANTUM MECHANICS**	**Credits: 4**	**Hours: 4**
Objectives	• To expose the students to the basic formulation of quantum mechanics. • To impart knowledge to the students about potential problems. • To introduce knowledge on angular momentum to the students. • To explore the ideas on approximation methods to the students. • To inspire the students with knowledge of scattering theory.			
Unit I	**BASIC FORMULATION-**Inadequacy of Classical Mechanics - Postulates of quantum mechanics-wave function, probabilistic interpretation, observables and operators - Eigenvalues andEigenfunctions, Expectation values - Commutators - Bra &Ket vectors, completeness, orthonormality, Basic theorems-Uncertainty principle-Ehrenfest's theorem-Schrodinger wave equation-stationary state solutions.			
Unit II	**POTENTIAL PROBLEMS-** Free particle in three dimensions, particle in a box-one dimension and three dimension-potential step, potential barrier, tunnel effect, square well potential, periodic potential, linear harmonic oscillator, rigid rotator, the hydrogen atom, atomic orbitals.			
Unit III	**ANGULAR MOMENTUM-** Angular momentum operators, commutation rules, Eigenvalues of angular momentum operator, matrix representations, addition of two angular momenta, Clebsch-Gordon coefficients coefficients for j = ½ system, properties - Pauli matrices.			
Unit IV	**APPROXIMATION METHODS -** Time - independent perturbation theory (First order only), non-degenerate case - An harmonic oscillator and Stark effect - Variation method - Application to the deutronand helium atom - Time dependent perturbation theory – Fermi Golden rule - Harmonic perturbation.			
Unit V	**SCATTERING THEORY -** Centre of mass and Laboratory systems - Scattering amplitude and cross sections-Scattering of a wave packet-optical theorem - Born approximation-validity-partial wave analysis-phase shifts.			
Reference and Text Books: - AruldhasG. (2009). *Quantum Mechanics*, PHI Learning Pvt. Ltd., New Delhi. DevanathanV. (2011). *Quantum Mechanics*. Narosa Publishing House Pvt. Ltd, New Delhi. Mathews P.M andVenkatesanK. (2017). *A Text book of Quantum mechanics*, McGraw Hill Education. SakuraiJ.J. andNapolitano J. (2017). *Modern Quantum Mechanics*, Cambridge University Press. Schiff L.I. (2019). *Quantum Mechanics*, McGraw Hill Education. ZettiliN. (2016). *Quantum Mechanics: Concepts and Applications*. Wiley India Pvt. Ltd.				
Outcomes	After end of the course, the students will be able to • Make use of fundaments of quantum mechanics to various physics problems. • Utilize the potential problems to solve real practical problems. • Gain the understandings of angular momentum and its usefulness in spectroscopy. • Learn about the approximation methods and its usefulness to various physics problems. • Understand the basic knowledge about scattering theory and its uses in various physics problems.			

II Semester				
Course code		**PHYSICS OF MATERIALS**	**Credits: 4**	**Hours: 4**
Objectives	To impart knowledge on various properties of materials - To introduce the concepts of various mechanical test and plastic deformation the students. - To introduce the students about various dielectric materials and their application. - To expose the students to different types of magnetic materials and their properties. The various applications used in magnetic materials. - To study the properties of various optical materials, LED and LCD and their applications. - To make the students understand about various properties of smart materials, shape memory alloys CCD and nanomaterials and their applications.			
Unit -I	**MECHANICAL PROPERTIES -** Plastic deformation by slip – the shear strength of perfect and real crystals -dislocation movement– methods of strengthening against plastic yield – Creep – mechanisms – fracture – ductile fracture – brittle fracture – Griffith criterion – fracture toughness – fatigue fracture - mechanical tests - tensile, hardness and creep tests.			
Unit-II	**DIELECTRIC PROPERTIES -** Dielectric constant and polarizability - different kinds of polarization - Internal electric field in a dielectric -Clausius- Mossotti equation - dielectric in a ac field - dielectric loss - ferroelectric - types and models of ferro electric transition - electrets and their applications – piezoelectric and pyroelectric materials.			
Unit III	**MAGNETIC PROPERTIES -** Classification of magnetic materials- origin of magnetism – Langevinand Weiss theories - exchange interaction - magnetic anisotropy - magnetic domains - molecular theory – hysterisis - hard and soft magnetic materials - ferrite structure and uses - magnetic bubbles - magnetoresistance - GMR materials - dilute magnetic semiconductor (DMS) materials.			
Unit IV	**OPTICAL PROPERTIES -** Optical absorption in insulators, semiconductors and metals – band to band absorption – luminescence - photoconductivity. Injection luminescence andLEDs- LED materials - super luminescent LED materials - liquid crystals - properties and structure - liquid crystal displays-comparison between LED and LC displays.			
Unit V	**ADVANCED MATERIALS -** Metallic glasses - preparation, properties and applications - SMART materials - piezoelectric, magnetostrictive, electrostrictive materials - shape memory alloys - rheological fluids - CCD device materials and applications - solar cell materials (single crystalline, amorphous and thin films) - introduction to nanoscale materials and their properties.			
Reference and Text Books: - KasapS.O. (2019). *Principles of Electronic Materials and Devices*. McGraw-Hill Education. OtsukaK. andWaymanC.M. (1998). *Shape Memory Materials*, Cambridge University Press. RaghavanV. (2015). *Materials Science and Engineering: A First Course*. PHI Learning. Suryanarayana C.andInoue A. (2017). *Bulk Metallic Glasses*, CRC Press.				
Outcomes	After completing the course, the students should be able to: - The students have gained knowledge in mechanical tests and plastic deformation mechanism. - Would have known the application and various properties of dielectric materials. - Make use of fundamental on magnetic materials properties and their application. - To gain knowledge on optical materials properties and their applications. - Understand the basic knowledge about advanced materials and preparation methods for nanomaterials and their properties.			

Course Code	LAB – II BIO-MATERIALS SCIENCE	L T P C
		0 0 6 3

LIST OF EXPERIMENTS

Any ten experiments: 45

1. Electrical conductivity of metals and alloys with temperature-four probe method.
2. Hall effect - Determination of Hall co-efficient, charge carrier density and mobility.
3. Magnetic susceptibility-Quincke's method.
4. Crystal Growth-Solution technique.
5. Crystal Growth-Gel technique.
6. Determination of melt flow index of polymers.
7. Creep characteristics of a metallic wire.
8. Particle size determination-laser - Determination of wave length of He-Ne laser-Diffraction method.
9. Ultrasonic interferometer – ultrasonic velocity in liquids.
10. Ferroelectricity – Hysteresis loop - coercivity, retentivityand saturation magnetisation.
11. Fraunhoferdiffraction - using laser.

Strength of Materials Laboratory 45

1. Tensile test on mild steel rod.
2. Compression test on wood.
3. Torsion test on mild steel rod.
4. Impact test.
5. Compression test on helical spring.
6. Deflection test on Carriage spring.
7. Double shear test.
8. Hardness shear test.
9. Deflection test on metal beams.
10. Tension test on helical spring.

TOTAL: 90 PERIODS

Laboratory equipments requirements:

1. Four probe.
2. Electromagnet.
3. Laser source.
4. Melt flow index device.
5. Ultrasonic interferometer.
6. Universal testing machine.

III Semester				
Course code		**FUNDAMENTALS OF NANOSCIENCE & TECHNOLOGY**	**Credits: 4**	**Hours: 4**
Objectives	To make the students understand the structure and properties of nanomaterials. To educate students about the various synthesis methods of nanostructure materials. To introduce the students about quantum dots. To give awareness about characterization of materials like crystallite size analysis, scanning etc., To inspire the nanotechnology applications.			
Unit -I	**NANOSCALE SYSTEMS -** Length, energy, and time scales - Quantum confinement in 3D, 2D, 1D and zero dimensional structures - Quantum confinement of electrons in semiconductor nanostructures- Size effect and properties of nanostructures- Top down and Bottom up approach.			
nit-II	**SYNTHESIS OF NANOSTRUCTURE MATERIALS -** Gas phase condensation – Vacuum deposition - Physical vapor deposition (PVD) - chemical vapor deposition (CVD) – laser ablation- Sol-Gel- Ball milling –Electro deposition- electroless deposition – spray pyrolysis – plasma based synthesis process (PSP) - hydrothermal synthesis – carbon nanotubes and graphene synthesis.			
Unit III	**QUANTUM DOTS -** Excitons andexcitonic Bohr radius – nanoparticles and quantum dots - Preparation through colloidal methods - Epitaxial methods- MOCVD and MBE growth of quantum dots - Absorption and emission spectra - photo luminescence spectrum - optical spectroscopy – linear andnonlinear optical spectroscopy.			
Unit IV	**CHARACTERIZATION -** Crystallite size analysis using Scherrer formula - Particle size measurement using DLS and HRTEM - Atomic Force Microscopy (AFM) and Scanning tunneling microscopy (STM) - applications to nanostructures – Nanomechanical characterization – Nanoindentation – femotosecond laser.			
Unit V	**NANOTECHNOLOGY APPLICATIONS -** Applications of nanoparticles, quantum dots, nanotubes and nanowires for nanodevice fabrication– Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions - nanoparticles based solar cells and quantum dots based white LEDs – CNT based transistors – principle of dip pen lithography.			
Reference and Text Books: - BrinkerC.J. andScherrer G.W. (1994).*Sol-Gel Science*. Academic Press, Boston. *Hand book of Nanoscience, Engineering and Technology (The Electrical Engineering handbook series)*,(2002). Kluwer Publishers. Hari Singh Nalwa. (2000).*Hand book of Nanostructured Materials and Technology*. Vol.1-5. Academic Press, USA. Hari Singh Nalwa. (2002). *Nanostructured materials and nanotechnology*. Academic Press, USA. John DinardoN.(2000).*Nanoscale Characterization of Surfaces & Interfaces*. Weinheim Cambridge: Wiley-VCH. TimpG. (1999). *Nanotechnology*. AIP press, Springer-Verlag, New York.				
Outcomes	Plan and develop the application of semiconductor nanomaterials. Familiar with various synthesizing methods. Workout various quantum dot synthesis. Advance the applications of nanostructures andnanomechanical characterization. The students can understand the importance of nanoscience and technology with the fundamental concepts behind size reduction.			

<table>
<tr><td colspan="5">III Semester</td></tr>
<tr><td>Course code</td><td></td><td>POLYMER AND COMPOSITE MATERIALS</td><td>Credits: 4</td><td>Hours: 4</td></tr>
<tr><td>Objectives</td><td colspan="4">To introduce polymers, their synthesis and polymerization techniques.
To impart knowledge on the various properties of polymers.
To gain knowledge of various polymer processing techniques, and applications.
To introduce the fundamentals of composites and their mechanical behavior.
To impart knowledge on the fabrication of different types of composites.</td></tr>
<tr><td>Unit -I</td><td colspan="4">INTRODUCTION TO POLYMERS-Classification of polymers – copolymers – tacticity – geometric isomerism – molecular weight distribution and averages – Measurement of molecular weight – synthesis of polymers – step growth polymerisation – chain growth polymerisation – polymerisation techniques.</td></tr>
<tr><td>Unit-II</td><td colspan="4">PROPERTIES OF POLYMERS- Polymer conformation and chain dimensions – Freely jointed chains- amorphous state – glass transition temperature – the crystalline state – ordering of polymer chains – crystalline melting temperature – techniques to determine crystallinity – Mechanical properties – Introduction to viscoelasticity – dynamic mechanical analysis – mechanical models of viscoelastic behaviour – Boltzmann superposition principle</td></tr>
<tr><td>Unit III</td><td colspan="4">POLYMER PROCESSING, RHEOLOGY AND APPLICATIONS- Basic processing operations – extrusion, molding, calendaring, coating – Introduction to polymer rheology – non-Newtonian flow – analysis of simple flows – rheometry – capillary rheometer, Couette rheometer and plate rheometer - applications-conducting polymers-biopolymers-liquid crystal polymers - high temperature polymers.</td></tr>
<tr><td>Unit IV</td><td colspan="4">INTRODUCTION TO COMPOSITES - Classification of composite materials – the concept of load transfer - matrix materials - polymers, metals and ceramics - fibers - glass, carbon and metallic fibers - fiber packing arrangements - bonding mechanisms – mechanical behavior of composites.</td></tr>
<tr><td>Unit V</td><td colspan="4">FABRICATION OF COMPOSITES- Polymer matrix composites – liquid resin impregnation routes, pressurized consolidation of resin pre-pregs, consolidation of resin moulding compounds, injection mouldingof thermoplastics, hot press mouldingof thermoplastics – metal composites – squeeze infiltration, stir casting, powder blending – ceramic composites – powder based routes, layered ceramic composites, carbon/carbon composites.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Crawford R.J. (2014). Plastics Engineering. Elsevier India.
Gowarikar V.R, ViswanathanN.V.&Sreedhar J. (2019). Polymer Science. New Age International.
HullD.&Clyne T.W. (2008). An Introduction to Composite Materials. Cambridge University Press.
Joel R.Fried. (2014). Polymer Science and Technology. Pearson Prentice Hall.
MallickP.K. (2008). Fiber-Reinforced Composites: Materials, Manufacturing and Design. CRC Press, Boca Raton.</td></tr>
<tr><td>Outcomes</td><td colspan="4">The students will be able to understand
The basics properties ofpolymers, their synthesis and various polymerization techniques.
The conformation, glass transition temperature, crystallinity and mechanical behavior of polymers.
Different polymer processing methods, and various applications of polymers.
Classification ofcomposites, matrix and reinforcement, and mechanical behavior of composites.
Fabrication techniques of composites and apply them in practice.</td></tr>
</table>

<table>
<tr><td colspan="5">III Semester</td></tr>
<tr><td>Course code</td><td></td><td>SOLID STATE PHYSICS</td><td>Credits: 4</td><td>Hours: 4</td></tr>
<tr><td>Objectives</td><td colspan="4">
- To understand the basic crystal structures, bonding of solids and the lattice energy calculations.
- To explain electrical and thermal conduction in metals and Fermi distribution function.
- To discuss how our understanding of lattice dynamics is formulated in terms of travelling waves, together with the role of the interatomic forces.
- To study the properties of different Semiconducting materials and superconducting materials and their applications.</td></tr>
<tr><td>Unit -I</td><td colspan="4">CRYSTAL STRUCTURE AND BONDING - Crystalline solids - crystal systems - Bravais lattices –coordination number – packing factors – cubic, hexagonal, diamond structure, Sodium Chloride Structure – lattice planes and Miller Indices– interplanar spacing – directions. Types of bonding - lattice energy - Madelung constants – Born Haber cycle – cohesive energy.</td></tr>
<tr><td>Unit-II</td><td colspan="4">FREE ELECTRON THEORY - Drude theory – Wiedemann-Franz Law and Lorentz number –Quantum state and degeneracy-density of states, concentration - free electron statistics (Fermi-Dirac), Fermi energy and electronic Specific heat, Electrical resistivity and conductivity of metals – Boltzmann transport theory —electrical and thermal conductivity of electrons.</td></tr>
<tr><td>Unit III</td><td colspan="4">LATTICE DYNAMICS - Mono atomic and diatomic lattices – anharmonicityand thermal expansion- phonon –Momentum of phonons, Inelastic scattering of photons by long wavelength phonons, Local phonon model – Einstein and Debye model, density of states, Thermal conductivity of solids- due to electron-due to phonons – thermal resistance of solids – phonon-phonon interaction-normal andUmklapp processes - scattering experiments.</td></tr>
<tr><td>Unit IV</td><td colspan="4">PERIODIC POTENTIALS AND ENERGY BANDS - Bloch’s theorem – Kronig-Penney model-Construction of Brillouin Zones- Effective mass of electron-nearly free electron model – Tight binding approximation-Construction of Fermi Surfaces-density of states curve-electron, holes and open orbits-Fermi surface studies - Cyclotron resonance – anomalous skin effect –de Hass van Alphen effect.</td></tr>
<tr><td>Unit V</td><td colspan="4">PHYSICS OF SEMICONDUCTORS AND SUPERCONDUCTIVITY - Semiconductors – direct and indirect gaps – carrier statistics (intrinsic and extrinsic) – law of mass action– electrical conductivity and its temperature variation - III - V and II – VI compound semiconductors. Superconductivity – critical parameters – anomalous characteristics – isotope effect, Meissner effect – type I and II superconductors - BCS theory (elementary) - Josephson junctions and tunneling – SQUID - High temperature superconductors - applications.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Ali Omar M. (2002). Elementary Solid State Physics. Pearson Education.
Ashcroft N.WandMerminN.D. (2003). Solid State Physics, Cengage Learning.
Dekker A.J. (2008). Solid State Physics. Laxmi Publications.
James D. Patterson andBernad C. Bailey. (2018). Solid State Physics: Introduction to the Theory. Springer.
RogalskiM.S. andPalmer S.B. (2000). Solid State Physics. Gordon Breach Science Publishers.
WahabM.A. (2019). Solid State Physics: Structure and Properties of Materials. Narosa Publishing House Pvt. Ltd.</td></tr>
<tr><td>Outcomes</td><td colspan="4">At the end of the course the students should be able to:
- Make use of fundamental concepts of various crystal systems, types of bonding and calculate the cohesive energy.
- Understand the basics concepts of free electron theory and Boltzmann transport theory.
- To gain knowledge on atomic lattice vibrations, phonon-phonon interactions and Einstein and Debye models.
- The students would have gained knowledge on periodic potentials and Fermi surface studies.
- Would have known the applications and various properties of semiconductors and superconductive materials.</td></tr>
</table>

Course Code **MATERIALS SCIENCE LAB - III AND MINI PROJECT** **LTPC**
00 6 3

A. MATERIALS SCIENCE LABORATORY – III

LIST OF EXPERIMENTS
Any Ten experiments

1. Density measurements – organic materials and polymers.
2. NDT – Ultrasonic flaw detector.
3. TGA – Measurement and interpretation of results.
4. Faraday effect.
5. X-ray powder method – indexing, cell determination and identification of unknown elements.

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6. Charge density, atomic scattering factor calculations.
7. Kerr effect.
8. Laser coherence, divergence measurement.
9. Optical Fibre – Measurement of numerical aperture and bending loss.
10. Optical absorption – spectrophotometer.
11. Identification of phases using metallurgical microscope.
12. Preparation of buffer solutions and pH measurements.
13. Laser Raman - sample preparation, recording and analysis.
14. FTIR studies - sample preparation, recording and analysis.
15. Etch pattern of single crystals.
16. MATLAB/SCILAB/MATERIALS STUDIO – simple programs and plots.
17. Synthesis of Nanomaterials.

B. MINI PROJECT

TOTAL: 45+45 = 90 PERIODS

<table>
<tr><td colspan="5">IV Semester</td></tr>
<tr><td>Course code</td><td></td><td>MOLECULAR SPCTROSCOPY</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">• To impart understanding on the fundamental thoughts of Atomic and Molecular Spectroscopy in physics to the students.</td></tr>
<tr><td>Unit -I</td><td colspan="4">SYMMETRY ASPECTS OF MOLECULAR ORBITALS -Valence bond theory – Molecular orbital theory- Heitler London theory for Hydrogen molecule - Hybridization – SP – SP^2&SP^3 Hybrids.</td></tr>
<tr><td>Unit-II</td><td colspan="4">ROTATIONAL SPECTRA - Rotational energy of a diatomic molecule – Rigid and non-rigid rotators – isotopic substitution – Stark effect – its importance in microwave spectroscopy – quadrupole hyperfine interaction - Rotational spectra of polyatomic molecules – pure rotational Raman spectra – diatomic linear molecule – symmetric top molecules- Molecular structure – using IR & Raman spectroscopy.</td></tr>
<tr><td>Unit III</td><td colspan="4">VIBRATIONAL PROPERTIES- Vibrational spectra of diatomic and polyatomic molecules – Information on molecular constitution from IR studies – Vibrational Raman spectra – Vibrational course structure – Rotational course spectra – Franck – Condon principle – intensity distribution – portrait parabolae – disassociation – pre-disassociation – mutual exclusion principle.</td></tr>
<tr><td>Unit IV</td><td colspan="4">NON LINEAR SPECTROSCOPIC PHENOMINANon-linear Raman Phenomena-Hyper Raman effect- Classical treatment –Experimental techniques- Stimulated Raman Scattering –Inverse Raman Effect-Coherent Anti-Stoke’s Raman Scattering-Photo acoustic Raman Scattering-Multi photon spectroscopy-two photon absorption-Multiphoton absorption. X-ray spectra; rotational and vibrational spectra of diatomic molecules.</td></tr>
<tr><td>Unit V</td><td colspan="4">RESONANCE SPECTROSCOPY - Interaction between spin and magnetic field – Nuclear resonance – Bloch equations - Chemical shift – Dipole –Dipole interaction and spin lattice interaction – Mossbauer –ESR-NQR (principle only) spectroscopy and its application – Mossbauer spectroscopy - applications – Electronic structure – molecular structure – crystal symmetry and molecular structures.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
AruldhassG. (2001). Molecular structure and spectroscopy. Prentice Hall of India, New Delhi.
Colin N Banwell. (2019). Fundamentals of Molecular Spectroscopy, McGraw Hill.
DograS.K. (2015).Atomic and Molecular Spectroscopy. Pearson Publications.
Mchale, Jeanne L. (2008).Molecular Spectroscopy. Pearson Publications.
Mool ChandGuptha. (2001).Atomic and Molecular Spectroscopy. New age International Publishers, New Delhi,
Sindhu P.S. (2010).Elements of Molecular Spectroscopy. New Age International.
Willard et al. (2005). Instrumental methods of analysis. CBS publishers.</td></tr>
<tr><td>Outcomes</td><td colspan="4">• Appreciate the principles of spectroscopy in the different regions of the electromagnetic spectrum.
• Apply the concepts of group theory to molecular vibrations.
• Relate the theory of spectroscopy to the study of molecular structure.</td></tr>
</table>

ELECTIVE PAPERS

I Semester				
Course code		**BIOMATERIALS**	**Credits: 3**	**Hours: 3**
Objectives	To introduce the response of biomaterials to host environment, and host response to biomaterials. To introduce various materials used in bone and joint replacement. To gain knowledge about materials used in cardiovascular implants. To know about dental materials and dental implants. To impart knowledge on soft tissue and drug delivery materials.			
Unit -I	**BIOLOGICAL PERFORMANCE OF MATERIALS -**Biocompatibility- introduction to the biological environment – material response: swelling andleaching, corrosion and dissolution, deformation and failure, friction and wear – host response: the inflammatory process - coagulation and hemolysis- approaches to thrombo- resistant materials development.			
Unit-II	**ORTHOPAEDIC MATERIALS -** Bone composition and properties - temporary fixation devices - joint replacement – biomaterials used in bone and joint replacement: metals and alloys – stainless steel, cobalt based alloys, titanium based materials – ceramics: carbon, alumina, zirconia, bioactive calcium phosphates, bioglassand glass ceramics – polymers: PMMA, UHMWPE/HDPE, PTFE – bone cement – composites.			
Unit III	**CARDIO VASCULAR MATERIALS**- Blood clotting – blood rheology – blood vessels – the heart – aorta and valves – geometry of blood circulation – the lungs - vascular implants: vascular graft, cardiac valve prostheses, cardiac pacemakers – blood substitutes – extracorporeal blood circulation devices.			
Unit IV	**DENTAL MATERIALS**- Teeth composition and mechanical properties – impression materials – bases, liners and varnishes for cavities – fillings and restoration materials – materials for oral and maxillofacial surgery – dental cements and dental amalgams – dental adhesives.			
Unit V	**SOFT TISSUE MATERIALS -** Biomaterials in ophthalmology – viscoelastic solutions, contact lenses, intraocular lens materials – tissue grafts – skin grafts – connective tissue grafts - suture materials – tissue adhesives – drug delivery: methods and materials – selection, performance and adhesion of polymeric encapsulants for implantable sensors.			
Reference and Text Books: - Black J. (1992). *Biological Performance of Materials: Fundamentals of Biocompatibility*. Marcel Dekker Inc, New York. Chen Q.andThouasG. (2015). *Biomaterials. A Basic Introduction*. CRC Press. ParkJ.&LakesR.S. (2010).*Biomaterials: An Introduction*. Springer. RatnerB.D, Hoffman A.S, SchoenF.J.&LemonsJ.E. (2004). *Biomaterials Science: An Introductionto Materials in Medicine*. Academic Press. Sujata V. Bhat. (2019). *Biomaterials*. Springer. WilliamsD.F. (editor). (1992).*Materials Science and Technology: A Comprehensive treatment*, Volume 14. Medical and Dental Materials. VCH Publishers Inc, New York.				
Outcomes	After completion of this course, the students should able to Understand the response of biomaterials to host environment, and host response to biomaterials. Know and prepare various materials used in bone and joint replacement. Gain knowledge on materials used in synthetic blood vessels, pacemakers and in other cardiovascular implants. To prepare impression materials and dental cements, and know about dental implants. To gain knowledge on soft tissue replacement and drug delivery materials.			

I Semester				
Course code		**MOLECULAR ELECTRONICS**	**Credits: 3**	**Hours: 3**
Objective	• To provide basics of the role of molecules in electronics industry.			
Unit -I	**INTRODUCTION TO NANOTECHNOLOGY -**Background to nanotechnology: periodic table – atomic structure – molecules and phases – energy – molecular and atomic size – surface and dimensional space – Nanaomaterials-top down and bottom up approaches.			
Unit-II	**CARBON NANOSTRUCTURES -** Fullerenes – CNTs-types of nanotubes – formation of nanotubes – assemblies – purification of carbon nanotubes – electronic properties – synthesis of carbon nanotubes – carbon nanotube interconnects – carbon nanotube FETs – CNTs for memory applications.			
Unit III	**NANOELECTRONIC DEVICES-FUNDAMENTALS** - Electrodes & contacts – functions – molecular electronic devices – first test systems – simulation and circuit design – fabrication; Future applications: MEMS – robots – random access memory – mass storage devices.			
Unit IV	**MOLECULAR COMPUTERS** - Molecular wires and switches. Biomolecular computer, molecular arrays as memory stores, DNA for molecular devices - DNA's ability to conduct electrical currents. Charge transfer rates in solution - molecules between nanofabricated electrodes.			
Unit V	**FLEXIBLE ELECTRONIC DEVICES -** Electroactive organic molecules, Plastic Electronics, Electrical conduction in ploymers, Donor molecules, Acceptor molecules, Optoelectronic devices: OLEDs, OTFTs.			

Reference and Text Books: -

Aswal D.K., Yakhmi J.V. (2010). *Molecular and Organic Electronics Devices (Electrical Engineering Developments) Ed*. Nova Science Pub Inc; 1 edition.

Geoffrey J, Ashwell. (1992). *Molecular Electronics*, Ed., John Wiley & Sons Inc.

James M Tour. *Molecular Electronics; Commercial Insights, Chemistry, Devices, Architecture and Programming*: (Rice University, USA), ISBN: 978-981-238-269.

Juan Carlos Cuevas and Elke Scheer. (2010). *Molecular Electronics: An Introduction to Theory and Experiment (Nanotechnology and Nanoscience) (World Scientific Series in Nanotechnology and Nanoscience)*. World Scientific Publishing Company; 1st Edition.

Michael C. Petty. *Molecular Electronics: From Principles to Practice (Wiley Series in Materials for Electronic & Optoelectronic Applications).*

Michael Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons andBurkhardRaguse.(2002). *Nanotechnology: Basic Science and Emerging Technologies*, Chapman & Hall CRC.

Pradeep T. (2007). *NANO: The Essentials – Understanding Nanoscience and Nanotechnology*.

Rainer Waser (Ed.), (2003). *Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices*, Wiley-VCH.

Outcomes	On successful completion of the course, a student will be able to • Understand the molecular nanotechnology and its applications in electronic devices. • Realize the importance of carbon nanotubes and their utility as molecular electronic devices**.**

I Semester				
Course code		**NON-DESTRUCTIVE TESTING**	**Credits: 3**	**Hours: 3**
Objectives	To introduce the students to liquid penetrant and magnetic particle inspection. To make the students understand the principle, working and uses of radiographic testing. To impart knowledge about the ultrasonic testing. To make the students understand the principle, working and application of eddy current technique. To expose the thermal and optical methods used in NDT.			
Unit -I	**INTRODUCTION AND SURFACE NDT METHODS -**Definition of terms, discontinuities and defects/flaws – fracture mechanics concept of design and the role of NDT – life extension and life prediction – penetrant testing and magnetic particle testing, basic principle of penetrant testing – limitations and advantages – basic principle involved in magnetic particle testing – development and detection of large flux – longitudinal and circular magnetization – demagnetization.			
Unit-II	**RADIOGRAPHIC TESTING -** Properties of X-rays and gamma rays – attenuation and differential attenuation – interaction of radiation with matter – Principle of radiographic testing and recording medium – films and fluorescent screens – nonimaging detectors – film radiography – calculation of exposure for X-ray and gamma rays – quality factors – Image quality indications and their use in radiography – neutron radiography.			
Unit III	**ULTRASONIC TESTING** - Ultrasonic waves – velocity, period, frequency and wavelength – reflection and transmission – near and far field effects and attenuation – generation – piezoelectric andmagnetostriction methods – normal and angle probes – methods of Ultrasonic testing – Principle of pulse echo method – Equipment – examples – rail road inspection, wall thickness measurement – range and choice of frequency.			
Unit IV	**EDDY CURRENT TESTING** - Introduction – Principles of eddy current inspection – conductivity of a material – magnetic properties – coil impedance – lift off factor and edge effects – skin effect – inspection frequency – coil arrangements – inspection probes – types of circuit – Reference pieces – phase analysis – display methods – typical applications of eddy current techniques.			
Unit V	**THERMAL AND OPTICAL METHODS-** Imaging – principle and applications – testing of composites – acoustic emission testing – application of AET – on-line monitoring or continuous surveillance and applications in materials science – Optical methods of NDT – photo elasticity – evaluation procedure – Holographic NDT procedure – speckle phenomenon – speckle interferometry – speckle shear interferometry – Fourier optics – Fourier filtering techniques for non-destructive testing.			
Reference and Text Books: - Dainty J.C. (1984). *Laser Speckle & Related Phenomena*, Springer-Verlag, New York. Hull B.andJohn V. (2012). *Non-Destructive Testing*. Springer-Verlag New York Inc. McGonnagleW.J. (1961). *Non-Destructive Testing Methods*, Mc Graw Hill Co., NY. *Metals Hand Book*, Vol.2, 8th Edition, ASTM, Metals Park, Ohio.				
Outcomes	The students will learn about liquid penetrant and magnetic particle inspection. The students will understand the principle, working and uses of radiographic testing. The students will gain knowledge on ultrasonic testing. The students will be able to apply their knowledge on eddy current technique. The students would be able to analyse the thermal and optical methods used in NDT.			

<table>
<tr><td colspan="5">I Semester</td></tr>
<tr><td>Course code</td><td></td><td>NONLINEAR OPTICS AND MATERIALS</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">□ To introduces the concepts of electromagnetic theory and refractive index of materials.
□ To expose the students the concept of optical susceptibility.
□ To make the students to understanding the concept of second order non linearity.
□ To introduce the processes of third order nonlinear optical effects.
□ To make the students to understand the properties of non-linear optical materials.</td></tr>
<tr><td>Unit -I</td><td colspan="4">ELECTROMAGNETIC THEORY -Maxwell equations – wave equations in various media and its propagation – origin of complex refractive index – classical theory of optical absorption (electron oscillator model) and dispersion (Lorenz oscillator model) – classical theory ofanharmonic oscillators.</td></tr>
<tr><td>Unit-II</td><td colspan="4">OPTICAL SUSCEPTIBILITIES - Wave equation description of nonlinear optical susceptibilities – quantum mechanical treatment of nonlinear optical susceptibilities – frequency and intensity dependence of polarization – and dielectric susceptibility – first and higher order susceptibilities.</td></tr>
<tr><td>Unit III</td><td colspan="4">SECOND-ORDER NONLINEARITIES - Second harmonic generation – sum and difference frequency generation – parametric processes – simple theory and calculations of nonlinear polarization – various phase matching techniques in second harmonic generation (SHG).</td></tr>
<tr><td>Unit IV</td><td colspan="4">THIRD-ORDER NONLINEARITIES - Third harmonic generation – four-wave mixing – Kerr nonlinearity – intensity dependent effect – self-phase modulation – cross-phase modulation. Stimulated Raman scattering – stimulated Brillioun scattering. Parametric gain – parametric amplification and oscillation -. Applications of frequency mixing and up-conversion – difference frequency generation – optical phase conjugation: theory and applications – Photorefractive effect and applications – solitons: theory and applications – optical bistability.</td></tr>
<tr><td>Unit V</td><td colspan="4">NONLINEAR OPTICAL MATERIALS - Nonlinear optics of organic materials and polymers – liquid crystals – photorefractive materials – organic doped glasses – rare earth doped glasses and crystals – semiconductors – optical fibers and photonic crystal fibers – ferroelectric materials and other novel optical materials.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Bloembergen N. (2005). Nonlinear Optics. World Scientific, Singapore.
LaudB.B. (2011). Lasers and Non-linear Optics. New Age International Pvt. Ltd.
MurtiY.V.G.S. andVijayanC. (2014). Essentials of Nonlinear Optics. Wiley.
Robert W.Boyd. (2009). Nonlinear Optics. Academic Press, London.
Shen Y.R. (2003). Principles of Nonlinear optics. Wiley-Interscience, New York.
Singh N.B. (1990). Growth and characterization of nonlinear optical materials. Pergamon Press.</td></tr>
<tr><td>Outcomes</td><td colspan="4">After the completion of the course the students able to
□ Understand the concept of electromagnetic theory.
□ Appreciate the importance of optical susceptibility.
□ Reveal the origin of second harmonic generation and other second nonlinear optical processes.
□ Understand the important third order optical nonlinearities.
□ Gain knowledge on the properties of non-linear optical materials.</td></tr>
</table>

<table>
<tr><th colspan="5">I Semester</th></tr>
<tr><th>Course code</th><td></td><th>LASERS AND APPLICATIONS</th><th>Credits: 3</th><th>Hours: 3</th></tr>
<tr><th>Objectives</th><td colspan="4">To introduce knowledge on basics of lasers and its application
• To make the students understand about theoretical studies on laser systems.
• To impact the basic knowledge on laser system compound.
• To introduce the knowledge about various laser systems.
• The students will be able to know about laser system used for materials processing.
• To impact knowledge on the laser applications.</td></tr>
<tr><th>Unit -I</th><td colspan="4">PRINCIPLES OF LASERS-Spontaneous emission, Stimulated emission, Einstein coefficients, ratio of rates of stimulated and spontaneous emission – Threshold condition for laser action – Rate equations – Population inversion in three level and four level systems.</td></tr>
<tr><th>Unit-II</th><td colspan="4">OPTICAL RESONATORS- Resonant cavities, Gaussian beam characteristics, resonator modes, spot size – Types of resonators, geometries, quality factor of an optical resonator – Q-switching andModelocking concepts and techniques.</td></tr>
<tr><th>Unit III</th><td colspan="4">LASER SYSTEMS- Gas lasers: He-Ne laser, Carbon dioxide gas laser, Nitrogen gas laser, Argon ion gas laser – Solid state lasers: Ruby laser, Nd-YAG laser, fiber laser, Ti-Sapphire - Semiconductor Laser – homojunctionand heterojunction laser - Liquid Lasers: Dye lasers.</td></tr>
<tr><th>Unit IV</th><td colspan="4">MATERIALS PROCESSING- Laser power density – heat affected zone - Welding - Fusion depth and welding geometry - Welding speeds - Advantages and uses of laser welding - Drilling hole geometry - Advantages and uses of laser drilling - resistor trimming - Capacitor height adjustment and fabrication, Scribing - Controlled fracturing.</td></tr>
<tr><th>Unit V</th><td colspan="4">APPLICATIONSMetrology - interferrometric techniques - Laser ranging and tracking - Laser Doppler velocimetry - Ring laser and rotation sensing - Pollution monitoring - Holography and speckle in displacement and deformation measurements – ions – Medical applications.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
CharchanS.S. (1975). Lasers in Industry. Van Nostrand Reinhold Co.
Laud B.B. (2011). Lasers and Non-Linear Optics. New Age International (P) Ltd.
Shea D.C.O, Callen W.RandRhodes W.T. (1977). An Introduction to Lasers and their Applications. Pearson.
Steen William M. (2010). Laser Material Processing. Springer.
VerdeyenJ.T.(1990).Laser Electronics. Prentice Hall.</td></tr>
<tr><th>Outcomes</th><td colspan="4">After the completion of course, the students should be able to
• Understood the principle involved in Einstein coefficient and laser action.
• Gained knowledge on laser compound and Q switching mode focusing concepts.
• Understand the basic knowledge about various laser systems working methods.
• The students have gained knowledge on various laser processing methods and advantages.
• The students would have known the laser applications on industrial and medical fields.</td></tr>
</table>

<table>
<tr><th colspan="5">I Semester</th></tr>
<tr><th>Course code</th><th></th><th>PYTHON PROGRAMMING</th><th>Credits: 3</th><th>Hours: 3</th></tr>
<tr><td>Objectives</td><td colspan="4">• To introduce the concepts of algorithms and developing them.
• To make the students to understand different types ofdata,expressionsand statements in Python environment.
• To elucidate the aspects of control flow and functions in Python environment.
• To introduce the concepts of lists, tuples and dictionaries in Python environment.
• To make the students to use files, modules and packages.</td></tr>
<tr><td>Unit -I</td><td colspan="4">ALGORITHMIC PROBLEM SOLVING -Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion) . Illustrative problems: find minimum in a list, insert a card in a list of sorted cards, guess an integer number in a range, Towers of Hanoi.</td></tr>
<tr><td>Unit-II</td><td colspan="4">DATA, EXPRESSIONS, STATEMENTS - Python interpreter and interactive mode; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; modules and functions, function definition and use, flow of execution, parameters and arguments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.</td></tr>
<tr><td>Unit III</td><td colspan="4">CONTROL FLOW, FUNCTIONS – Conditionals: Boolean valuesand operators, conditional (if), alternative(if-else), chainedconditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.</td></tr>
<tr><td>Unit IV</td><td colspan="4">LISTS, TUPLES, DICTIONARIES - Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: selection sort, insertion sort, mergesort, histogram.</td></tr>
<tr><td>Unit V</td><td colspan="4">FILES, MODULES, PACKAGES -Files and exception: text files, reading and writing files, format operator; command line arguments,errorsand exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Eric Matthes. (2015). Python Crash Course. No Starch Press.
Kenneth Lambert. (2012). Fundamentals of Python: First Programms. Cengage Learning.
Mark Lutz. (2013). Learning Python. O’Reilly Media.
Nageswara RaoR. (2019). Core Python Programming. Dreamtech Press.
Yuxi Liu.(2017).Python Machine Learning by Example. Packt Publishing Ltd.</td></tr>
<tr><td>Outcomes</td><td colspan="4">After completing this course, the students should able to
• Develop algorithms.
• Understand different types ofdata,expressionsand statements in Python environment.
• Make use of control flow and functions in Python environment.
• Use lists, tuples and dictionaries in Python environment.
• Use files, modules and packages Python programming environment.</td></tr>
</table>

II Semester				
Course code		**SEMICONDUCTOR MATERIALS AND DEVICES**	**Credits: 3**	**Hours: 3**

Objectives	• To introduce the basic aspects of electronic energy band structures. • To make the students to understand optical properties of materials. • To aid the students to understand transport properties of charges in materials. • To expose the students on the aspects of fabrication of semiconductor devices. • To make the students to understand fabrication of optoelectronic devices.
Unit -I	**INTRODUCTION -**Introduction: Properties of semiconductors –Freeelectron Theory - Transport properties. Bonds andBandsinSemiconductor: -Electronicband structure - Junction Properties of semiconductors- Recombination mechanism - Electron, Hole recombination through traps - Junction properties of p-n, n+-n, p+-p junctions - Surface recombination - Recombination withdonorsand acceptors at lowtemperatures - Quantum theory of junction devices - Generation ofrecombination processes injunctiondevices.
Unit-II	**OPTICAL PROPERTIES -** Optical properties of semiconductors - Optical constants - Light absorption spectrum – Light absorption edge - Effect of free charge carriers on the absorption edge - Fundamentals ofabsorption and reflection- Electron transport phenomena: Theory of electron transport in crystalline semiconductors - Boltzmann's transport equation for Bloch states - relaxation time - relaxation time approximation to the low field transport coefficients - scattering mechanism.
Unit III	**TRANSPORT PROPERTIES –** Basic Process in Semiconductor Devices: Equilibrium properties - electrons and holes – impurities in semiconductors - carrier concentration as a function of temperature - High doping effects - Non-equilibrium phenomena - carrier transport - Transport properties in high fields – recombination and generation processes - breakdown mechanism – Basic equations for Semiconductor devices - equations for the interior of devices – boundary conditions – Systems.
Unit IV	**FABRICATION OF TRANSISTORS AND THYRISTORS** - Unipolar devices: Metal-Semiconductor contacts - Energy - Band Relation - Schottky Effect - Characterization of Barrier Height - Device Structure - Ohmic Contact - JFET and MESFET - basic device characteristic - general characteristic - MOSFET - basic device characteristic - MOSFET Structures - Nonvolatile memory devices. Bipolar transistor - Static characteristics - power transistor - switching transistor – Thyristors - basic characteristics - Schottky diode - Three terminal thyristor.
Unit V	**FABRICATION OF LED'S AND SENSORS -**Photonic Devices: Light Emitting diodes - LED for fiber optics - LED performance - reliability - Photodetectors - Photoconductor - Photodiode - Avalanche Photodiode - Phototransistor - Solar cells - Thin film solar cells - solid state sensors, optical Sensors - optoelectronic components.

Reference and Text Books: -

Butcher P.N, MarchN.H. andTosi M.P. (2014). *Crystalline Semiconducting Materials and Devices*. Springer.

Fraser D.A. (1986). *The Physics of Semiconductor devices*. Clarendon Press, Oxford.

Keller S.P. (1980). *Handbook on Semiconductors*, Vol. 1-4. T.S. Moss, Ed., North-Holland, Amsterdam.

Sze S.M.andNg K.K. (2008). *Physics of Semiconductor devices*. Wiley India, New Delhi.

Schroder D.K. (1990). *Semiconductor Material and Device Characterization*. JohnWiley& Sons Inc., New York.

Wolfe C.M,Holonyak J.R.NandStillman G.E. (1989).*Physical Properties of Semiconductors*. Prentice Hall International Inc., London.

Outcomes	After the completion of the course the students able to • Gain knowledge on energy band structures. • Understand the optical properties of materials. • Understand the transport materials in properties. • Gain knowledge on fabrication of semiconductor devices. • Understand different fabrication steps involved in optoelectronic devices.

<table>
<tr><td colspan="5">II Semester</td></tr>
<tr><td>Course code</td><td></td><td>ADVANCES IN CRYSTAL GROWTH</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">To introduce the concepts of nucleation and types of nucleation.
To explain about the theories related to crystal growth.
To expose the various methods of melt growth.
To impact knowledge on the growth of crystals by solution growth.
To make the students understand various methods of growing crystals from vapor phase.</td></tr>
<tr><td>Unit -I</td><td colspan="4">NUCLEATION -Nucleation concept – Homogeneous, heterogeneous nucleation – classical theory – Energy of formation of nucleus – kinetic theory of nucleation – statistical theory of nucleation – nucleation rate – induction period.</td></tr>
<tr><td>Unit-II</td><td colspan="4">THEORIES OF CRYSTAL GROWTH - Two dimensional nucleation theory – Temkins model of crystal growth – limitations ofTemkins model – BCF surface diffusion theory – solution of BCF surface diffusion equation. Atmospheric nucleation.</td></tr>
<tr><td>Unit III</td><td colspan="4">MELT GROWTH – Temperature measurement and control – Starting materials and purification – conservative and non-conservative process – Bridgman method – Czochralski method – Verneuil method – Zone melting – Fluid flow analysis in melt growth – theory and experiment.</td></tr>
<tr><td>Unit IV</td><td colspan="4">SOLUTION GROWTH - Measurement of supersaturation – Low temperature solution growth – High temperature solution growth – Accelerated crucible rotation technique (ACRT) – Electrocrystallization – Crystal growth in gel – Growth of biological crystals – Hydrothermal technique – Sol-gel growth</td></tr>
<tr><td>Unit V</td><td colspan="4">VAPOUR GROWTH -Physical vapour transport –chemical vapor transport. Epitaxial growth techniques – Liquid phase epitaxy - vapour phase epitaxy: chloride, hydride, metalorganic - molecular beam epitaxy - chemical beam epitaxy.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Bhat H.L. (2019). Introduction to crystal growth. Tailor and Francis.
Brice J.C. (1986). Crystal Growth Processes. John Wiley and sons, New York.
Dryburgh P.M, Cockayane Band BarracloughK.G. (1986). Advance Crystal Growth. Prentice Hall, London.
OharaM. and ReidR.C. (1973). Modelling Crystal Growth Rates from Solution.
PamplinB.R. (1975). Crystal Growth. Pergamon press, London.
ZxettlemoyerA.C. (1969). Nucleation. Marcel-Dekker Publishers.</td></tr>
<tr><td>Outcomes</td><td colspan="4">The students will understand the concepts of nucleation and types of nucleation.
The students would have learnt the theories related to crystal growth.
Students would have known the various methods of melt growth.
Students would have gained knowledge on solution growth.
Students would have gained knowledge on growth of crystals from vapour phase.</td></tr>
</table>

II Semester				
Course code		**MATERIALS PROCESSING**	**Credits: 3**	**Hours: 3**
Objectives	- To understand the basics of manufacturing processes. - To impart the knowledge about surface treatment processes. - Teaching the students about various processes of welding. - To teach the students about mechanical working of metals. - To understand the knowledge about powder metallurgical processes.			
Unit -I	**BASIC MANUFACTURING PROCESSES -**Fundamental analysis of Manufacturing processes, casting, casting processes, forging, methods of forging, extrusion, rolling, spinning, turning, planingand shaping, milling, grinding.			
Unit-II	**SURFACE TREATMENT PROCESSES -** Necessity for surface modification, surface cladding, surface alloying, hard facing, shock hardening, conventional methods, carburising, nitriding, cyaniding, advantages of laser surface treatment over conventional methods, typical laser variables used in surface alloying, laser cladding, experimental set up.			
Unit III	**WELDING PROCESSES –** Various processes of welding, fusion welding, pressure welding, oxyacetelene welding, resistance welding, spot welding, thermit welding, hermetic welding, projection welding, seam welding, butt welding, thermal effects of welding, effects on grain size and microstructure, internal stresses effect, corrosion effect, high energy beam welding, laser beam and electron beam welding, key hole effect.			
Unit IV	**MECHANICAL WORKING OF METALS** - Hot working, cold working, normalising, full annealing, tempering, theory of tempering, effect of tempering temperature on mechanical properties of carbon steels, different tempering process, deformation of metals, elastic deformation, plastic deformation, slip, twinning – assessment of processed materials.			
Unit V	**POWDER METALLURGICAL PROCESS -**Production of powders, powder mixing, compacting, types of presses, sintering, soaking, finishingprocess, limitations and advantages of powder metallurgy, applications , production of cemented carbide cutting tools, self lubricating bearings, magnets, cermets, ultrasonic ceramic transducers.			
Reference and Text Books: - Gupta R.B. (1995). *Materials Science and Processes*. Satya Prakashan, New Delhi. MuralidharaM.K. (1998). *Materials Science and Processes*. Dhanpat Rai Publishing Co., New Delhi. Rajan T.V, Sharma C.Pand Sharma A.(2010). *Heat Treatment: Principles and Techniques*. Prentice Hall India Learning Private Limited. Rykalin, Uglov A, Kokona, (1987). *A Laser and Electron beam material processing hand book*, MIR Publishers.				
Outcomes	- The students will gain the knowledge about the basics of various manufacturing processes. - The students will learn the various surface treatment processes. - The students will understand the different welding techniques. - The students will have better knowledge with mechanical working of metals. - The students will get clear understanding of powder metallurgical process.			

<table>
<tr><td colspan="5">II Semester</td></tr>
<tr><td>Course code</td><td></td><td>NANOELECTRONICS AND PHOTONICS</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">To expose the students to the introductory concepts of nanoelectronics andnanophotonics.
To explain the electron transport in semiconductors &nanostructures.
To make the students recognize the concept ofelectro migration.
To make the students acquire the knowledge in the theory of low-dimensional structures andnanodevices science ofmolecular electronic devices.
To accomplish nanophotonicsand basic properties of electromagnetic effects in periodic media.</td></tr>
<tr><td>Unit -I</td><td colspan="4">MATERIALS FOR NANOELECTRONICS -Introduction – semiconductors – crystal lattices: bonding in crystals – electron energy bands –semiconductor heterostructures – organic semiconductors – carbon nanomaterials: graphene, nanotubes, and fullerenes.</td></tr>
<tr><td>Unit-II</td><td colspan="4">ELECTRON TRANSPORT IN SEMICONDUCTORS & NANOSTRUCTURES - Introduction – time and length scales of the electron in solids – statistics of the electrons in solids and nanostructures – density of states of electrons in nanostructures – electron transport in nanostructures.</td></tr>
<tr><td>Unit III</td><td colspan="4">ELECTROMIGRATION – Introduction – electro-migration (EM) – wire morphology – electron wind – EM induced stress in nanodevice – current-induced heating in nanowire device – diffusion of material – importance of surfaces – failure of wires – wire heating – EM consequences for nanoelectronics.</td></tr>
<tr><td>Unit IV</td><td colspan="4">LOW-DIMENSIONAL STRUCTURES AND NANODEVICES - Introduction – Quantum confinement: Quantum wells, wires and dots – Uses of quantum structures– band gap of nanomaterials. Tunneling – Single electron phenomena: Coulomb blockade – uncertainty - resonant-tunneling diodes – field-effect transistors – single-electron transfer devices. Molecular electronic devices.</td></tr>
<tr><td>Unit V</td><td colspan="4">NANOPHOTONICS -Light-matter interaction: Review of Maxwell’s equations – dispersion in materials – optical properties of insulators, semiconductors and metals – electromagnetic properties of molecules, microscopic and nano particles – photonic crystals: introduction – basic properties of electromagnetic effects in periodic media – photonic crystal waveguides – photonic devices.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
DurkanC. (2007). Current at the Nanoscale. Imperial College Press, London.
Hanson G.W. (2009). Fundamentals of Nanoelectronics. Pearson, New Delhi.
Mitin V.V,Kochelap V. A. andStroscio M.A. (2008). Introduction to Nanoelectronics. Cambridge University Press.
Rogers B,Pennathur Sand AdamsJ. (2008). Nanotechnology: Understanding small systems. CRC Press, Boca Raton.
SupriyoDatta. (2005). Quantum Transport: Atom to transistor. Cambridge University Press, Cambridge.</td></tr>
<tr><td>Outcomes</td><td colspan="4">Utilize the ideas with materials for nanoelectronics carbon nanomaterials: graphene, nanotubes, and fullerenes.
Gain knowledge on the density of states of electrons in nanostructures and electron transport in nanostructures.
Apply ideas ofelectromigration consequences for nanoelectronics.
Design the Molecular electronic devices.
The students will gain knowledge on the basics of nanoelectronics, nanoelectronic devices andnanophotonics.</td></tr>
</table>

II Semester				
Course code		**CORROSION SCIENCE AND ENGINEERING**	**Credits: 3**	**Hours: 3**
Objectives	To introduce the students to corrosion process and corrosion control. To make the students understand the methods used for testing corrosion. To introduce the different methods used for coating. To impart knowledge on various types of corrosion with respect to corrosion. To expose the students to various application of coating.			
Unit -I	**CORROSION PROCESSES -**Basic principles of electrochemistry and aqueous corrosion processes - Electrochemical Thermodynamics and Electrode Potential - Electrochemical Kinetics of Corrosion Cathodic and anodic behavior - Faraday's Law - Nernst equation; standard potentials Pourbaix diagram - Tafel equations, corrosion rate - Evans diagram - pitting, crevice and exfoliation corrosion; influence of deposits and anaerobic conditions; corrosion control; high temperature oxidation and hot corrosion; corrosion/mechanical property interactions.			
Unit-II	**CORROSION TESTING -** Materials and specimens – surface preparation – measuring and weighing – linear polarization – AC impedance – *in vivo* corrosion – paint tests – seawater tests.			
Unit III	**COATING MANUFACTURE –** Electrodeposition; flame and plasma spraying; thermal, HV of detonation gun, physical vapour deposition; chemical vapour deposition; HIP surface treatments.			
Unit IV	**CORROSION IN SELECTED ENVIRONMENTS** - Atmospheric Corrosion, Corrosion in Automobiles, Corrosion in Soils, Corrosion of Steel inConcrete, Corrosion in Water, Microbiologically Induced Corrosion, Corrosion in the Body, Corrosion in the Petroleum Industry, Corrosion in the Aircraft Industry, Corrosion in the Microelectronics Industry.			
Unit V	**COATING APPLICATIONS -**Abrasive, erosive and sliding wear. The interaction between wear and corrosion. Coating systems for corrosion and wear protection; new coating concepts including multi-layer structures, functionally gradient materials, intermetallic barrier coatings and thermal barrier coatings.			

Reference and Text Books: -

Bockris J.O.M, Conway B.E, Yeager Eand White. (2013). *Electrochemical Materials Science in Comprehensive Treatise of Electrochemistry*, Volume 4. Plenum press.

Denny A.Jones. (2013). *Principles and Prevention of Corrosion*. Pearson.

FontanaM.G. (2017). *Corrosion Engineering*, McGraw Hill Education.

Hutchings Iand Philip Shipwar. (2019). *Tribology: Friction and Wear of Engineering Materials*. Butterworth-Heinemann.

Sprowds D.O.(1986). *Corrosion Testing and Evaluation*. Corrosion Metals Hand book, Vol. 13.

Outcomes	The students would have learnt various corrosion process and corrosion control. The students would have understood the methods used for testing corrosion. They analyze and apply the different methods for coating. The students would have gained knowledge on corrosion type with respect to environment. The students would have learnt about the various concepts and applications of coating.

II Semester				
Course code		**SOLID STATE IONICS**	**Credits: 3**	**Hours: 3**
Objectives	To introduce the basic aspects of solid state physics. To impart knowledge on solid state ionics, hydrogen storage and nano-ionic materials. To introduce the students to micro batteries, fuel cells, super capacitors and their applications. To familiarize the students to various characterization techniques for new cathode materials. To expose the students to the various application of ionic materials.			
Unit -I	**BASIC ASPECTS OF SOLID STATE PHYSICS -**Types of bonding in solids-Fundamentals of Crystallography-Simple Crystal structures-BCC, FCC, HCP - X -ray diffraction-band structures of metals, semiconductors and insulators-Ionicand electronic conductivities.			
Unit-II	**SOLID STATE IONICS -** Concept of solid state ionics- Importance of super-ionic materials and structures -Classification of Superionic solids- crystalline anionic and cationic conductors, mixed ionic and electronic conductors-structural factors responsible for high ionic conductivity - Experimental probes pertaining to solid state ionics-Theoretical models of fast ion transport- Applications of fast ionic solids-Nano-ionic materials.			
Unit III	**MICRO BATTERIES AND APPLICATION –** Concept of a thin film solid state battery- electrolyte thin films - flash evaporation technique - electromotive force - reversible cells-free energy changes-capacity of a cell-power and energy density of a cell-polymer electrolytes-application of polymer electrolytes in micro batteries, Fuel cells-solid state battery-super capacitors.			
Unit IV	**CHARACTERIZATION OF NEW CATHODE MATERIALS** - Phase identification- Thermal analysis-DTA-DSC-TG- Energy dispersive X-ray fluorescence spectroscopy (EDX)-X-ray - X-ray photoelectron spectroscopy (XPS) - Structural characterization – XRD studies -Extended X-ray absorption fine structure - FTIR-Transport measurements.			
Unit V	**APPLICATIONS OF IONIC MATERIALS -**Primary lithium batteries-thermodynamics and mass transport in solid state batteries, battery performance and electrode kinetics-Secondary lithium batteries-Li-ion electrode materials-preparation and fabrication- -characterization of Li-ion cells- Comparison of Li- iodine andNiCd cells in CMOS-RAM applications. Applications of Lithium batteries.			
Reference and Text Books: - ChandraS. (1981). *Superionic Solids-Principles and applications*. North Holland Amsterdam. Clive D.S.Tuck, (1991). *Modern Battery Technology*, Elis Horwood Publishers. Crompton T.R. (2000). *Battery Reference Book*, Newnes. Geoffrey,OzinA.&Andre C Arsenault, (2008).*Nanochemistry: A Chemical Approach to Nanomaterials*, Royal Society of Chemistry. KeerH.V. (2019). *Principles of the Solid State*. New Age International Private Limited.				
Outcomes	The students would have learnt the basic aspects of solid state physics. Gained knowledge on solid state ionics, hydrogen storage. Learnt about microbatteries, fuel cells, super capacitors. Learnt about the various characterization techniques available for cathode materials. The students are familiar with various applications of ionic materials			

III Semester				
Course code		**BIOELECTRONICS**	**Credits: 3**	**Hours: 3**
Objectives	To provide basics ofbioelectronic devices and their applications in various fields.			
Unit -I	**METAL OXIDE SEMICONDUCTOR (MOS) STRUCTURE** -*pn* Junction, *pn*Junction Equilibrium, Effect of the Bias Voltage, Current – Voltage Characteristics of*pn* junction - MOS Structure - Accumulation Operating Mode- Depletion Operating Mode- Inversion Operating Mode, C-V Plots of an MOS Structure.			
Unit-II	**METAL OXIDE SEMICONDUCTOR BASED BIOELECTRONIC DEVICES -** Biosensor overview- Transducers – characteristics - Ion sensitive field effect transistor – enzyme field effect transistor- Cell based biosensors and sensor of cell metabolism – light addressable potentimetric sensors (LAPS).			
Unit III	**MOLECULAR ELECTRONICS –** Molecular wires and switches; molecular arrays as memory stores biomolecular computer, Properties of DNA and its potential applications in molecular electronics.			
Unit IV	**MICROELECTRODES FOR BIOLOGICAL MONITORING** - Electrochemical cells, oxidation reduction reactions – Polarization, polarizable and non-polarizable electrodes, electrode behavior of circuit methods. Body surface recording electrode array, Microelectrodes for electric stimulation of tissues.			
Unit V	**BIOELECTRICITY AND BIOELECTRIC PHENOMENON -**Biology of the Neuron , Biophysical Description of the Action Potential, The Neuron as the threshold device – Synapses, Networks, NeurobioengineeringNeuroelectronic Junctions, Silicon Neurons Neurons - Equivalent Circuit Model for Cell Membrane - Hodgkin & Huxley and Equivalent Circuits.			
Reference and Text Books: -				
Andreas Offenhausserand Ross Rinaldi. (2009). *Nanobioelectronics-for electronics, biology and medicine*. Chad A. Mirkinand Christof Niemeyer M. (2007). *Nanobiotechnology II More Concepts and Applications.* Christ of NiemeyerM and Chad A. Mirkin. (2004). *Nanobiotechnology Concepts, Applications and Perspectives.* David S. Goodsell. (2004). *Bionanotechnology*. Jason J Davis. (2009). *Engineering the bioelectronic interface*. LagothetidisandStergios. (2012). *Nanomedicine andNanobiotechnology*. OdedShoseyov, Ilan Levy. (2008). *Nanobotechnology.*				
Outcomes	On successful completion of the course, a student will be able to - Understanding the electrical conduction in biological materials. - Basic knowledge in semiconductor interfacing with biomolecules towards bioelectronicsdevices. - Understanding the role of organic and biomolecules in developing molecular electronicsFamiliarize with electrodes for monitoring cells and tissues.			

III Semester				
Course code		**CHEMICAL SENSORS**	**Credits: 3**	**Hours: 3**
Objectives	• To provide a solid foundation for students to understand principles and application of modern chemical sensor technology. • To provide the student with the ability to operate with existing sensor systems and transducers, as well as to design new sensors, based on application of "smart materials".			
Unit -I	**GENERAL PRINCIPLES, DEFINITIONS AND CONCEPTS -**Introduction to principles of chemical sensing; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies. Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time; Problems and trade-offs.			
Unit-II	**PHYSICO-CHEMICAL SENSORS ANDTRANSDUCERS -** Thermal sensors; Electrochemical sensors (amperometric, potentiometric, conductimetric); Semiconductor transducers (ISFET, ENFET); Optical transducers (absorption, fluorescence, bio/chemiluminescence, SPR); Piezoelectric and acoustic wave transducers; Limitations & problems to be addressed.			
Unit III	**BIOCHEMICAL SENSORS** – a. Enzymes; Oligonucleotides and Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Limitations & problems. b. Catalytic biosensors: mono-enzyme electrodes; bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes. c. Affinity-based biosensors; Inhibition-based biosensors; Cell-based biosensors; Biochips and biosensor arrays; Problems and limitations.			
Unit IV	**SENSOR ENGINEERING -** Methods for sensors fabrication: self-assembled monolayers, screen printing, photolithography, microcontact printing, MEMS. Engineering concepts for mass production.			
Unit V	**APPLICATION -** Environmental monitoring; Technological process control; Food quality control; Clinical chemistry; Test-strips for glucose monitoring; Implantable sensors for long-term monitoring; Forensic science benefits; Problems & limitations.			

Reference and Text Books: -

AjitSadanaandNeetiSadana, (2011). *Handbook of Biosensors and Biosensor Kinetics*, Elsevier B.V. Amsterdam, The Netherlands. (ISBN: 978-0-444-53262-6)

FriederSchelferAnd Florian Schubert, (1992). *"Biosensors" Techniques And Instrumentation In Analytical Chemistry -Volume 11*, Elsevier Science Publishers B.V. Amsterdam, The Netherlands, (ISBN 0-444-98783-5).

Janata J. (2009). *Principles of Chemical Sensors*. Springer.

Jeong-Yeol Yoon, (2016). *Introduction to Biosensors: From Electric Circuits to Immunosensors*, Springer Int. Publishers (ISBN: 978-3-319-27411-9).

Jonathan M. Cooper and CassA.E.G. (2004). *Biosensors: a practical approach*, Oxford University press. (ISBN 0-19- 9-63846- 2).

Vinod Kumar Khanna, (2011). *Nanosensors: Physical, Chemical, and Biological*, CRC Press. (ISBN: 978-1-439-82712-3).

Outcomes	On successful completion of the course, a student will be able to • Understand the working principles of various sensors. • Develop sensors for clinical, food, environmental applications.

<table>
<tr><th colspan="5">III Semester</th></tr>
<tr><th>Course code</th><th></th><th>THIN FILM SCIENCE AND TECHNOLOGY</th><th>Credits: 3</th><th>Hours: 3</th></tr>
<tr><td>Objectives</td><td colspan="4">• To introduce about mechanical pumps, production of high vacuum and thin film coating unit
• To expose the various methods for preparation of thin films.
• To make the students understand the characterization methods used for thickness measurement.
• To make the students gain knowledge on the nucleation theories and thin film structures.
• To impact knowledge on the various properties of thin films.</td></tr>
<tr><td>Unit -I</td><td colspan="4">GROWTH AND STRUCTURE OF FILMS -Introduction to thin films and applications - General features - Nucleation theories - Post-nucleation growth – Thin film structures- Structural defects.</td></tr>
<tr><td>Unit-II</td><td colspan="4">THICKNESS MEASUREMENT AND MONITORING - Multiple beam interference - quartz crystal - ellipsometric - stylus techniques. Characterization: X-ray diffraction - electron microscopy - high and low energy electron diffraction.</td></tr>
<tr><td>Unit III</td><td colspan="4">PREPARATION METHODS – Physical methods: thermal evaporation - vapour sources - Wire, crucible and electron beam gun - sputtering mechanism and methods - Pulsed laser deposition (PLD), photochemical deposition (PCD) - Chemical methods: chemical vapour deposition and chemical solution deposition techniques - spray pyrolysis - laser ablation.</td></tr>
<tr><td>Unit IV</td><td colspan="4">PROPERTIES OF THIN FILMS - Optical - reflection and anti-reflection coatings - interference filters - thin film solar cells - electrophotography. Electrical and dielectric behaviourof thin films - components - thin film diode and transistor - strain gauges and gas sensors. Anisotropy in magnetic films - domains in films - computer memories - superconducting thin films - SQUID - mechanical properties: testing methods - adhesion - surface andtribological coatings.</td></tr>
<tr><td>Unit V</td><td colspan="4">HIGH VACUUM PRODUCTION- Mechanical pumps - Diffusion pump - measurement of vacuum - gauges - production ofultra high vacuum - thin film vacuum coating unit.</td></tr>
</table>

Reference and Text Books: -

Berry R.W, Hall P.MandHarris M.T. (1968). *Thin Film Technology*. Von Nostrand.
ChopraK.L. (1979). *Thin Film Phenomena*. Krieger Pub Co.
ChopraK.L. andKaur I. (2011). *Thin Film Device Applications*. Springer-Verlag New York Inc.
George Hass. (1963) *Physics of Thin Films: Volumes 1 -12*. Academic Press.
Goswami A.(2017). *Thin films Fundamentals*, New Age International (P) Ltd.
MaisselL.I. andGlangR. (Eds.). (1970). *Handbook of Thin film Technology*. McGraw- Hill.
OhringM. (2001). *Materials Science of Thin Films*. Academic Press.
Smith D. L. (1995). *Thin-Film Deposition: Principles and Practice*. McGraw-Hill.

<table>
<tr><td>Outcomes</td><td>• The students would have gained knowledge on production of high vacuum and thin film coating unit.
• The students would apply the various methods for the preparation of thin films.
• The students know the methods of characterization of thin films and thickness measurement.
• Gained knowledge on nucleation theories and thin film structures.
• Gained knowledge on properties of thin films.</td></tr>
</table>

III Semester				
Course code		**NANOMATERIALS PREPARATION AND CHARACTERIZATION**	**Credits: 3**	**Hours: 3**
Objectives	To introduce the basic aspects of preparation of nanomaterials and their related characterization techniques. To study the synthesis and purification Single walled and Multi walled Nanotubes (SWNT and MWNT). To impart the concepts behind 1 dimensional nanowires and nanofibers. To inculcate characterization of materials with various techniques. To inspire the knowledge ofnanodevices for magnetic storage.			
Unit -I	**BASIC PROPERTIES OF NANOPARTICLES -**Size effect and properties of nanoparticles - particle size - particle shape - melting point, surfacetension, wettability - specific surface area and pore size – Reason for change in optical properties, electrical properties, and mechanical properties – advantages.			
Unit-II	**NANOTUBES -** Single walled and Multi walled Nanotubes (SWNT and MWNT) - synthesis and purification - synthesis of carbon nanotubes by pyrolysis techniques - arc-discharge method – CVD - nanotube properties – Nanowires – methods of preparation of nanowires –VLS mechanism.			
Unit III	**NANOWIRES AND NANOFIBERS** – Semiconductor and oxide nanowires – preparation –solvothermal – electrochemical –PVD –Pulse laser deposition – template method (qualitative)- nanofibers –electro spinning technique.			
Unit IV	**CHARACTERIZATION** - FESEM - near-field Scanning Optical Microscopy - High-resolution Transmission Electron Microscopy (HRTEM)- Absorption and emission spectra – PL spectrum - single nanoparticle characterization –Scanning capacitance microscopy – capillary electrophoresis- laser induced fluorescence (CE-LIF).			
Unit V	**NANODEVICES -** Magnetic storage: - magnetic quantum well; magnetic dots - magnetic date storage - high density quantized magnetic disks - magnetic super lattices – MRAMS - MTJs using nanoscale tunneling junctions - Millipede for storage – nano-material sensors.			

Reference and Text Books: -

EbbesenT.W. (Editor). (1997). *Carbon nanotubes: preparation and properties*. CRC Press, USA.

Edelstein A.S. (Editor). (1996). *Nanomaterials Synthesis, properties and applications*. IOP Publishing, UK.

Hari Singh Nalwa (Editor). (2000). *Hand book of Nanostructured Materials and Technology*, Vol.1-5. Academic Press, USA.

Hari Singh Nalwa (Editor). (2002). *Nanostructured materials and nanotechnology*. Academic Press, USA.

Masuo Hosokawa, Kiyoshi Nogi, Makio Naito andToyokazu Yokoyama. (2007). *Nanoparticle Technology Handbook*. Elsevier Publishers.

Zhon Ling Wang. (2000). *Characterization of nanophase materials*. Wiley-VCH Verlag GmbH.

Outcomes	Familiarize the properties of nanoparticles and its advantages. The students apply ideas on enlightenment of Nanowires. Gain the idea of ID nanostructures. The students will be able to crack its application. The students will understand the principle involved in preparation and characterization of nanostructures and fabrication ofnanodevice.

<table>
<tr><td colspan="5">III Semester</td></tr>
<tr><td>Course code</td><td></td><td>CERAMIC MATERIALS</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">• To expose the students to various processing techniques used for ceramic materials.
• To introduce the students to structural ceramics and familiarize them with their properties.
• To impact knowledge to the students on various electronic ceramics, magnetic ceramics, superconducting materials and fuel cells.
• To introduce the students about various types of refractories.
• To make the students understand about various glass forming processes, types of glass and their applications.</td></tr>
<tr><td>Unit -I</td><td colspan="4">CERAMIC PROCESSING-Powder processing – precipitation, spray drying, freeze drying, sol-gel, CVD – milling techniques – forming – die pressing, slip casting, injection moulding, doctor blade processing – sintering techniques – standard pressure sintering, hot pressing, HIP, reaction bonded sintering, microwave sintering – surface finishing techniques.</td></tr>
<tr><td>Unit-II</td><td colspan="4">STRUCTURAL CERAMICS - Oxide ceramics – zirconia, alumina, silica, mullite, magnesia andtitania – carbides – silicon carbide, boron carbide, tungsten carbide, titanium carbide – nitrides – silicon nitride, boron nitride, titanium nitride, borides, silicides, - sialon – bio ceramics.</td></tr>
<tr><td>Unit III</td><td colspan="4">ELECTRONIC CERAMICS– Ceramic insulators and capacitors – ferroelectric ceramics – barium titanate, PZT, PLZT materials– properties and applications of electronic ceramics - magnetic ceramics – spinel ferrites, zinc ferrites – applications - garnets – superconducting ceramics – varistors – oxides and non-oxide varistorsand fuel cells.</td></tr>
<tr><td>Unit IV</td><td colspan="4">REFRACTORY CERAMICS - Refractories – types of refractories - special refractories - silica, alumina, mullite, zirconia, cordierite - carbide based and nitride based refractories – Fusion cast refractories – ceramic fibers– high temperature applications.</td></tr>
<tr><td>Unit V</td><td colspan="4">GLASS CERAMICS - Glass forming processes – Glass transition – Glass transformation range - Heat treatment schedule, crystal nucleation in glass, nucleation agent – high purity silica glass, laser glasses, fiber glasses, optical glasses and non-oxide glasses.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
CableM. andParker J.M. (1992). High Performance Glasses. Chapman and Hall, London.
Chester J.H. (1992). Refractories, Production and Properties. Iron and Steel Institute, London.
Lewis M.H. (2011). Glasses and Glass Ceramics. Springer.
ReedJ.S. (2008). Principles of Ceramic Processing. Wiley-Interscience.
RichersonD.W.&Lee W.E. (2018). Modern Ceramic Engineering: Properties, Processing and Use in design. CRC Press.</td></tr>
<tr><td>Outcomes</td><td colspan="4">After completing the course, the students
• Will analyze and apply the various processing techniques they have studied.
• Would have gained knowledge on various structural ceramic materials and their applications.
• Would have known the applications of electronic ceramics and magnetic ceramics and also they would know about the functioning ofvaristorsand fuel cells.
• Would have gained knowledge on refractories and their applications.
• Would be familiar with various glass forming methods, types of glasses and their applications.</td></tr>
</table>

<table>
<tr><td colspan="5">III Semester</td></tr>
<tr><td>Course code</td><td></td><td>PHYSICAL METALLURGY</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">• To introduce the concepts of phase diagrams.
• To impact knowledge about iron carbon phase equilibrium diagram and alloys.
• To expose the students to various heat treatment processes those are employed.
• To make the students to understand about various phase transformations.
• To introduce various engineering alloys and their applications.</td></tr>
<tr><td>Unit -I</td><td colspan="4">PHASE DIAGRAMS -Composition and classification of pig iron and cast iron – iron ores - manufacture of wrought iron and steel - The phase rule - Types of Binary Diagrams,– invariant reactions- eutectic, eutectoid, peritecticandperitectoid reactions – Thermodynamics, Solution theory - free energy composition curves – Experimental determination of equilibrium diagram-grain size analysis, grain size measurement - effect of grain size on properties of metals and alloys.</td></tr>
<tr><td>Unit-II</td><td colspan="4">SOLID SOLUTION - Types of solid solution – solid solution factors governing substitutional solubility –Hume-Rothery rules- intermediate phases -solid solution alloys –Vegards law – Lever rule - mechanical mixtures-- Iron-Carbon equilibrium diagram – Aluminum alloys – Copper alloys – Effect of alloying elements.</td></tr>
<tr><td>Unit III</td><td colspan="4">HEAT TREATMENT – Recovery, recrystallisationand grain growth: property changes, annealing twins, textures in cold worked and annealed alloys,-TTT diagrams – CCT diagrams – heat-treatment processes – annealing, normalising, quenching and tempering – baths used in heat treatment – hardenability – Jominy's end quench test – martemperingandaustempering – case hardening – induction, flame, laser - carburising, cyaniding, nitriding, carbo nitriding.</td></tr>
<tr><td>Unit IV</td><td colspan="4">PHASE TRANSFORMATIONS - Types of phase changes – Driving forces, N-G aspects, diffusion in solids – solidification – pearlitic transformations – martensitic transformations – kinetics of transformation - precipitation and age hardening.</td></tr>
<tr><td>Unit V</td><td colspan="4">ENGINEERING ALLOYS - Low carbon steels – mild steels – high strength structural steels – tool materials – stainless steels – super alloys – light alloys – shape memory alloys – applications.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
AvnerS.H. (2019). Introduction to Physical Metallurgy. Mc Graw Hill Education.
GuyA.G. andHrenJ. (1984). Elements of Physical Metallurgy. Oxford Univ. Press.
LakhtinY. (2005). Engineering Physical Metallurgy. CBS Publishers & Distributors.
PolmearI.S. (1995). Light Alloys. Metallurgy and Materials Science.
RaghavanV. (2015). Physical Metallurgy: Principles and Practice. PHI Learning Private Limited, New Delhi.
Robert E.Reed-Hill. (2008). Physical Metallurgy Principles. Affiliated East-West Press.
Smith W.F. (2014). Structural Properties of Engineering Alloys, McGraw Hill Education.</td></tr>
<tr><td>Outcomes</td><td colspan="4">• The students would be able to construct phase diagrams.
• The students would have gained knowledge on Iron-Carbon phase equilibrium diagram.
• Students would be able to apply the various heat treatment processes.
• Students would gain knowledge on phase transformations.
• To analyze the various properties of engineering alloys and apply them.</td></tr>
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<table>
<tr><th colspan="5">III Semester</th></tr>
<tr><td>Course code</td><td></td><td>SUPERCONDUCTING MATERIALS AND APPLICATIONS</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">• To introduce the basic experimental aspects of the superconductivity.
• To know about superconducting materials and its alloys.
• To make the students to understand the experimental studies of superconducting materials.
• To inspire the theoretical aspects of superconductivity.
• To progress the students with various application in superconductivity.</td></tr>
<tr><td>Unit -I</td><td colspan="4">BASIC EXPERIMENTAL ASPECTS -Zero electrical resistance – Meissner effect – a.c. diamagnetic susceptibility – heat capacity – optical absorption by superconductor – entropy change –thermal conductivity – destruction of superconductivity by external magnetic fields – type I and type II materials – superconducting behaviour under high pressures –flux quantisation – normal and Josephson tunneling.</td></tr>
<tr><td>Unit-II</td><td colspan="4">SUPERCONDUCTING MATERIALS - Elemental superconductors –superconducting compounds and its alloys – A-I5 compounds – chevral phase compounds.</td></tr>
<tr><td>Unit III</td><td colspan="4">HIGH TEMPERATURE SUPERCONDUCTORS – La-Ba-Cu-O, Y-Ba-cu-O, Bi-Sr-Ca-Cu-O and new systems and their crystal structures – Experimental studies on the new materials – organic superconductors –fullerenes.</td></tr>
<tr><td>Unit IV</td><td colspan="4">THEORETICAL ASPECTS - Isotope effect – BCS theory – Role of electrons and phonons – applications of electron band structure results to calculate electron-phonon coupling constant McMillan’s formula – GLAG theory– recent theories on high Tc materials, Coherence length, expression for critical temperature Tc, critical field Hc, critical current Jc – heavy fermion superconductivity.</td></tr>
<tr><td>Unit V</td><td colspan="4">APPLICATIONS - Superconducting magnets – power generators, motors, transformers, power storage, power transmission – Josephson junction devices – IR sensors – SQUIDS –SLUGS – magnetically leviated trains – computer storage elements.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Blundell S. (2009). Superconductivity: A Very Short Introduction. Oxford University Press.
KowkH.S. andShawD.T (Eds.). (1988). Superconductivity and its Applications. Elsevier Science Publishing.
NarlikarA.V. (1990). Studies on High temperature superconductors- Advances in research and applications. Nova Scientific, New Delhi.
NarlikarA.V. andEkbote. (1983). Introduction to Superconductivity. South Asia publishers.
Schrieffer J.R. (2009). Theory of Superconductivity, Levant Books.
TilleyD.R. and Tilley. (1986). Superfluidityand Superconductivity. Adam Hilger.
TinkhamM. (2008). Introduction to Superconductivity. CBS Publishers & Distributors, New Delhi.</td></tr>
<tr><td>Outcomes</td><td colspan="4">• The students will understand the basic concepts of superconductivity.
• Gain knowledge in superconducting materials.
• Crack the experimental studies of superconducting materials.
• Apply the theoretical aspects of superconductivity.
• The students will able to understand various technological application of the superconductivity.</td></tr>
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<table>
<tr><th colspan="5">IV Semester</th></tr>
<tr><td>Course code</td><td></td><td>NANO-BIOELECTRONICS</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">□ To provide basic knowledge in the interface between chemistry, physics and biology on the nanostructural level with a focus on biotechnological usage.</td></tr>
<tr><td>Unit -I</td><td colspan="4">INTERPHASE SYSTEMS -Lab-on-a-Chip Devices- Microcontact Printing of Proteins-Protein-based Nanostructures-Genetic Approaches to Programmed Assembly-Nanoscale Magnetic Iron Minerals in Bacteria.</td></tr>
<tr><td>Unit-II</td><td colspan="4">DNA-BASED NANOSTRUCTURES - DNA-templated Electronics-Biomimetic Fabrication of DNA-based Metallic Nanowires and Networks-DNA–Gold-Nanoparticle Conjugates-Nanoparticles as Non-Viral Transfection Agents.</td></tr>
<tr><td>Unit III</td><td colspan="4">SELF ASSEMBLY AND NANOSTRUCTURES – Self-Assembled Artificial Transmembrane Ion Channels: Self-Assembling Nanostructures from Coiled-Coil Peptides-Proteins and Nanoparticles: Covalent and Noncovalent Conjugates-Self-Assembling DNA Nanostructures for Patterned Molecular Assembly.</td></tr>
<tr><td>Unit IV</td><td colspan="4">NANOSTRUCTURES FOR ANALYTICS - Nanoparticles for Electrochemical Bioassays-Luminescent Semiconductor Quantum Dots in Biology-Nanowire and Nanotube based Biomolecular Sensors for In-Vitro Diagnosis of Cancer and other Diseases-Bionanoarrays.</td></tr>
<tr><td>Unit V</td><td colspan="4">NANOSTRUCTURES FOR MEDICINAL APPLICATIONS - Biological Barriers to Nanocarrier-Mediated Delivery of Therapeutic and Imaging Agents-Adapting Emerging Techniques from the Electronics Industry for the Generation of Shape-Specific, Functionalized Carriers for Applications in Nanomedicine-Poly(amidoamine) Dendrimer-Based Multifunctional Nanoparticles.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Chad A. Mirkinand Christof M. Niemeye (2007). Nanobiotechnology II More Concepts and Applications.
Christof M. Niemeyer and Chad A. Mirkin (2004). Nanobiotechnology Concepts, Applications and Perspectives.
David S. Goodsell. (2004). Bionanotechnology.
LagothetidisandStergios (2012). Nanomedicine andNanobiotechnology.
OdedShoseyov, Ilan Levy (2008). Nanobotechnology.</td></tr>
<tr><td>Outcomes</td><td colspan="4">On successful completion of the course, a student will be able to
□ Account for interaction of biomolecules with surfaces of different chemical and physical species.
□ Suggest methods for the design of enzyme reactors and other bioconjugates on surfaces and second carriers, and explain the carrier's influence on the activity of the biomolecule.
□ Analyse applications within the field of bioelectronics and account for the basic principles they are based on.
□ Use basic principles of microfluidics to solve biotechnical and bioanalytical problems</td></tr>
</table>

IV Semester				
Course code		**HIGH PRESSURE SCIENCE AND TECHNOLOGY**	**Credits: 3**	**Hours: 3**
Objectives	▯ To introduce the aspects of High pressure science and the technology. ▯ To expertise the measurements of high pressure. ▯ To familiarize high pressure devices for various properties and applications. ▯ To inspire physical properties of high pressure and spectroscopy studies. ▯ To insight mechanical properties under pressure.			
Unit -I	**METHODS OF PRODUCING HIGH PRESSURE -**Definition of pressure – Hydrostaticity – generation of static pressure, pressure units – piston cylinder – Bridgmann Anvil – Multi-anvil devices – Diamond anvil cell.			
Unit-II	**MEASUREMENT OF HIGH PRESSURE -** Primary gauge – Secondary gauge – Merits and demerits – Thermocouple pressure gauge – Resistance gauge – fixed point pressure scale – Ruby fluorescence – Equation of state.			
Unit III	**HIGH PRESSURE DEVICES FOR VARIOUS APPLICATIONS** – X-Ray diffraction, Neutron diffraction – Optical studies – Electrical studies – Magnetic studies – High and low temperature applications – Ultra high pressure anvil devices.			
Unit IV	**HIGH PRESSURE PHYSICAL PROPERTIES** - PVT Relation in fluids – Compressibility of solids – properties of gases under pressure **-** Melting phenomena – viscosity – thermoemf – thermal conductivity. Electrical conductivity – phase transitions phonons superconductivity – Electronic structure of metals and semiconductors – NMR and magnetic properties. Liquid crystals – spectroscopy studies –Infrared, Raman Optical absorption – EXAFS.			
Unit V	**MECHANICAL PROPERTIES UNDER PRESSURE -** Elastic constants – Measurements – mechanical properties – Tension and compression – Fatigue– Creep – Hydrostatic extrusion. Material synthesis – Superhard materials – Diamond – Oxides and other compounds – water jet.			
Reference and Text Books: - Bridgmann.P.W. (1931). *The Physics of High Pressure*. G. Bell and SONS Ltd., London. Eremets M.I. (1996). *High pressure Experimental methods*. New York. LiH. andPugh D. (1970). *Mechanical Behaviourof Materials under Pressure*. Elsevier Publishing Co., Ltd., New York. VodarB. and Ph. Marteam. (1980). *High Pressure Science and Technology*, Vol.Iand II. Pergamon Press, Oxford.				
Outcomes	▯ Establish the operation of anvil and Multi-anvil devices. ▯ Crack the gauge operations. ▯ Design various anvil device applications. ▯ Apply ideas of Electronic structure of metals and semiconductors. ▯ After completing this course the students will be able to understand the basic concepts of the high pressure and various technological applications of high pressure.			

IV Semester				
Course code		**OPTICAL MATERIALS**	**Credits: 3**	**Hours: 3**

Objectives	• To explain the optical properties of conducting materials. • To make the students to understand the optical properties of semiconductors. • To elucidate the concepts of optical properties in insulating materials. • To elucidate the notion of optical gain the different types of lasers. • To introduce the concept of nonlinear optical processes.
Unit -I	**OPTICAL PROPERTIES OF CONDUCTORS -**Atomistic view: Drude model – plasma frequency – band structure in metals – density of states – coloration in metals – coloration by means of small metal particles – optical properties of superconductors – photoacoustic absorption spectroscopy – differential reflection spectroscopy.
Unit-II	**OPTICAL PROPERTIES OF SEMICONDUCTORS -** Free electron gas – nearly free electron model – band structure – impurity states and lattice imperfections – carrier densities – absorption and photoluminescence – measurements: polarized light, absorption, photoluminescence, differential reflection spectroscopy. Optical materials and properties: Fabrication and growth – color – band gap energies – contact potentials.
Unit III	**OPTICAL PROPERTIES OF INSULATORS** – Propagation of light through insulators – reflection and transmission – optical attenuation – optical scattering – refractometers – thin films – glasses, crystals and birefringence – photochromic and electrochromic behavior – oxides, chalcogenides and halides – optical plastics – sources of color.
Unit IV	**OPTICAL GAIN AND LASERS -** Spontaneous emission – line shapes – stimulated emission and absorption – absorption and amplification – characteristics of lasers – cavity dynamics – laser systems – semiconductor lasers: p-n junctions, homo and hetero junction lasers.
Unit V	**NONLINEAR OPTICAL PROCESSES -** Linear materials – nonlinear processes – second-order optical nonlinearity – second-order susceptibility – materials – second harmonic generation – optical parametric oscillation – third-order susceptibility – materials – photorefraction – z-scan measurement – third harmonic generation.

Reference and Text Books: -

BosshardCh. Sutter K. PretrePh. HulligerJ. FlorsheimerM. KaatzP. and GunterP.(1995).*Organic Nonlinear Optical Materials*. Gordon and Breach Publishers.

Joseph Simmons and Kelly S. Potter. (2000). *Optical Materials*. Academic Press.

Marvin J. Weber. (2003). *Handbook of Optical Materials*. CRC Press.

MusikantS. (1985). *Optical Materials: An introduction to selection and application*. Marcel Dekker Inc.

WakakiM. (2013). *Optical Materials and Applications*. CRC Press.

Outcomes	After completion of this course, the students should able to • Explain the optical properties of conducting materials. • Understand the optical properties of semiconductors. • Understand the optical properties in insulating materials. • Understand the optical gain properties of materials and functioning of different types of lasers. • Explain different nonlinear optical processes.

IV Semester				
Course code		**BIOSENSORS**	**Credits: 3**	**Hours: 3**
Objectives	During this course the learners will be acquiring the following knowledge, skills and competences Knowledge in basic requirements to fabricate a sensor for a given application. To select a molecular recognition layer based on the target molecule. Understand different methods for attaching recognition molecule on the sensor surface. To identify the interaction between the surface attached molecule and target molecule in the solution. Understanding the working principles of electronic and optical sensor devices. Role of affinity sensors in disease diagnosis. - Utility of resistivity based sensors compared to other competitive sensors.			
Unit -I	**BASICS OF BIOSENSORS-**Biosensor – definition-Historical perspective; Sensor characteristics - calibration, dynamic Range, signal to noise, sensitivity, selectivity, interference- examples - applications –Problems.			
Unit-II	**TYPES OF TRANSDUCERS-** Transducer – definition- types – optical, electrochemical, Electrochemical transducers (amperometric, potentiometric, conductimetric); - thermal, Mass – piezoelectric – acoustic wave with examples.			
Unit III	**BIORECOGNITION SYSTEMS**– Enzymes; Microorganism based biosensor, immobilization of microorganism - botanical biosensors-Biosensors using cultured cells-intact tissues-receptor elements.			
Unit IV	**DNA ELECTRONIC APPLICATIONS-** Molecular wires and switches Biomolecular computer, molecular arrays as memory stores, DNA for molecular devices - molecules between nanofabricated electrodes.			
Unit V	**GLUCOSE SENSORS-** Definition- Historical developments – generations of glucose sensing -types of glucose monitoring – invasive and non-invasive – sensor market-Indian status.			
Reference and Text Books: - CooperJ. Cass T. (2004).*Biosensors*. 3- Biotechnology Advances. Cooper J.M. Cooper J. Cass A.E.G. (2004). *Biosensors*. Oxford University Press. Malhotra B.D. Turner A.P.F. (2003). *Advances in Biosensors*.Elsevier JAI. MulchandaniA. Rogers K.R. (1998). *Enzyme and Microbial Biosensors Techniques and Protocols.* Humana Press, Totowa, New Jersey. Zhang X. ZuH. Wang J. (2018). *Electrochemical Sensors, Biosensors and their Biomedical applications*. Elsevier Science and Technology Books.				
Outcomes	The students shall be familiar with Basic characteristics, classification, immobilization methods for preparing a sensor with recent advancements - Principles of electrochemical techniques and recent advancements in glucose sensor, DNA and immune sensing for disease diagnosis - Applications of optical sensors in DNA, antibody and cells sensing - Molecular affinity based sensing technology in DNA and immuno sensing and resistivity based sensing technology.			

<table>
<tr><td colspan="5">IV Semester</td></tr>
<tr><td>Course code</td><td></td><td>COMPOSITE MATERIALS AND STRUCTURES</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">To introduce about the properties of fibers and matrices.
To make the students to understand the interface region and their testing.
To impart knowledge on the fabrication techniques of composites.
To expose the students to various micro and macro mechanics involved.
To impart knowledge on the various mechanical properties of composites.</td></tr>
<tr><td>Unit -I</td><td colspan="4">FIBERS AND MATRICES -Types of composite materials – the concept of load transfer - fibers – glass, boron, carbon, organic, ceramic and metallic fibers – the strength of reinforcements – volume fraction and weight fraction- fiber packing arrangements – long fibers – laminates, woven, braided and knitted fiber arrays – short fibers – fiber orientation and length distributions – matrix materials – polymers, metals and ceramic matrices.</td></tr>
<tr><td>Unit-II</td><td colspan="4">INTERFACE REGION - Bonding mechanisms – adsorption and wetting, interdiffusionand chemical reaction, electrostatic attraction, mechanical keying – experimental measurements of bond strength – single fiber pull out, push-out and push-down tests – three-point bend test - control of bond strength – coupling agents, toughness reducing coatings, diffusion barrier coatings, interfacial chemical reaction, the interphase region.</td></tr>
<tr><td>Unit III</td><td colspan="4">FABRICATION – Polymer matrix composites – liquid resin impregnation routes, pressurized consolidation of resin pre-pregs, consolidation of resin moulding compounds, injection mouldingof thermoplastics, hot press mouldingof thermoplastics – metal composites – squeeze infiltration, stir casting, spray deposition, powder blending and consolidation, diffusion bonding of foils, physical vapour deposition – ceramic composites – powder based routes, reactive processing, layered ceramic composites, carbon/carbon composites.</td></tr>
<tr><td>Unit IV</td><td colspan="4">MICROMECHANICS AND MACROMECHANICS - Prediction of elastic constants – micromechanical approach - Halpin Tsai equations – transverse stresses – mechanics of load transfer from matrix to fiber – micromechanics – elastic constants of an isotropic material – elastic constants of a lamina – Analysis of laminated composites.</td></tr>
<tr><td>Unit V</td><td colspan="4">STRENGTH AND TOUGHNESS OF COMPOSITES - Failure modes of long fiber composites axial and transverse tensile failure, shear and compression failure – strength of laminates – fracture mechanics – contributions to work of fracture – sub-critical crack growth – Applications of composite materials.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
AgarwalB.D. BroutmanL.J.&ChandrashekharaK. (2012). Analysis and Performance ofFibre Composites. Wiley.
ChawlaK.K.(2014).Ceramic Matrix Composites. Springer-Verlag New York Inc.
ChawlaK.K. (2015).Composite Materials: Science and Engineering. Springer India.
Hull D.andClyne T.W. (2008). An Introduction to Composite Materials. Cambridge University Press,.
Jones R.M. (2015). Mechanics of Composite Materials. Taylor and Francis.
MallickP.K. (2008). Fiber-Reinforced Composites: Materials, Manufacturing and Design. CRC Press, Boca Raton.</td></tr>
<tr><td>Outcomes</td><td colspan="4">The students would have gained knowledge about various fibers and matrices.
The students would gain knowledge about the interface region and chemical reactions.
To apply the fabrication methods they have learnt.
Understood the micromechanics and macro mechanics involved.
Learnt the various mechanical properties and applications of composites.</td></tr>
</table>

IV Semester				
Course code		**NUCLEAR PHYSICS AND REACTOR MATERIALS**	**Credits: 3**	**Hours: 3**
Objectives	• To introduce the students to nuclear structure and radioactivity. • To expose the students about nuclear models, exchange forces and elementary particles. • To make the students understand about nuclear fission, fusion and controlled thermo nuclear reaction. • To make the students understand about neutron and reactor physics. • To impart knowledge on the reactor design, materials and radioactive waste disposal.			
Unit -I	**NUCLEAR STRUCTURE AND RADIOACTIVITY -**Nuclear charge, mass, spin, magnetic moment, electric quadrupole moment, Binding energy,Semi-empirical mass formula – mass parabola – applications – Radioactivity – Soddy-Fajans law – Successive disintegration – transient and secular equilibrium.			
Unit-II	**NUCLEAR MODELS, FORCES AND ELEMENTARY PARTICLES -** Liquid drop model – shell model-compound nucleus model – Breit-wigner formula – Mesion theory – ground state ofdeutron – exchange forces – n-p, p-p scattering-spin dependence – classification of elementary particles – conservation laws – elementary idea about quarks, gluons and quantum chromodynamics.			
Unit III	**NUCLEAR FISSION AND FUSION** – Types of fission-distribution of fission products – fissile and fertile materials – neutron emission in fission – spontaneous fission – Bohr – Wheeler theory – chain reaction – four factor formula – criticality condition – fusion- energy released – stellar energy – controlled thermo nuclear reaction – plasma confinement.			
Unit IV	**NEUTRON AND REACTOR PHYSICS-** Nuclear transmutation, Q value – exoenergic – endoenergic reactions – Nuclear cross sections – neutron sources – classification of neutrons – themalisation – average logarithmic decrement – thermal neutron diffusion – Fermi age equation.			
Unit V	**REACTOR DESIGN AND MATERIALS-** Fuels, moderator, coolants, shielding – reactor size – radioactive waste disposal – radiation detection and measurement – film badge – TLD pocket dosimetry – application of radio isotopes – irradiation technology – radiation protection – units and dosage.			
Reference and Text Books: - Evans. (1986). *Atomic Physics*. Tata McGraw Hill, New Delhi. GlasstoneS. (1985). *Principles of Nuclear Reactor Engineering*. Van Nostrand Co, Inc., New York. RoyR.R. andNigam B.P. (1985). *Nuclear Physics*. Wiley Easter, New Delhi. TayalD.S. (1998). *Nuclear Physics*. Himalaya Publishers, Bombay.				
Outcomes	• The students will learn about nuclear structure and radioactivity. • The students would have gained knowledge about nuclear models exchange forces and elementary particles. • The students would have understood about nuclear fission, fusion and controlled thermo nuclear reaction. • The students would have understood about neutron and reactor physics. • The students would learn about reactor design, materials and radioactive waste disposal.			

<table>
<tr><td colspan="5">IV Semester</td></tr>
<tr><td>Course code</td><td></td><td>SMART MATERIALS AND STRUCTURES</td><td>Credits: 3</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">• To introduce the students to various intelligent, structural and biocompatible material.
• To introduce the concept of hybrid smart materials and structural systems.
• To make the students understand the principle, working and application of electro-rheological fluids.
• To expose the students to industrial piezo-electric materials and their properties.
• To impart knowledge on shape memory alloys, their properties and applications.</td></tr>
<tr><td>Unit -I</td><td colspan="4">INTRODUCTION -Classification of materials and their uses – Intelligent /Smart materials – Evaluation of materials Science – Structural material – Functional materials – Polyfunctional materials – Generation of smart materials – Diverse areas of intelligent materials – Primitive functions of intelligent materials– Intelligent inherent in materials – Examples of intelligent materials, structural materials, Electrical materials, bio-compatible materials etc. – Intelligent biological materials – Biomimetics – Wolff's law – Technological applications of Intelligent materials.</td></tr>
<tr><td>Unit-II</td><td colspan="4">SMART MATERIALS AND STRUCTURAL SYSTEMS - The principal ingredients of smart materials – Thermal materials – Sensing technologies – Micro sensors – Intelligent systems – Hybrid smart materials – An algorithm for synthesizing a smart material – Passive sensory smart structures–Reactive actuator based smart structures – Active sensing and reactive smart structures – Smart skins – Aero elastic tailoring of airfoils – Synthesis of future smart systems.</td></tr>
<tr><td>Unit III</td><td colspan="4">ELECTRO-RHEOLOGICAL (FLUIDS) SMART MATERIALS – Suspensions and electro-rheological fluids – Bingham -body model – Newtonian viscosity and non-Newtonian viscosity – Principal characteristics of electro rheological fluids – The electro-rheological phenomenon – Charge migration mechanism for the dispersed phase – Electro-rheological fluid domain – Electrorheological fluid actuators – Electro-rheological fluid design parameter – Applications of Electro-rheolgoical fluids.</td></tr>
<tr><td>Unit IV</td><td colspan="4">PIEZOELECTRIC SMART MATERIALS - Background – Electrostriction – Pyroelectricity – Piezoelectricity – Industrial piezoelectric materials– PZT – PVDF – PVDF film – Properties of commercial piezoelectric materials – Properties of piezoelectric film (explanation) – Smart materials featuring piezoelectric elements – smart composite laminate with embedded piezoelectric actuators – SAW filters.</td></tr>
<tr><td>Unit V</td><td colspan="4">SHAPE – MEMORY SMART MATERIALS - Background on shape – memory alloys (SMA) Nickel – Titanium alloy (Nitinol) – Materials characteristics of Nitinol – Martensitic transformations – Austenitic transformations – Thermoelastic martensitic transformations – Cu based SMA, chiral materials – Applications of SMA – Continuum applications of SMA fastners – SMA fibers – reaction vessels, nuclear reactors, chemical plants, etc. – Micro robot actuated by SMA – SMA memorisation process-SMA blood clot filter – Impediments to applications of SMA – SMA plastics – primary molding – secondary molding – Potential applications of SMA plastics.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
DeurigT.W. Melton K.N. StockelD. andWaymanC.M. (1990). Engineering aspects of Shape Memory alloys. Butterworth –Heinemann.
GandhiM.V. andThompson B.S. (1992). Smart Materials and Structures. Chapman and Hall, London, First Edition.
Rogers C.A. (1989).Smart Materials, Structures and Mathematical issues. TechnomicPublising Co., USA.</td></tr>
<tr><td>Outcomes</td><td colspan="4">• The students would gain knowledge on the intelligent, structural and biocompatible materials.
• The students would learn the concepts of hybrid smart materials and structural systems.
• The students will understand the principle, working and application of electro-rheological fluids.
• The students would be able to implement the knowledge gained on industrial piezo-electric materials.
• The students would have gained knowledge on shape memory alloys, their properties and applications.</td></tr>
</table>

NON – MAJOR ELECTIVE

I Semester				
Course code		**ELECTRONICS FOR DAILY LIFE**	**Credits: 2**	**Hours: 3**
Objective	• To provide basics of electrical and electronics home appliances			
Unit -I	**ELECTRICAL SAFETY -**General principles of electrical safety – Electricity and Human body - Electric shock and burn - Respiratory protection - Risk assessment and management - Safety against over voltage, extra-low and residual voltages - Hazardous areas, Electrical insulation - Electrical fires, Arc flash - Safety issues with emerging energy sources.			
Unit-II	**ELECTRICAL ACCESSORIES AND EARTHING -** Switches – holders – sockets – ceiling rose – plugs – main switch – fuse – circuit breaker – Earthing/grounding – importance – components ofearthing system – types ofearthing – pipe , plate and rod earthing – SI specifications ofearthing.			
Unit III	**SMART ELECTRONICS**– Historical Background of processor and Memory storage- Smart Phone, TAB, Laptop, Kindle – LCD and LED TV – smart watch- Medical diagnosis based on smart phone- Human–Computer Interaction.			
Unit IV	**ENEGRY DEVICES-** Energy density vs Power density – Primary, Secondary Batteries- Wet Cell, Dry Cell- Alkaline-Lithium ion –Flow battery- Supercapacitor- Fuel Cell.			
Unit V	**ENERGY CONSERVATION-** Renewable Energy Source- Photovoltaic Cell – Energy Efficient lamps (CLF, LED)- Green Computing-Home appliance- Energy efficiency in Vehicles – Solar car.			

Reference and Text Books: -

Albert Malvino, David J Bates.(2007).*Electronic Principles*, 7th Edition, McGraw Hill.
David A. Bell.(2007).*Electronic Devices and circuits*, 4th Edition, Prentice Hall.
Kishore, K. Lal.(2008).*Electronic Devices and circuits*, BS Publications; Third edition.
MehtaV.K. (2001).*Principles of Electronics*, 6th Revised Edition, S. Chandand Company.
PadiyarK.R. *Understanding the structure of electricity Supply*, B.S. Publications.
SzeS.M. (2008).*Semiconductor Devices: Physics and Technology*, Wiley India Pvt Ltd.

Outcomes	• Familiar in handling electrical appliances and electronics gadgets • Capable of choosing the right products from the host of choices available in the market • Able to conserve electricity by opting renewable energy sources and energy efficient home appliances.

I Semester				
Course code		**FOOD CHEMISTRY**	**Credits: 2**	**Hours: 3**
Objectives	• To enable the students to acquire knowledge on the macro and micro constituents of the food. • To know the structure and chemical characteristics of constituents of food. • To demonstrate the knowledge of food chemistry and applying, the principles and concepts of chemistry as they apply to food systems. • To familiarize the student with the relationship between water and food. • To explain the rationale for certain food processes and preservation.			
Unit -I	**INTRODUCTION TO FOOD AND ITS PROPERTIES -**Proteins-Enzymes-Chemistry and structure, kinetics, Maillard reaction. Food carbohydrates: Structural, nutritional and functional aspects. Emulsifiers-role ofemulsifiers selection of emulsifier based on hydrophilic and Lipophilic balance (HLB) and its application. Thickeners-definition, chemical structure, gel formation, list of permitted thickeners and food application. Chemical and biochemical changes: changes occur in foods during different processing.			
Unit-II	**PROCESSING AND PRESERVATION -** Scope and benefits of industrial food preservation. Preservation of foods by chemicals, antibodies, antioxidants, salt and sugar. Principles of food freezing: freezing point of foods Psychrometric chart, Freeze concentration, freeze drying, IQF. Nanotechnology: Principles and application in foods, Hurdle technology: Types of preservation techniques and their principles, concept of hurdle technology and its application.			
Unit III	**FLAVOURS AND COLOURING AGENTS** – Chemistry of food flavor, definitions, Flavourmatics /flavouring compounds, flavor retention-off flavoursand food taints. Colour -Natural and synthetic food colours, their chemical structure, stability, permitted list ofcolours, usage levels and food application.			
Unit IV	**WATER RELATIONS IN FOOD -** Moisture in food: Structure, properties, Types of water in food and their specific function water activity and stability.			
Unit V	**FOOD ADDITIVES-** Definitions, uses and functions of: Acids, Bases, Buffer system, chelating/sequestering agents, Antioxidants, Anti-caking agents, Firming agents. Flour bleating agents and Bread improvers. Anti-microbial agents/ class I & II.			
Reference and Text Books: -				
Belitz, H-D., Grosch, W. &Schieberle, P. (2004) *Food Chemistry 3rd Ed.* (translation of fifth German edition), Springer Damodaran, S., Parkin, K. L., andFennema, O.R. (2008) *Fennema's Food Chemistry 4th Edition,* CRC Press DeMan, J.M. (2018). *Principles of Food Chemistry 4rd Ed.* Aspen Publishers. Harish Kumar Chopra andParmjit Singh Panesar, (2010). *Food Chemistry*, Narosa Publication. Jaswinder Kaur and Barry H. Grump.(2010). *Fundamentals of Food Chemistry*, Abhizeet Publications. Peter C. K. Cheng, (2015). *Handbook of Food Chemistry*, Vol 1, Springer Reference.				
Outcomes	• Will know about the factors governing the food quality and chemical constituents. • Will be able to name and describe the general chemical structures of the major components of foods and selected minor components • Will come to know about the techniques involved in food processing and preservation • Will be acquitted with food additives and their function in preservation • Will be familiarize with the nature of packed food from industrial processes			

<table>
<tr><th colspan="5">II Semester</th></tr>
<tr><td>Course code</td><td></td><td>NANOBIOSENSORS</td><td>Credits: 2</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">• To understand basic characteristics of biosensors, nanoparticles and hybrids.
• Synthetic methods of nanoparticles in presence of biological molecules.
• Understanding important biorecognition elements in biosensing.
• To know electrical and optical techniques in biosensing.
• Biosensor applications in medical and food industries.</td></tr>
<tr><td>Unit -I</td><td colspan="4">BASICS OF NANOBIOSENSORS -Basic concepts, Classification, Components; Features of Biosensors – Sensitivity, Selectivity, Reproducibility, Portability, Stability, Detection Limit, Response time - types of nanobiosensors;. Nanoparticle biomolecule - hybrids, Nanoparticle for biosensing.</td></tr>
<tr><td>Unit-II</td><td colspan="4">BIOSYNTHESIS OF NANOPARTICLES - Metal: Silver, gold, Platinum. Metal oxide: cerium, titanium, iron and zinc oxide nanoparticles - synthesis using bacteria, fungi, plant extracts, Biological applications of inorganic nanoparticles.</td></tr>
<tr><td>Unit III</td><td colspan="4">MOLECULAR RECOGNITION ELEMENTS IN NANOSENSING – Transducers-biorecognizing elements – Enzymes, Antibodies; Nucleic acids; Methods of Immobilization - Co-valent and non-covalent, self-assembly.</td></tr>
<tr><td>Unit IV</td><td colspan="4">ELECTRICAL AND OPTICAL BIOSENSORS - Principles –Conductometric, amperometric and Impedimetric biosensors; Glucose biosensors - Optical Biosensors: Principles – Absorbance, Chemi-luminescence - Fluorescence, Phosphorescence; Colorimetric sensors.</td></tr>
<tr><td>Unit V</td><td colspan="4">NANOTECHNOLOGY AND ITS APPLICATION IN HEALTH AND FOOD INDUSTRY - Nanotechnology and food packaging, natural biopolymers, advantages of nanomaterials in food packaging applications, nanosensors, outstanding issues, risks and regulations, public perception. Nanotechnology in Agriculture, Precision farming, Smart delivery system, Insecticides using nanotechnology, Potential of nano fertilizers.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Charles P.Poole, Jr., FrankJ.Owens.(2006).Introduction to Nanotechnology, Wiley India.
Eltekhari, John Wiley Weinhim (2008).Nanostructured Materials in Electrochemistry.
Hari Singh Nalwa. Nanostructured Materials and Nanotechnology, Academic Press London USA, Concise Edition.
KouroshKalantar, Zadeh Benjamin Fry.(2008). Nanotechnology Enabled Sensors, Springer, Newyork.
Seminario, Jorge.(2014).Design and applications of Nanomaterials for Sensor, Springer Publications.
Vijay K.Vardan, L. Chen, Jining, John Wiley.(2008).Nanomedicine Design and applications of Magnetic Nanoparticles, Nanosensors andNanosystems, New Jersey.
William A. Goddard. Handbook of Nanoscience and Technology, CRC, Boca Raton, 2^{nd} edition.</td></tr>
<tr><td>Outcomes</td><td colspan="4">• Basic characteristics and methods of nanoparticles
• Familiar with different green synthesis methods of metal/oxide nanoparticles using bacteria, fungi and plant extracts , different types ofbiorecognition elements
• Techniques based on electrical and optical properties for molecular sensing
• Applications of nanosensors in medical and food industries</td></tr>
</table>

<table>
<tr><td colspan="5">II Semester</td></tr>
<tr><td>Course code</td><td></td><td>GREEN CHEMISTRY</td><td>Credits: 2</td><td>Hours: 3</td></tr>
<tr><td>Objectives</td><td colspan="4">• To introduce the basic concept and principles of green chemistry for environmental management.
• To make the students know about green reagents and its importance to the environment
• To acquaint the student with green solvents and its impacts in green chemistry
• To familiarize the synthesis of materials using green methods
• To impart the knowledge on applications of green synthesis technology</td></tr>
<tr><td>Unit -I</td><td colspan="4">PRINCIPLES OF GREEN CHEMISTRY -History of green chemistry and sustainability- Prevention of waste/by-products – maximum incorporation of reactants in final product-Atom economy – Prevention/minimization of hazardous products – Designing safer chemicals – optimizing reaction conditions.</td></tr>
<tr><td>Unit-II</td><td colspan="4">GREEN REAGENTS AND CATALYSTS - Choice of starting materials – reagents (Dimethyl carbonate, polymer supported reagents) – catalysts (microencapsulated Lewis acids, zeolites, basic catalysts polymer supported catalysts, introduction to biocatalysts).</td></tr>
<tr><td>Unit III</td><td colspan="4">GREEN SOLVENTS – Aqueous phase reactions (Claisen rearrangement, Aldol condensation, wurtz reaction, reduction of carbon carbon double bond, oxidation of amines into nitro compounds – Electrochemical synthesis (synthesis ofadiponitrile) - Ionic liquids – reactions in acidic ionic liquids- reactions in neutral ionic liquids (hydrogenations, diels-Alder reactions, Heck reactions, O-alkylation and N-alkylation, methylene insertion reactions.</td></tr>
<tr><td>Unit IV</td><td colspan="4">GREEN SYNTHESES - Microwave induced green synthesis (Hoffmann Elimination and Oxidation of alcohols) – Ultra sound assisted green synthesis (Esterification, Saponification andCannizaro reaction) – Solid state green synthesis (Dehydration of alcohols to alkenes, Grignard reaction)- Solid supported organic synthesis (Synthesis of furans and pyrrole).</td></tr>
<tr><td>Unit V</td><td colspan="4">APPLICATIONS OF GREEN SYNTHESIS - Introduction – synthesis of styrene, adipica acid, catechol, 3-Dehydroshikimic acid, methyl methacrylate, urethane. Environmentally benign synthesis of aromatic amines – free radical bromination – synthesis of ibuprofen and paracetamol.</td></tr>
<tr><td colspan="5">Reference and Text Books: -
Ahluwalia V. K. (2012). Green Chemistry, Narsoa publishers.
AhluwaliaV.K. andKidwaiM. (2004). New trends in Green Chemistry, Anamaya Publishers.
Bela Torokand Timothy Dransfield , (2017). Green Chemistry, An Inclusive Approach, 1st Edition, Elsevier.</td></tr>
<tr><td>Outcomes</td><td colspan="4">• To be familiar with basic concepts of green chemistry and apply to them in various field.
• To recognize the catalytic reaction with green reagents and its importance. To identify available green solvents and apply them to various synthesis process
• To recognize the preparations of materials with green process and its application to the environment.
• To gain the knowledge of preparation of various drugs using green synthesis methods
• To be have the skills and technology towards green chemistry and apply in industry.</td></tr>
</table>

CURRICULUM VITAE

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Tamil Nadu,INDIA

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Educational qualification:

Ph.D. - Crystal Growth Centre, Anna University, Chennai.
M.Sc. – Pachaiyappa's College, University of Madras
B.Sc. - Sacred HeartCollege, University of Madras

Professional experience:

- Research – 14 Years
- Teaching – 21 Years

Area of Research:

- Materials Science: Metal oxide semiconductors, Carbon nanostructures, Biomaterials, Low dimensionalcuprates
- Sensors: Chemical Sensors, Biosensors for Medical, Food, Agricultural and EnvironmentalApplications

Honoursand Awards:

- International Centre for Theoretical Physics (ICTP)-Italy (Travel grant-2015)
- Alagappa Excellence Award for Research(2016-17)
- SERB-DST, Govt. of India (International Travel Support – May2017)
- Best Poster Award –International Conference on Environmental Medicine, 10- 11thDecember 2017, Kaohsiung Medical University,Taiwan.
- Visiting Researcher, University ofMessina, Italy (May-July2017)
- International Centre for Theoretical Physics (ICTP)-Italy (Special grant-2019)

Recent publications:

- $MgNi_2O_3$ nanoparticles as novel and versatile sensing material for non-enzymatic electrochemical sensing of glucose and conductometric determination of acetone.
- Nicotinamide adenine dinucleotide immobilized tungsten trioxide nanoparticles for simultaneous sensing of norepinephrine, melatonin and nicotine.
- SnO_2-SnS_2 nanocomposite as electro-catalyst for simultaneous determination of depression biomarkers serotonin and tryptophan.
- Gamma Irradiated WO_3 Nanostructures for Electrochemical Sensing of Multiple Depression Biomarkers.
- Manganese Doped Hydroxyapatite Nanoparticles Based Enzyme-Less Electrochemical Sensor for Detecting Hydroquinone.

Total Publications: 149, Total Citation: 2137, h- index: 26, i10- index: 54

CURRICULUM VITAE

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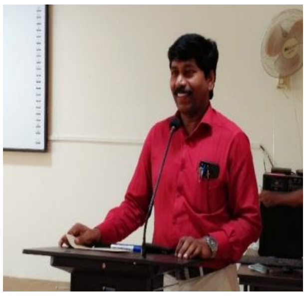

Educational qualification:

- Ph.D. - Anna University, Chennai
- M.Phil. – Anna University, Chennai
- M.Sc. – Bharathidasan University
- B.Sc. - Bharathidasan University

Professional experience:

- Research – 27 Years
- Teaching – 23 Years

Area of Research:

- Crystal growth of organic & inorganicmaterials
- Nano materials synthesis and Thin Films preparation for supercapacitors, Photocatalyticand sensorapplications
- Opto-electronics and E-O modulator–Devices

Honors and Awards:

- Visiting Professor, Shizuoka University, Japan, Aug-Nov. 2012
- Honorable Guest Professor, Shizuoka University, Japan, April2014
- Alagappa Excellence Award for Research (2015-2016), Alagappa University, 2016
- Honorable Guest Professor, Shizuoka University, Japan, April2016
- JSPS Invitation Fellowship, Japan, Nov.-Dec. 2016
- Appreciation Award, Alagappa University, Karaikudi, Feb. 2017
- Honorable Guest Professor, Shizuoka University, Japan, April 2018 17.
- Honorable Guest Professor, Shizuoka University, Japan, April2019

Recent publications:

- Synthesis of self-assembled micro/nano structured manganese carbonate for high performance, long lifespan asymmetric supercapacitors and investigation of atomic-level.
- Synthesis of $X_3(PO_4)_2$ [X = Ni, Cu, Mn] Nanomaterials as an Efficient Electrode for Energy Storage Applications.
- Neutral and alkaline chemical environment dependent synthesis of Mn_3O_4 for oxygen evolution reaction (OER)
- Fabrication and electrochemical OER activity of Ag doped MoO_3 nanorods.
- Supercapacitor and OER activity of transition metal (Mo, Co, Cu) sulphides.

Total Publications: 295, Total Citation: 3434, h- index: 31, i10- index: 91

CURRICULUM VITAE

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Educational qualification:

- Ph.D. - Alagappa University, Karaikudi
- M.Phil. – Madurai Kamaraj University, Madurai
- M.Sc. – Madurai Kamaraj University, Madurai

Professional experience:

- Research – 26 Years
- Teaching – 23 Years

Area of Research:

- MaterialsScience
- Crystallization kinetics of organic and inorganicmaterials.
- Unidirectional growth of bulk organic and inorganiccrystals.
- III-V Semiconductor materials – synthesis andgrowth.

Honoursand Awards:

- Indo-China Bilateral Students Exchange Fellowship*(1992-93)*
by Ministry of Human Resource Development, Govt. of India, New Delhi.
- Young Scientist Fellowship *(1995-96)* by Tamil Nadu State Council for Scienceand Technology, Govt. of Tamil Nadu, Chennai,India.
- Prof.P.Ramasamy National Award for Crystal Growth *(2005)* by IndianAssociation for Crystal Growth, Anna University,Chennai.
- Best Researcher Cash Award *(2005-2006)*, Alagappa University, Karaikudi
- Visiting Professor (*April, 2010-July, 2010)* – Research Institute of Electronics, Shizuoka University, Hamamatsu, Japan.
- Visiting Scientist (19-10-2014 to 24-10-2014) – Hebei SemiconductorResearch Institute, Shijiazhuang,China.

Recent publications:

- Electrochemical, structural, compositional and optical properties of Cuprous Selenide thin films.
- Unidirectional growth of pure and composite t-stilbene single crystals for scintillator applications.
- Sol–gel mediated microwave synthesis of pure, La andZr doped SnS_2 nanoflowers an efficient photocatalyst for the degradation of methylene blue.
- Electrochemical synthesis, single-crystal growth, physicochemical and dielectric studies oftetrabromobisphenol A.
- Crystal growth and characterization of 1, 3, 5-triphenylbenzene organic scintillator crystal.

Total Publications: 83, Total Citation: 1201, h- index: 19, i10- index: 34

CURRICULUM VITAE

Name : Dr. V. Dharuman
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Educational qualification:

- Ph.D. - University of Madras
- B.Ed. – University of Madras
- M.Sc. – University of Madras
- B.Sc. - University of Madras

Professional experience:

- Research – 15 Years
- Teaching – 9 Years

Area of Research:

- Chemistry/Electrochemistry/ Diabetic, cancer biosensors development using, DNA, antibody (immunosensors) and neurological disorder sensors

Honoursand Awards:

1. Best poster award, National Conference on Futuristic Materials (NCFM-2017), March 27 & 28th, 2017 Alagappa University, Karaikudi-630003
2. Best poster award, International conference on recent advance in materials and chemical sciences (ICRAMCS-2015), Dec.14-15, 2015, Gandhigram Rural Institute
3. Alagappa Excellence Award for Research2015-2016
4. Best poster award, Indo-Japan workshop on Biomolecular Electronics & Organic Nanotechnology for Environment Preservation (IJWBME 2013), 13- 15th December 2013, Delhi Technological University, Delhi,India
5. Young Biomedical scientist Research Fellowship by Indian Council of Medical Research, India, for the year2012-2013
6. Article Gold nano particle decorated graphene core first generation PAMAM dendrimer for label free electrochemical DNA hybridization sensing, Biosens. Bioelectr., 31 (2012) 406-412 . Ranked 16th on the TOP 25 articles in the Journal of Biosensors and Bioelectronics, March2012
7. Research Scientist , AIST, Japan, Oct.2006 – March2007
8. Brain Korea Post doctoral research fellowship, Decmber2004

Recent publications:

- Physicochemical and electrochemical analysis of rare earth metal doped BTO perovskite thin films.
- Carbon dots stabilized silver-lipid nano hybrids for sensitive label free DNA detection.
- Carbon dots stabilized silver–lipid nano hybrids for sensitive label free DNA detection.
- Single step sol-gel synthesized Mn_2O_3-TiO_2 decorated graphene for the rapid and selective ultra sensitive electrochemical sensing of dopamine.
- Self-powered polymer–metal oxide hybrid solar cell for non-enzymatic potentiometric sensing of bilirubin.

Total Publications: 58, Total Citation: 947, h- index: 18, i10- index: 24

CURRICULUM VITAE

Name : Dr. J. Wilson
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Educational qualification:

- Ph.D. - Alagappa University Karaikudi.
- M.Sc. –St.Joseph's College Bharathidasan University Trichy
- B.Sc. - Alagappa University Karaikudi

Professional experience:

- Research – 14 Years
- Teaching –8Years

Area of Research:

- Conducting polymers, Metal oxides, Carbon based materials, Biosensors, lithium batteries

Honoursand Awards:

- Nature India has published my paper doi:10.1038/nindia.2016.27 Published online 24 February 2016

Recent publications:

- Sensitive voltammetric sensor based on silver dendrites decorated polythiophene nanocomposite: Selective determination of L-Tryptophan.
- Size controllable, pH triggered reduction of bovine serum albumin and its adsorption behavior with SnO_2/SnS_2 quantum dots for biosensing application.
- Solvothermal synthesis of magnetically separable reduced graphene oxide/Fe_3O_4 hybrid nanocomposites with enhanced photocatalytic properties.
- Mesoporous nickel oxide nanostructures: Influences of crystalline defects and morphological features on mediator free electrochemical monosaccharide sensor application.
- Non – Enzymatic L – Tyrosine Detection Based on PEDOT/ZrO_2 /rGO Composite.

Total Publications: 37, Total Citation: 919, h- index: 13, i10- index: 19

CURRICULUM VITAE

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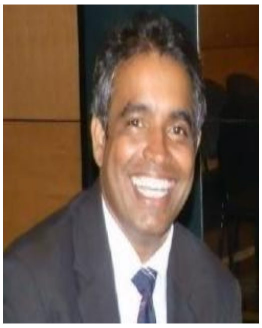

Educational qualification:

- Ph.D. - Anna University, Madras
- M.Sc. – Anna University, Madras
- B.Sc. - Madurai Kamaraj University

Professional experience:

- Research – 20 Years
- Teaching –16 Years

Area of Research:

- Nanophase materials
- MOFs and other nano/micro/measo-porous materials
- Hydrogen Storage & Battery Materials
- Solar Energy Materials including Tranparent conducting oxides
- Defects in semiconductors
- Linear, nonlinear optical properties and other Excited State properties
- Magneto-optical and Magneto-caloric materials.
- Magnetic properties, Magnetic anisotropy, Spin, Charge and Orbital ordering
- Multi-ferroicand other multifunctional materials
- Structural Phase Stability and High Pressure studies

Recent publications:

- Comment on the paper titled "Two-dimensional Sc_2C: A reversible and high capacity hydrogen storage material predicted by first-principles calculations" by Hu et al.
- Role of W-site substitution on mechanical and electronic properties of cubic tungsten carbide.
- Thermal, electronic and thermoelectric properties ofTiNiSnandTiCoSb based quaternary half Heusler alloys obtained from ab initio calculations.
- Giant Magnetoelectric Coupling in Multiferroic $PbTi_{1-x}V_xO_3$ from Density Functional Calculations.
- Earth-abundant nontoxic direct band gap semiconductors for photovoltaic applications by ab-initio simulations.

Total Publications: 233, Total Citation: 8002, h- index: 44, i10- index: 113

CURRICULUM VITAE

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Educational qualification:

- Ph.D. in X-ray Crystallography from Faculty of Science and Humanities, CEG Campus, Anna University (1988 - 1991).
- .M.Phill. in PHYSICS , CEG Campus, Anna University (1987 - 1988)
- M.Sc. in Biophysics, Department of Crystallography and Biophysics, University of Madras
- B.Sc. in PHYSICS, SRMV Arts College, Coimbatore, University of Madras (1980 - 1983).

Area of Research:

- X-Ray Crystallography
- Materials science

Recent publications:

- 1, 3-Dicyclohexyl-1-(4-nitrobenzoyl) urea.
- 3-Benzyl-7-bromo-9-phenyl-2-tosyl-2, 3, 3a, 4, 9, 9a-hexahydro-1H-pyrrolo [3, 4-b] quinolone.
- 3-Benzyl-7-chloro-9-phenyl-2-tosyl-2, 3, 3a, 4, 9, 9a-hexahydro-1H-pyrrolo [3, 4-b] quinolone.
- 3-Benzyl-9-phenyl-2-tosyl-2, 3, 3a, 4, 9, 9a-hexahydro-1H-pyrrolo [3, 4-b] quinolone.
- 3-Benzyl-7-methoxy-9-phenyl-2-tosyl-2, 3, 3a, 4, 9, 9a-hexahydro-1H-pyrrolo [3, 4-b] quinolone.

Total Publications: 210, Total Citation: 1541, h- index: 19, i10- index: 45

CURRICULUM VITAE

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Educational qualification:

- Ph.D. - Anna University, Chennai.
- M.Phil,Bharathidasan University, Tiruchirappalli.
- M.Sc. – Sri Pushpam College (Bharathidasan University), Poondi, Thanjavur.
- B.Sc. - Voorhees College (University of Madras), Vellore.

Professional experience:

- Research – 30 years
- Teaching –25 Years

Honoursand Awards:

- Best Poster Presentation award, Indian Academy of Science, India (2018)
- MRSI Medal Lectures Award, Materials Research Society of India, India (2018).
- Tamil Nadu Scientist Award in Physical Sciences, Tamil Nadu State Council for Science and Technology, India (2014).
- Visiting Professorship, Institute of Solid State Physics, University of Tokyo, Japan (2016).
- GCOE Fellowship, Institute of Solid State Physics, University of Tokyo, Japan (2008).
- TWAS-UNESCO Associate Scheme at Centres of Excellence in South Third World Academy of Sciences, C/O ICTP, Italy (2009-2012).
- OCU fellowship, Osaka city university, Japan (2006).
- INSA Exchange Fellowship, DFG, Germany (2005).
- Post-Doctoral Fellowship, JSPS, Japan (2002-2003).
- Prof. M. A. Ittyachen Award, CTMS 2001, Mahatma Gandhi University, Kottayam, India (2001).
- Post-Doctoral Fellowship, JSPS, Japan (1998-2000).
- Young Scientist Fellowship, TSNCT, Chennai, Tamil Nadu, India (1996-1997).
- Proficiency Prize award, A.V.V.M Sri Pushpam College, Thanjavur, India (1986).

Recent publications:

- Influence of ERTA on magnetocaloric properties ofSr doped $BaFe_{12}O_{19}$ thin films.
- Complex magnetic structure andmagnetocapacitance response in a non-oxide NiF_2system .
- Effect of Multi-functional Hierarchical Flower-like CoS Nanostructure on its Electrochemical Behavior for Room Temperature Supercapacitor and DSSC Applications and Low Temperature Superconducting application.
- Enhancement of Superconducting properties and flux pinning mechanism on $Cr_{0.0005}NbSe_2$ Single crystal Under hydrostatic pressure.
- Electrical resistivity, magnetic and magneto-caloric studies on perovskite manganites $Nd_{1-x}Cd_xMnO_3$ (x = 0 and 0.1) polycrystals.

Total Publications: 218, Total Citation: 1641, h- index: 21, i10- index: 50

CURRICULUM VITAE

Name : **Dr. Giovanni Neri**
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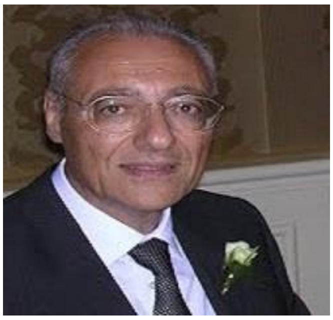

Educational qualification:

- M. S Chemistry – University of Messina, Italy.

Area of Research:

- Catalysis, Gas sensors, Biosensors

Honoursand Awards

- Awarded a grant by Samsung SAIT Global Research Outreach program for the project Smart sensors for breath analysis.
- Invited researcher/professor at the College of Chemical Engineering, The University of Michigan (1991 and 1996), at University of Alagappa (2013 and 2019) and Indian Institute of Technology (IIT) Indore (2016).
- Associate Editor-in-Chief ofChemosensors, member of the Editorial Board of Sensors and Academic Editor for the "Gas Sensors" topical collection.

Recent publications:

- High performance Gd-doped γ-Fe_2O_3 based acetone sensor.
- High Performance CO Gas Sensor Based on ZnO Nanoparticles.
- Development of ZnO-based sensors for fuel cell cars equipped with ethanol steam-reformer for on-board hydrogen production.
- Electrochemical Sensing of Serotonin by a Modified MnO_2-Graphene Electrode.
- $MgNi_2O_3$ nanoparticles as novel and versatile sensing material for non-enzymatic electrochemical sensing of glucose and conductometric determination of acetone.

Total Publications: 476, Total Citation: 11366, h- index: 59, i10- I index: 196

CURRICULUM VITAE

Name : **Dr. Subramainan Tamil Selvan**
Designation : Professor
Address : Translational Neuroscience Laboratory,
Lee Kong Chian School of Medicine,
Nanyang Technological University,
59 Nanyang Drive, Singapore 636921
Email : subra.selvan@ntu.edu.sg

Area of Research:

Nanomedicine, Bioimaging, Nanoparticle, Quantum dots, Energy.

Recent publications:

- Mushroom-Derived Carbon Dots for Toxic Metal Ion Detection and as Antibacterial and Anticancer Agents.
- Bimodality Probes ofGd Enhanced T1-Weighted Magnetic Resonance/Optical Imaging.
- Silica-Coated Mn-Doped ZnS Nanocrystals for Cancer Theranostics.
- Nanotechnology-Based Diagnostics and Therapy for Pathogen-Related Infections in the CNS.
- Experimental and Theoretical Structural Characterization of Cu−Au Tripods for Photothermal Anticancer Therapy.

Total Publications: 89, Total Citation: 2094, h- index: 34, i10- I index: 58

CURRICULUM VITAE

Name : **Dr. Nanda Gunawardhana**
Designation : Professor
Address : Sri Lanka Technological Campus
New Kandy Rd,
Malabe 10115,
Sri Lanka

Email : nandhag@sltc.ac.ik

Area of Research:

Capacitors, Gas sensors, Nanomaterials, LIBs.

Honoursand Awards:

- Director, Sri Lanka Technological Campus.

Recent publications:

- Seed-Assisted Growth of TiO_2 Nanowires by Thermal Oxidation for Chemical Gas Sensing.
- TiO_2Microparticles/Reduced Graphene Oxide Composite as Anode Material for Lithium Ion Battery
- Gold functionalized MoO_3 nano flakes for gas sensing applications.
- Fabrication of Hollow Co_3O_4 Nanospheresand Their Nanocomposites of CNT and rGO as High-Performance Anodes for Lithium-Ion Batteries.
- UV Light Assisted NO_2Sensing by SnO_2/Graphene Oxide Composite.

Total Publications: 47, Total Citation: 936, h- index: 19, i10- I index: 25

CURRICULUM VITAE

Name : Pratima R. Solanki
Designation : Assistant Professor
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Jawaharlal Nehru University,
New Delhi, 110 067.
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Area of Research:

Nano Biosensors, Nano bio-interface.

Recent publications:

- One-step green approach to synthesize highly fluorescent carbon quantum dots from banana juice for selective detection of copper ions.
- Non-enzymatic detection of Glucose using a capacitive nanobiosensor based on PVA capped CuO synthesized via co-precipitation route.
- A highly sensitive label-free amperometric biosensor for norfloxacin detection based on chitosan-yttria nanocomposite.
- Studies on Carbon quantum dots embedded Iron Oxide Nanoparticles and their Electrochemical response.
- Molecularly Imprinted Polymer-based Novel Electrochemical Sensor for the Selective Detection ofAldicarb.

Total Publications: 165, Total Citation: 6027, h- index: 43, i10- I index: 95

CURRICULUM VITAE

Name : **Dr. N. Lakshminarasimhan**
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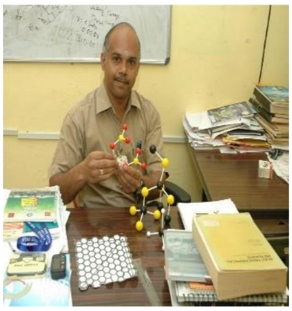

Educational qualification:

- Ph.D. - Indian Institute of Technology (IIT) Madras.
- M. Sc. - Muthurangam Govt. Arts College, Vellore, affiliated to Univ. of Madras.
- B.Sc. –Muthurangam Govt. Arts College, Vellore, affiliated to Univ. of Madras

Area of Research:

- Solid State Chemistry and Materials Science, Photofunctional Materials - Phosphors, Photocatalysts, Transparent Conductors, Materials for Energy Conversion and Storage, Structure-Morphology-Property Correlations in Nanomaterials andPhotofunctional Materials

Honoursand Awards:

- CSIR-Young Scientist Award in Chemical Sciences for 2012
- Listed in Marquis Who's Who in the World for 2010 and 2013
- University of Madras IV rank holder (1999) in Master's degree

Recent publications:

- The effects of morphology, microstructure and mixed-valent states of MnO_2 on the oxygen evolution reaction activity in alkaline anion exchange membrane water electrolysis.
- Reversible Thermochromismof Nickel (II) Complexes and Single-Crystal-to-Single-Crystal Transformation.
- Electronic, thermal and magneto-transport properties of the half-Heusler, DyPdBi.
- Structure-magnetic property relations in $FeNbO_4$ polymorphs: A spin glass perspective.
- Oxo-bridged trinuclearandtetranuclear manganese complexes supported with nitrogen donor ligands: syntheses, structures and properties.

Total Publications: 45, Total Citation: 1407, h- index: 21, i10- I index: 25

CURRICULUM VITAE

Name : Dr. J. Mathiyarasu
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CSIR-Central Electrochemical Research Institute, India.
Email : almathi@cecri.res.in

Area of Research:

Electrochemical biosensors.

Honoursand Awards:

- BOYSCAST Fellowship (2007-08) Department of Science and Technology, New Delhi

Recent publications:

- Amperometric determination ofMyo-inositol using a glassy carbon electrode modified with nanostructured copper sulfide.
- Magnetosome-anti-Salmonella antibody complex based biosensor for the detection of Salmonella typhimurium.
- Electrochemical Detection ofAlloxan on Reduced Graphene oxide Modified Glassy Carbon Electrode.
- Disintegration of Flower-Like MoS2 to Limply Allied Layers on Spherical Nanoporous TiO2: Enhanced Visible-Light Photocatalytic Degradation of Methylene Blue.
- MOF assisted synthesis of new porous nickel phosphate nanorods as an advanced electrode material for energy storage application.

Total Publications: 91, Total Citation: 2434, h- index: 26 i10- I index: 48

CURRICULUM VITAE

Name : **Dr. J. JEYAKANTHAN**
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Educational qualification:

- Ph.D. - University of Madras, Chennai.
- M. Phil - M. K. University.
- M.Sc. – M. K University.

Area of Research:

- Structural Biology and Bio-Computing, Small and Macro Molecule X-ray Crystallography

Honoursand Awards:

- UGC Research Award (2016)
- Fellow of Academy of Sciences, Chennai (2015)
- Post Doctoral Fellowship – DST, DBT and IRPHA (2000-2003)
- IUCr Young Scientist (1999)
- Young Scientist Travel Award by DST and UNESCO (1999)
- Research Fellow award by CSIR (1997)

Recent publications:

- Structural Insights on Binding Mechanism of CAD Complexes (CPSase, ATCaseandDHOase).
- Conformational changes in glutaminyl-tRNAsynthetases upon binding of the substrates and analogs using molecular docking and molecular dynamics approaches.
- In silico characterization of the NiRAN domain of RNA-dependent RNA polymerase provides insights into a potential therapeutic target against SARS-CoV2.
- IMRPS: Inserted and Modified Residues in Protein Structures. A database.
- Conformational insights into the inhibitory mechanism ofphyto-compounds against Src kinase family members implicated in psoriasis.

Total Publications: 150, Total Citation: 1339, h- index: 18, i10- index: 38

CURRICULUM VITAE

Name : Dr.K.Gurunathan
Designation : Professor
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Tamil Nadu, INDIA
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gurukar50@gmail.com

Educational qualification:

- Ph.D. - University of Madras, Chennai.
- M. Sc. - M. K. University, Madurai.
- B. Sc. – M. K University, Madurai.

Professional experience:

- Research – 27 years
- Teaching – 12 years

Area of Research:

- Hydrogen Energy, PhotocatalysisandPhotoelectrochemistry, Nano (Quantum dots &Core-Shell Solar cells), Flexible (Plastic) Solar cells, Nanomaterials for Electronics and Power sources, Conducting Polymers and their r-GO-MO-Nanocomposites, Nano Magnetism (Core-Shell Magnetic materials for MRI), Nano Toxicology & Phytochemical synthesis of Nanomaterials

Honoursand Awards:

- Awardee of BOYSCAST Fellowship (DST, New Delhi) for the year 1999-2000.
- Awardee of Brain Pool scientist by Brain Pool program of KOFTS, South Korea, during July 2005-June 2006.
- Awardee of " RastriyaNirman Rattan" by Economic Growth Society of India, Delhi
- Awardee of "National Health leadership Award" by Health and Education Development Association, Delhi, 2012
- Listed in Marquis Who's who in Science and Engineering published by Marquis, USA, 2006-2007 and Who's Who in the World published by the same on upcoming 2009(26th Edn.)
- Awardee Institute –RA in CECRI, Karaikudi, (1995-1997).
- Direct CSIR-SRF from CSIR, India, 1991-1993
- Awardee of Student Membership from Electronic Division of Electrochemical Soc, Inc, USA, 1991-1994

Recent publications:

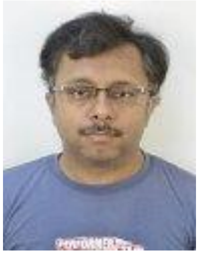
- Investigation of NH3 gas sensing behaviorof intercalated PPy–GO–WO3 hybrid nanocomposite at room temperature.
- Composites of π-stacking materials with low-dimensional metal oxide nanoblends for photocatalytic hydrogen production.
- Inspection of room temperature hydrogen sensing property of nanostructured polypyrrole/polyaniline hetero-junctions synthesized by one-pot interfacial polymerization.
- Surface bound nanostructures of ternary r-GO/Mn3O4/V2O5 system for room temperature selectivity of hydrogen gas.
- Size controllable, pH triggered reduction of bovine serum albumin and its adsorption behavior with SnO2/SnS2 quantum dots for biosensing application.

Total Publications: 65, Total Citation: 1248, h- index: 11, i10- index: 13

CURRICULUM VITAE

Name : **Dr. Jitendra Kumar**
Designation : Scientific officer.
Address : Nuclear agriculture and Biotechnology division
Bhabha Atomic Research Centre, Mumbai.

Email : jkumar@barc.gov.in



Educational qualification

Ph. D – University of Mumbai.
M. Sc – Indian Agricultural Research Institute
B. Sc - Banaras Hindu University.

Area of Research:

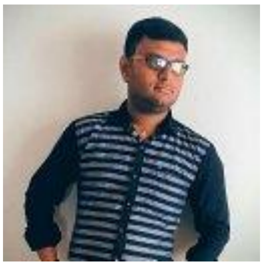
Biosensors.

Recent publications:

- Enhanced electromechanicsof morphology-immobilized co-continuous polymer blend/carbon nanotube high-range piezoresistive sensor.
- Carbon nanotube functionalization and radiation induced enhancements in the sensitivity of standalonechemiresistors for sensing volatile organic compounds.
- Network density tailored standalone-flexible fluorocarbon elastomer/nanocarbon black chemiresistors for 2-propanone field detection.
- Biodegradation of methyl parathion and its application in biosensors.
- Mechanical hysteresis, interface and filler–filler structural breakdowns in ethylene vinyl acetateorganoclay composites internally lubricated via radiolytically degraded PTFE.

Total Publications: 25, Total Citation: 486, h- index: 10, i10- I index: 11

CURRICULUM VITAE



Name : **Dr. N. Sudhan**
Designation : Assistant Professor
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Email : sudhamadhu@gmail.com

Educational qualification:

- Ph.D. - Alagappa University, Karaikudi.
- M. Sc. - Thiyagarajar College, Madurai.
- B.Sc. –Thiyagarajar College, Madurai.

Area of Research:

Chemo-Biosensors, DNA Microarray, Gold nanorods

Recent publications:

- Monitoring of Chemical Risk Factors For Sudden Infant Death Syndrome(SIDS) by Hydroxyapatite-Graphene-MWCNT Composite-Based Sensors.
- Manganese Doped Hydroxyapatite Nanoparticles Based Enzyme-Less Electrochemical Sensor for Detecting Hydroquinone.
- Electrochemical detection of estrus specific phenolic compound p-cresol to assess the reproductive phase of certain farm animals.
- Investigations on the effect of gamma-ray irradiation on the gas sensing properties of SnO_2 nanoparticles.
- Electrochemical detection of mercury using biosynthesized hydroxyapatite nanoparticles modified glassy carbon electrodes without preconcentration.

Total Publications: 8, Total Citation: 91, h- index: 4, i10- I index: 4