ALAGAPPA UNIVERSITY

(A State University Established in 1985)

Karaikudi - 630003. Tamil Nadu, India

2017 Accredited with A+ Grade by NAAC (CGPA : 3.64)

2018 MHRD Govt. of India UGC Graded as Category – I & Granted Autonomy

2018 MHRD Swachh Campus Rank : 4

2021 nirf National Institutional Ranking Framework Rank : 33

2021 QS University Rankings Asia Rank : 199

FACULTY OF SCIENCE

DEPARTMENT OF BIOELECTRONICS AND BIOSENSORS

M.Sc., MATERIALS SCIENCE

REGULATIONS AND SYLLABUS

(For the candidates admitted from the Academic Year 2022 - 2023)

DEPARTMENT OF BIOELECTRONICS AND BIOSENSORS
M.Sc., Materials Science

REGULATIONS AND SYLLABUS
[For the candidates admitted from the Academic Year 2022 – 2023 onwards]

ALAGAPPA UNIVERSITY
(A State University Accredited with "A+" grade by NAAC (CGPA: 3.64) in the Third Cycle and Graded as Category-I University by MHRD-UGC)
Karaikudi -630003, Tamil Nadu.

The panel of Members-Broad Based Board of Studies

Chairperson: Dr. C. Sekar, Professor and Head, Department of Bioelectronics and Biosensors, Alagappa University, Karaikudi. Areas of Expertise Materials Science: Metal Oxide Semiconductors, Carbon Nanostructures, Biomaterials, Low Dimensional Cuprates Sensors: Chemical Sensors, Biosensors for Medical, Food, Agricultural and Environmental Applications.	
Foreign Expert: Dr. Giovanni Neri, Professor, Department of Engineering, University of Messina. Italy. Areas of Expertise Catalysis, Gas Sensors, Biosensors.	
Indian Expert: Dr. J. Mathiyarasu, Principal Scientist, Biosensors Division, CSIR-Central Electrochemical Research Institute, India. Email: almathi@cecri.res.in. Areas of Expertise: Electrochemical Biosensors.	
Indian Expert: Dr. N. Rameshbabu, Associate Professor, Department of Metallurgy, National Institute of Trichy, Tamil nadu, India. Email: rameshrohith@gmail.com. Areas of expertise: Bio materials, Ceramic materials, Plasma electrolytic oxidation coatings	
Industry Expert: Dr. V. Viswabaskaran, The General Manager, VB ceramics, kottivakkam, Chennai, India. Email: drvbcrc@gmail.com, Area of Expertise: Ceramic Consultant	
Members: Dr. G. Ravi, Professor and Head, Department of Physics, Alagappa University, Karaikudi – 630003, Tamil Nadu, India. Email: raviganesa@rediffmail.com. Areas of Expertise: Crystal Growth of Organic & Inorganic Materials, Nano Materials Synthesis and Thin Films Preparation for Supercapacitors, Photocatalytic and Sensor Applications, Opto-Electronics and E-O Modulator–Devices	
Dr. V. Dharuman, Assistant Professor, Department of Bioelectronics and 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 of Bioelectronics & 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.	

Alumnus/Alumna: Mrs. S.Meenakshi, Research Scholar, Department of Bioelectronics and Biosensors, Karaikudi, India. Email: meenakshisolaimani@gmail.com. Areas of Expertise: Chemo-Biosensors, Shock waves.

ALAGAPPA UNIVERSITY
DEPARTMENT OF BIOELECTRONICS & BIOSENSORS
Karaikudi -630003, Tamil Nadu.

REGULATIONS AND SYLLABUS (CBCS-University Department)
[For the candidates admitted from the Academic Year 2022 – 2023 onwards]

Name of the Department **:** Bioelectronics & Biosensors
Name of the Programme **:** M.Sc., Materials Science
Duration of the Programme **:** Full Time (Two Years)

Choice-Based Credit System

A Choice-Based Credit System is a flexible system of learning. This system allows students to gain knowledge at their own tempo. Students shall decide on electives from a wide range of elective courses offered by the University Departments in consultation with the Department committee. Students undergo additional courses and acquire more than the required number of credits. They can also adopt an inter-disciplinary and intra-disciplinary approach to learning, and make the best use of the expertise of available faculty.

Programme

"Programme" means a course of study leading to the award of a degree in a discipline.

Courses

'Course' is a component (a paper) of a programme. Each course offered by the Department is identified by a unique course code. A course contains lectures/ tutorials/laboratory work/seminar/project work / practical training/report writing /Viva-voce, etc or a combination of these, to meet effectively the teaching and learning needs.

Credits

The Term "Credit" refers to the weightage given to a course, usually in relation to the instructional hours assigned to it. Normally in each of the course's credits will be assigned on the basis of the number of lectures/tutorial/laboratory and other forms of learning required to complete the course contents in a 15-week schedule. One credit is equal to one hour of lecture per week. For laboratory/field work one credit is equal to two hours.

Semesters

An Academic year is divided into two **Semesters.** In each semester, courses are offered in 15 teaching weeks and the remaining 5 weeks are to be utilized for conduct of examination and evaluation purposes. Each week has 30 working hours spread over 5 days a week.

Medium of Instruction

Medium of instruction is English

Departmental committee

The Departmental Committee consists of the faculty of the Department. The Departmental Committee shall be responsible for admission to all the programmes offered by the Department including the conduct of entrance tests, verification of records, admission, and evaluation. The Departmental Committee determine the deliberation of courses and specifies the allocation of credits semester-wise and course-wise. For each course, it will also identify the number of credits for lectures, tutorials, practical's, seminars etc. The courses (Core/Discipline Specific Elective/Non-Major Elective) are designed by teachers and approved by the Departmental Committees. Courses approved by the Departmental Committees shall be approved by the Board of Studies. A teacher offering a course will also be responsible for maintaining attendance and performance sheets (CIA -I, CIA-II, assignments and seminar) of all the students registered for the course. The non-major elective programme and MOOCs coordinator are responsible for submitting the performance sheet to the Head of the department. The Head of the Department consolidates all such performance sheets of courses pertaining to the programmes offered by the department. Then forward the same to be Controller of Examinations.

Programme Educational Objectives- (PEO)

PEO-1	To educate basics and applied aspects of materials science
PEO-2	To make the students understand the interdisciplinary activities of materials
PEO-3	To enhance critical thinking on societal issues in using materials
PEO-4	To adhere to ethical consideration for sustainable development
PEO-5	To design material adhering to environmental condition and cost effectiveness
PEO-6	To motivate the students to become researchers in materials advancements
PEO-7	To enhance analytical skills to solve research problem
PEO-8	To apply materials science for future technology
PEO-9	To inculcate strong research culture among materials science students
PEO-10	To enrich curiosity and expand knowledge through lifelong learning

Programme Specific Objectives-(PSO)

PSO-1	Learning fundamental knowledge in materials design and development
PSO-2	Training in using analytical instruments in materials characterization
PSO-3	Educating different forms of materials and their applications
PSO-4	Undertaking research problems in material science and solving
PSO-5	Effective implementation of materials in research and professional applications

Programme Outcome

PO 1	Attaining proficiency in fundamental knowledge in the field of materials science
PO 2	Grasping the basic principles of relevant scientific theories
PO 3	Applying knowledge to practical situations and solving real-world problems
PO 4	Conducting research to advance the understanding of materials science
PO 5	Employing techniques for the characterization and evaluation of materials
PO 6	Generating innovative solutions and ideas in materials science
PO 7	Optimizing material properties and performance for specific applications
PO 8	Developing the skills to synthesize and fabricate materials, prototypes
PO 9	Performing thorough analysis of material properties and behavior
PO 10	Applying critical thinking and use knowledge in interdisciplinary areas

Programme Specific Outcome

PSO 1	In-depth understanding of principles governing the properties and behavior of materials at the atomic and molecular level
PSO 2	Proficiency in applying physio-chemical theory, thermodynamic principles, structured and properties of materials to analyze and predict material responses
PSO 3	Expertise in material integration with biomolecules for sensors, synthesizing and tailoring the properties of materials for specialized applications
PSO 4	Advanced skills in synthesizing nanomaterials using cutting-edge techniques and characterization of materials with controlled properties for diverse applications
PSO 5	Knowledge of sustainable materials for sensors/molecular electronics and green chemistry principles for developing environmentally friendly devices in response to global challenges

Eligibility for admission

A candidate who has passed B.Sc., Degree Examination with Physics, or Chemistry or equivalent degree in Science with maths, physics or chemistry as allied subjects as University accepted by the syndicate as equivalent thereto.

Minimum Duration of programme

The programme is for a period of two years. Each year shall consist of two semesters viz. Odd and Even semesters. Odd semesters shall be from June / July to October / November and even semesters shall be from November / December to April / May. For each semester, there shall be 90 working days consisting of 6 teaching hours per working day (5 days/week).

Components

A PG programme consists of a number of courses. The term "course" is applied to indicate a logical part of the subject matter of the programme and is invariably equivalent to the subject matter of a "paper" in the conventional sense. The following are the various categories of the courses suggested for the PG programmes:

A. Core courses (CC)- "Core Papers" means "the core courses" related to the programme concerned including practical's and project work offered under the programme and shall cover Core competency, critical thinking, analytical reasoning, and research skill.
B. Discipline-specific electives (DSE) means the courses offered under the programme related to the major but are to be selected by the students, shall cover additional academic knowledge, critical thinking, and analytical reasoning.
C. Non-Major Electives (NME)- Exposure beyond the discipline
    - Students have to undergo a total of two Non-Major Elective courses with 2 credits offered by other departments (one in II Semester another in III Semester)
    - A uniform time frame of 3 hours on a common day (Tuesday) shall be allocated for the Non-Major Electives
    - Non-Major Elective courses offered by the departments pertaining to a semester should be announced before the end of previous semester.
    - Registration process: Students have to register for the Non-Major Elective course within 15 days from the commencement of the semester either in the department or NME portal (University Website).
D. Self-Learning Courses from MOOCs platforms.
    - MOOCs shall be on voluntary for the students.
    - Students have to undergo a total of 2 Self Learning Courses (MOOCs) one in II semester and another in III semester.
    - The actual credits earned through MOOCs shall be transferred to the credit plan of programmes as extra credits. Otherwise, 2 credits/course be given if the Self Learning

Course (MOOCs) is without credit.

- While selecting the MOOCs, preference shall be given to the course related to employability skills.

E. Projects / Dissertation /Internships **(**Maximum Marks: 200**)**

The student shall undertake the dissertation work during the fourth semester.

- **Plan of work**

Project/Dissertation

The candidate shall undergo Project/Dissertation Work during the final semester. The candidate should prepare a scheme of work for the dissertation/project and should get approval from the guide. The candidate, after completing the dissertation /project work, shall be allowed to submit it to the university departments at the end of the final semester. If the candidate is desirous of availing the facility from other departments/universities/laboratories/organizations they will be permitted only after getting approval from the guide and HOD. In such a case, the candidate shall acknowledge the same in their dissertation/project work.

- **Format to be followed for dissertation/project report**

The format /certificate for thesis to be followed by the student are given below

- Title page
- Certificate
- Acknowledgment
- Content as follows:

Chapter No	Title	Page number
1	Introduction	
2	Aim and objectives	
3	Review of literature	
4	Materials and methods	
5	Result	
6	Discussion	
7	Summary	
8	References	

- **Format of the title page**

Title of Dissertation/Project work

Dissertation submitted in partial fulfilment of the requirement for the degree of Master of Science in Material Science to the Alagappa University, Karaikudi -630003.

By

(Student Name)
(Register Number)
University Logo

Department of ----------

Alagappa University

(A State University Accredited with "A+" grade by NAAC (CGPA: 3.64) in the Third Cycle and Graded as Category-I University by MHRD-UGC, 2019: QS ASIA Rank-216, QS BRICS Rank-104,QS India Rank-20)

Karaikudi - 630003

(Year)

- **Format of certificates**

Certificate - Guide

This is to certify that the thesis entitled "----------" submitted to Alagappa University, Karaikudi-630 003 in partial fulfilment for the degree of Master of Science in ---------- by Mr/Mis ----------(Reg. No:----------) under my supervision. This is based on the results of studies carried out by him/her in the Department of----------, Alagappa University, Karaikudi-630 003. This dissertation/Project or any part of this work has not been submitted elsewhere for any other degree, diploma, fellowship, or any other similar titles or record of any University or Institution.

Place: Karaikudi Research Supervisor

Date:_____

Certificate - (HOD)

This is to certify that the thesis entitled **"----------"** submitted by Mr/**Mis ----------(Reg No: ----------)** to the Alagappa University, in partial fulfilment for the award of the degree of **Master of** --------in ---------- is a bonafide record of research work done under the supervision of **Dr.----------,** Assistant Professor, Department of----------, Alagappa University. This is to further certify that the thesis or any part thereof has not formed the basis of the award to the student of any degree, diploma, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi Head of the Department

Date:_____

Declaration (student)

I hereby declare that the dissertation entitled **"----------"** submitted to the Alagappa University for the award of the degree of Master of -------- in ---------- has been carried out by me under the guidance of **Dr. ----------**, Assistant Professor, Department of----------, Alagappa University, Karaikudi – 630 003. This is my original and independent work and has not previously formed the basis of the award of any degree, diploma, associateship, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi **(----------)**

Date:_____

Internship

The students who have opted for an Internship must undergo industrial training in the reputed organizations to accrue industrial knowledge in the final semester. The student has to find industry related to their discipline (Public limited/Private Limited/owner/NGOs etc.,) in consultation with the faculty in charge and get approval from the head of the department and Departmental Committee before going for an internship.

- **Format to be followed for Internship report**

The format /certificate for internship report to be followed by the student are given below

- Title page -**Format of the title page**
-

Title of internship report

Internship report submitted in partial fulfilment of the requirement for the Master of degree in ---------
to the Alagappa University, Karaikudi -630003.

By

(Student Name)

(Register Number)

University Logo

Department of ----------

Alagappa University

(A State University Accredited with "A+" grade by NAAC (CGPA: 3.64) in the Third Cycle and Graded as Category-I University by MHRD-UGC, 2019: QS ASIA Rank-216, QS BRICS Rank-104,QS India Rank-20)

Karaikudi - 630003

(Year)

- Certificate-**Format of certificate – faculty in-charge**

This is to certify that the report entitled "----------" submitted to Alagappa University, Karaikudi-630 003 in partial fulfilment for the Master of Science in ---------- by Mr/Mis---------- (Reg. No:----------) under my supervision. This is based on the work carried out by him/her in the organization M/S ----------. This Internship report or any part of this work has not been submitted elsewhere for any other degree, diploma, fellowship, or any other similar record of any University or Institution.

Place: Research Supervisor
Date:_____

Certificate (HOD)

This is to certify that the Internship report entitled **"----------"** submitted by Mr/Mis**.----------(Reg No:----------)** to the Alagappa University, in partial fulfilment for the award of the Master of Science in **-------** is a bonafide record of Internship report done under the supervision of ----------, Assistant Professor, Department of ----------, Alagappa University and the work carried out by him/her in the organization M/S ----------. This is to further certify that the thesis or any part thereof has not formed the basis of the award to the student of any degree, diploma, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi Head of the Department

Date:_____

- Certificate-**Format of certificate – Company supervisor or Head of the Organization**

This is to certify that the report entitled "----------" submitted to Alagappa University, Karaikudi-630 003 in partial fulfilment for the Master of Science in ----------by Mr/Mis---------- (Reg. No: ----------) under my supervision. This is based on the work carried out by him/her in our organization M/S ---------- for the period of three months or ------. This Internship report or any part of this work has not been submitted elsewhere for any other degree, diploma, fellowship, or any other similar record of any University or Institution.

Place: Supervisor or in charge
Date:_____

Declaration (student)

I hereby declare that the dissertation/project entitled **"----------"** submitted to the Alagappa University for the award of the **Master of Science in** ---------- has been carried out by me under the supervision of----------, Assistant Professor, Department of----------, Alagappa University, Karaikudi – 630 003. This is my original and independent work carried out by me in the organization M/S ---------- for the period of three months or ------ and has not previously formed the basis of the award of any degree, diploma, associateship, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi **(----------)**

Date:_____

- Acknowledgment
- Content as follows:

- **No. of copies of the dissertation/project report/internship report**

The candidate should prepare three copies of the dissertation/project/report and submit the same for the evaluation of examiners. After evaluation, one copy will be retained in the department library, one copy will be retained by the guide and the student shall hold one copy.

Teaching methods

Department teachers shall instruct using power point presentation along with white board and smart boards. Use of internet and library as and when required for effective learning

Attendance

Students must have earned 75% of attendance in each course for appearing for the examination. Students who have earned 74% to 70% of attendance need to apply for condonation in the prescribed form with the prescribed fee. Students who have earned 69% to 60% of attendance need to apply for condonation in the prescribed form with the prescribed fee along with the Medical Certificate. Students who have below 60% of attendance are not eligible to appear for the End Semester Examination (ESE). They shall re-do the semester(s) after completion of the programme

Examination

The examinations shall be conducted separately for theory and practicals to assess (remembering, understanding, applying, analysing, evaluating, and creating) the knowledge required during the study. There shall be two systems of examinations viz., internal and external examinations. The internal examinations shall be conducted as Continuous Internal Assessment tests I and II (CIA Test I & II).

A. Internal Assessment

The internal assessment shall comprise a maximum of 25 marks for each subject. The following procedure shall be followed for awarding internal marks.

Theory -25 marks

Sr.No	Content	Marks
1	Average marks of two CIA test	15
2	Seminar/group discussion/quiz	5
3	Assignment/field trip report/case study report	5
	Total	25

Practical -25 Marks

1	Major Experiment	10 marks
2	Minor Experiment	5 marks
3	Spotter (2x 5/ 4 x4) or any other mode	10 marks
	Total	25 Marks

Project/Dissertation/internship-50 Marks (assess by Guide/in-charge/supervisor)

1	Two presentations (mid-term)	30 Marks
2	Progress report	20 Marks
	Total	50 Marks

B. External Examination

- There shall be examinations at the end of each semester, for odd semesters in the month of October / November; for even semesters in April / May.
- A candidate who does not pass the examination in any course(s) may be permitted to appear in such failed course(s) in the subsequent examinations to be held in October / November or April / May. However, candidates who have arrears in Practical shall be permitted to take their arrear Practical examination only along with Regular Practical examination in the respective semester.
- A candidate should get registered for the first semester examination. If registration is not possible owing to shortage of attendance beyond condonation limit / regulation prescribed OR belated joining OR on medical grounds, the candidates are permitted to move to the next semester. Such candidates shall re-do the missed semester after completion of the programme.
- For the Project Report/ Dissertation Work / internship the maximum marks will be 100 marks for project report evaluation and for the Viva-Voce it is 50 marks (if in some programmes, if

the project is equivalent to more than one course, the project marks would be in proportion to the number of equivalent courses).

- Viva-Voce: Each candidate shall be required to appear for Viva-Voce Examination (in defense of the Dissertation Work /Project/ internship).

C. Scheme of External Examination (Question Paper Pattern)

Theory - Maximum 75 Marks

Section A	10 questions. All questions carry equal marks. (Objective type questions)	10 x 1 = 10 Marks	10 questions – 2 each from every unit
Section B	5 questions Either / or type like 1.a (or) b. All questions carry equal marks.	5 x 5 = 25	5 questions – 1 each from every unit
Section C	5 questions Either / or type like 1.a (or) b. All questions carry equal marks.	5 x8 = 40	5 question –Should cover all units

Practical –Maximum 75 Marks

Section A	Major experiment	15 Marks
Section B	Minor experiment	10 Marks
Section C	Experimental setup	5 Marks
Section D	Spotters (5 x5)	25 Marks
Section E	Record note	10 Marks
Section F	Vivo voce	10 Marks

Dissertation /Project report/Internship report Scheme of evaluation

Dissertation /Project report/Internship report	100 Marks
Vivo voce	50 Marks

Results

The results of all the examinations will be published through the Department where the student underwent the course as well as through University Website

Passing minimum

- A candidate shall be declared to have passed in each course if he/she secures not less than 40% marks in the End Semester Examinations and 40% marks in the Internal Assessment and not less than 50% in the aggregate, taking Continuous assessment and End Semester Examinations marks together.
- The candidates not obtained 50% in the Internal Assessment are permitted to improve their Internal Assessment marks in the subsequent semesters (2 chances will be given) by writing the CIA tests and by submitting assignments.

- Candidates, who have secured the pass marks in the End-Semester Examination and in the CIA but failed to secure the aggregate minimum pass mark (E.S.E + C I.A), are permitted to improve their Internal Assessment mark in the following semester and/or in University examinations.
- A candidate shall be declared to have passed in the Project Work if he /she gets not less than 40% in each of the Project Report and Viva-Voce and not less than 50% in the aggregate of both the marks for Project Report and Viva-Voce.
- A candidate who gets less than 50% in the Project Report must resubmit the Project Report. Such candidates need to take again the Viva-Voce on the resubmitted Project.

Grading of the Courses

The following table gives the marks, Grade points, Letter Grades and classifications meant to indicate the overall academic performance of the candidate.

Conversion of Marks to Grade Points and Letter Grade (Performance in Paper / Course)

RANGE OF MARKS	GRADE POINTS	LETTER GRADE	DESCRIPTION
90 - 100	**9.0 – 10.0**	**O**	**Outstanding**
80 - 89	**8.0 – 8.9**	**D+**	**Excellent**
75 - 79	**7.5 – 7.9**	**D**	**Distinction**
70 - 74	**7.0 – 7.4**	**A+**	**Very Good**
60 - 69	**6.0 – 6.9**	**A**	**Good**
50 - 59	**5.0 – 5.9**	**B**	**Average**
00 - 49	**0.0**	**U**	**Re-appear**
ABSENT	**0.0**	**AAA**	**ABSENT**

a) Successful candidates passing the examinations and earning GPA between 9.0 and 10.0 and marks from 90 – 100 shall be declared to have Outstanding (O).
b) Successful candidates passing the examinations and earning GPA between 8.0 and 8.9 and marks from 80 - 89 shall be declared to have Excellent (D+).
c) Successful candidates passing the examinations and earning GPA between 7.5 – 7.9 and marks from 75 - 79 shall be declared to have Distinction (D).
d) Successful candidates passing the examinations and earning GPA between 7.0 – 7.4 and marks from 70 - 74 shall be declared to have Very Good (A+).
e) Successful candidates passing the examinations and earning GPA between 6.0 – 6.9 and marks from 60 - 69 shall be declared to have Good (A).
f) Successful candidates passing the examinations and earning GPA between 5.0 – 5.9 and marks from 50 - 59 shall be declared to have Average (B).

g) Candidates earning GPA between 0.0 and marks from 00 - 49 shall be declared to have Re-appear (U).
h) Absence from an examination shall not be taken as an attempt.

From the second semester onwards the total performance within a semester and continuous performance starting from the first semester are indicated respectively **by Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA).** These two are calculated by the following formulate

GRADE POINT AVERAGE (GPA) = $\Sigma_i C_i G_i / \Sigma_i C_i$

$$\text{GPA} = \frac{\text{Sum of the multiplication of Grade Points by the credits of the courses}}{\text{Sum of the credits of the courses in a Semester}}$$

Classification of the final result

CGPA	Grade	Classification of Final Result
9.5 – 10.0	**O+**	First Class – Exemplary*
9.0 and above but below 9.5	**O**	
8.5 and above but below 9.0	**D++**	First Class with Distinction*
8.0 and above but below 8.5	**D+**	
7.5 and above but below 8.0	**D**	
7.0 and above but below 7.5	**A++**	First Class
6.5 and above but below 7.0	**A+**	
6.0 and above but below 6.5	**A**	
5.5 and above but below 6.0	**B+**	Second Class
5.0 and above but below 5.5	**B**	
0.0 and above but below 5.0	**U**	Re-appear

The final result of the candidate shall be based only on the CGPA earned by the candidate.

a) Successful candidates passing the examinations and earning CGPA between 9.5 and 10.0 shall be given Letter Grade (O+), those who earned CGPA between 9.0 and 9.4 shall be given Letter Grade (O) and declared to have First Class –Exemplary*.
b) Successful candidates passing the examinations and earning CGPA between 7.5 and 7.9 shall be given Letter Grade (D), those who earned CGPA between 8.0 and 8.4 shall be given Letter Grade (D+), those who earned CGPA between 8.5 and 8.9 shall be given Letter Grade (D++) and declared to have First Class with Distinction*.
c) Successful candidates passing the examinations and earning CGPA between 6.0 and 6.4 shall be given Letter Grade (A), those who earned CGPA between 6.5 and 6.9 shall be given Letter Grade (A+), those who earned CGPA between 7.0 and 7.4 shall be given Letter Grade (A++) and declared to have First Class.

d) Successful candidates passing the examinations and earning CGPA between 5.0 and 5.4 shall be given Letter Grade (B), those who earned CGPA between 5.5 and 5.9 shall be given Letter Grade (B+) and declared to have passed in Second Class.
e) Candidates those who earned CGPA between 0.0 and 4.9 shall be given Letter Grade (U) and declared to have Re-appear.
f) Absence from an examination shall not be taken as an attempt.

CUMULATIVE GRADE POINT AVERAGE (CGPA) = $\Sigma_n \Sigma_i C_{ni} G_{ni} / \Sigma_n \Sigma_i C_{ni}$

$$\text{CGPA} = \frac{\text{Sum of the multiplication of Grade Points by the credits of the entire Programme}}{\text{Sum of the credits of the courses for the entire Programme}}$$

Where '**Ci**' is the Credit earned for Course i in any semester; '**Gi**' is the Grade Point obtained by the student for Course i and 'n' refers to the semester in which such courses were credited.

CGPA (Cumulative Grade Point Average) = Average Grade Point of all the Courses passed starting from the first semester to the current semester.

Note: * The candidates who have passed in the first appearance and within the prescribed Semesters of the PG Programme are alone eligible for this classification.

Maximum duration of the completion of the programme

The maximum period for completion of **M.Sc.,/ M.A.,/ M.B.A/ B.Ed.,/ M.Ed.,/ B.P.Ed/ M.P.Ed** in ---------- shall not exceed eight semesters continuing from the first semester.

Conferment of the Master's Degree

A candidate shall be eligible for the conferment of the Degree only after he/ she has earned the minimum required credits for the Programme prescribed there for (i.e. 90 credits). Programme).

Village Extension Programme

The Sivaganga and Ramnad districts are very backward districts where a majority of people Lives in poverty. The rural mass is economically and educationally backward. Thus the aim of the introduction of this Village Extension Programme is to extend out to reach environmental awareness, social activities, hygiene, and health to the rural people of this region. The students in their third semester have to visit any one of the adopted villages within the jurisdiction of Alagappa University and can arrange various programs to educate the rural mass in the following areas for three day based on the theme.1. Environmental awareness 2. Hygiene and Health. A minimum of two faculty members can accompany the students and guide them.

M.Sc., –Materials Science- Programme Structure

S. No	Paper Code	Title of the paper		T/P	Credits	Hours/ Week	Marks		
I Semester							**I**	**E**	**Total**
1	542101	Core 1	Materials Physics	T	5	5	25	75	100
2	542102	Core 2	Thermodynamics	T	5	5	25	75	100
3	542103	Core 3	Electronics and Instrumentation	T	4	4	25	75	100
4	542104	Core 4	Electromagnetic Theory and Optics	T	4	4	25	75	100
6	542105	Core 5	Lab-I : Electrical and Optical Characterization	P	4	8	25	75	100
7		Discipline Specific Elective (DSE) – I		T	3	3	25	75	100
		Library / Yoga/ Counselling/Field trip				1			
					25	**30**	**150**	**450**	**600**
II Semester									
8	542201	Core 6	Materials Chemistry	T	4	4	25	75	100
9	542202	Core 7	Characterization of Materials	T	4	4	25	75	100
10	542203	Core 8	Quantum Mechanics	T	4	4	25	75	100
11	542204	Core 9	Crystal Growth	T	4	4	25	75	100
12	542205	Core 10	Lab-II: Materials Synthesis and Characterization	P	4	8	25	75	100
13		Discipline Specific Elective (DSE) - II		T	3	3	25	75	100
14		Non-Major Elective :1		T	2	3	25	75	100
15		Self-learning course (SLC) –MOOCs**			Extra credit				
					25	**30**	**175**	**525**	**700**
III Semester									
15	542301	Core 11	Nanomaterials	T	4	4	25	75	100
16	542302	Core 12	Polymer and Composite Materials	T	4	4	25	75	100
17	542303	Core 13	Solid State Physics	T	4	4	25	75	100
18	542304	Core 14	Ceramic Materials	T	4	4	25	75	100
19	542305	Core 15	Lab-III: Device Characterization	P	4	8	25	75	100
20		Discipline Specific Elective (DSE) – III		T	3	3	25	75	100
21		Non-Major Elective:2		T	2	3	25	75	100
22		Self-learning course (SLC) –MOOCs**			Extra credit				
					25	**30**	**175**	**525**	**700**
IV Semester									
23	542999	Core 16	***Project Dissertation Work or Internship programme	P	15	30	50	150	200
					15	**30**	**50**	**150**	**200**
			Total		**90 +**		**550**	**1650**	**2200**

*DSE – Discipline Specific Elective.

**SLC- Voluntary basis

*** Dissertation / internship report –Marks -Vivo-voce (50) + thesis (100) + internal (50) = 200

T-Theory
P-Practical

Non-Major Elective-Courses offered to the other Department

S. No.	Paper Code	Semester	Title of the paper	Credits	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	Nanomaterials Biosensors	2	3	25	75	100
4	542704	III	Green Chemistry	2	3	25	75	100

DISCIPLINE SPECIFIC ELECTIVE (DSE)

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	Molecular Spectroscopy	3	3
8	542508	Semiconductor Materials and Devices	3	3
9	542509	Physical Metallurgy	3	3
10	542510	Materials Processing	3	3
11	542511	Corrosion Science and Engineering	3	3
12	542512	Solid State Ionics	3	3
III SEMESTER				
13	542513	Biosensors	3	3
14	542514	Bioelectronics	3	3
15	542515	Chemical Sensors	3	3
16	542516	Thin Film Science and Technology	3	3
17	542517	Superconducting Materials and Applications	3	3

I-SEMESTER					
Core 1	**Course code:542101**	**Materials Physics**	**T**	**Credits: 5**	**Hours:5**

Unit - I

Objective 1	**To introduce the concepts of various mechanical test and plastic deformation the students.**

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.

Outcome 1	**Students gain knowledge in mechanical tests and plastic deformation mechanisms.**	**K2**

Unit - II

Objective 2	**To introduce various dielectric materials and application.**

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.

Outcome 2	**Students know the application and various properties of dielectric materials.**	**K4**

Unit - III

Objective 3	**To expose different types of magnetic materials and properties.**

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.

Outcome 3	**Learners make use of fundamental magnetic materials properties and their application.**	**K4**

Unit - IV

Objective 4	**To study the properties of various optical materials, LED and LCD and applications.**

Optical Properties - Optical absorption in insulators, semiconductors and metals – band to band absorption – luminescence - photoconductivity. Injection luminescence and LEDs- LED materials - super luminescent LED materials - liquid crystals - properties and structure - liquid crystal displays-comparison between LED and LC displays.

Outcome 4	**Learners gain knowledge of optical materials properties and applications.**	**K2**

Unit - V

Objective 5	**To make the students understand about various properties of smart materials, shape. memory alloys CCD and nanomaterials and applications.**

Advanced Materials - Metallic glasses - preparation, properties and applications - SMART materials - piezoelectric, magneto strictive, electro strictive 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.

Outcome 5	**Learners understand the basic knowledge about advanced materials and preparation methods for nanomaterials and their properties.**	**K5**

Suggested Readings:-

Kasap S.O. (2019). *Principles of Electronic Materials and Devices*. McGraw-Hill Education.

OtsukaK. And WaymanC.M. (1998). *Shape Memory Materials*, Cambridge University Press.

RaghavanV. (2015). *Materials Science and Engineering: A First Course*. PHI Learning.

Online resources:-

Understanding the physical properties of hybrid perovskites for photovoltaic applications. Nat Rev Mater 2, 17042 (2017). https://doi.org/10.1038/natrevmats.2017.42

A review on metallic porous materials: pore formation, mechanical properties, and their applications. Int J Adv Manuf Technol 95, 2641–2659 (2018). https://doi.org/10.1007/s00170-017-1415-6.

A review of shape memory alloy research, applications and opportunities, 56, 2014, 1078-1113, https://doi.org/10.1016/j.matdes.2013.11.084

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Designed by: Dr. J. Wilson

Course Outcome

CO 1	Understand the basic principles of materials	**K1, K2**
CO 2	Gain the knowledge of various behaviors of materials	**K2, K3**
CO 3	Understand and design the material based on their properties	**K5**
CO 4	Expertise in learning the specified material for different application	**K3, K4**
CO 5	Explore the knowledge of sustainable material for device fabrication	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	S (3)	S (3)	L (1)	L (1)	L (1)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	S (3)	L (1)	L (1)	L (1)	S (3)	M (2)	S (3)	S (3)
CO 3	S (3)	S (3)	S (3)	M (2)	S (3)	M (2)	M (2)	L (1)	S (3)	S (3)
CO 4	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	M (2)
CO 5	M (2)	M (2)	S (3)	S (3)	M (2)	L (1)	L (1)	S (3)	M (2)	S (3)
W. AV	**2.8**	**2.8**	**3**	**1.8**	**1.8**	**1.4**	**2**	**2.2**	**2.8**	**2.8**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	L (1)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	S (3)	M (2)	S (3)	M (2)	S (3)
CO 4	S (3)	M (2)	M (2)	S (3)	S (3)
CO 5	S (3)	M (2)	M (2)	M (2)	M (2)
W. AV	**3**	**2.2**	**2.2**	**2**	**2.8**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
Core 2	**Course code:542102**	**Thermodynamics**	**T**	**Credits: 5**	**Hours: 5**

Unit - I

Objective 1	**To understand mechanical aspects of systems and mathematical methods of classical mechanics**	

LAGRANGIAN AND HAMILTONIAN DYNAMICS-Mechanics of single and system of particles - Conservation laws – Constraints - Generalized 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.

Outcome 1	**Learners understand basics of Lagrangian and Hamiltonian dynamics that provides deeper understanding in classical mechanics**	**K1**

Unit - II

Objective 2	**To discover the common abstractions and mechanisms greatly facilitates the complex system using canonical forms.**	

CANONICAL TRANSFORMATION, BRACKETS AND RIGID BODY- Canonical transformation – Generating functions - Poisson brackets - Lagrange brackets - Relation between Lagrange and Poisson brackets-Jacobi Identity. Rigid body dynamics: Euler's angles- -Angular velocity – Principal moment of inertia -Kinetic energy.

Outcome 2	**Learners understand applications of Canonical Transformations in defining movement of particles using different coordinates and laws of motion**	**K1, K2**

Unit - III

Objective 3	**To understand the concepts laws of thermodynamics its applications and phase equilibria.**	

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.

Outcome 3	**Students learn the application of laws of thermodynamics in designing automobile engines, refrigerators, air conditioners**	**K1, K2, K3**

Unit - IV

Objective 4	**To understand the statistical mechanics of systems, probability distribution laws**	

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.

Outcome 4	**Learners get knowledge on the applications of Maxwell, Boltzmann Fermi Dirac statistical in thermodynamical methods**	**K3, K5**

Unit - V

Objective 5	**To analyze the applications of statistical thermodynamical methods in solid state physics.**	

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.

Outcome 5	**Students gain knowledge on the application of statistics in practice.**	**K5, K6**

Suggested Readings:-

Callen.H.B. (1966).*Thermodynamics*. John Wiley and Sons.

Engel. T. andReid.P. (2007). *Thermodynamics, Statistical Thermodynamics & Kinetics*, Pearson Edu.

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.

Online resources:- (http://hyperphysics.phy-astr.gsu.edu/hbase/thermo.html) (https://www.engineeringmindset.com/thermodynamics-explained/) (https://www.youtube.com/watch?v=7KXV7omzP6I)					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**
Course designed by: Dr. V. Dharuman					

Course Outcome

CO 1	Understand the basics of Lagrangian and Hamiltonian dynamics that provides deeper understanding in classical mechanics	**K1**
CO 2	Defining applications of Canonical Transformations in defining movement of particles using different coordinates and laws of motion	**K1, K2**
CO 3	Understand the application of laws of thermodynamics in designing automobile engines, refrigerators, air conditioners	**K1, K2, K3**
CO 4	Get knowledge on the applications of Maxwell, Boltzmann Fermi Dirac statistical in thermodynamical methods	**K3, K5**
CO 5	Gain knowledge on the application of statistics in practice.	**K5, K6**

Course outcome Vs Programme outcome

PO/ CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	M (2)	S (3)	S (3)	M (2)	L (1)	M (2)	M (2)	S (3)	M (2)	M (2)
CO 2	L (1)	M (2)	M (2)	L (1)	M (2)	L (1)	M (2)	M (2)	M (2)	L (1)
CO 3	S (3)	M (2)	L (1)	M (2)	M (2)	L (1)	M (2)	S (3)	L (1)	L (1)
CO 4	S (3)	M (2)	M (2)	L (1)	M (2)	S (3)	M (2)	M (2)	M (2)	L (1)
CO 5	L (1)	L (1)	L (1)	L (1)	M (2)	L (1)	S (3)	M (2)	M (2)	L (1)
W. AV	**2**	**2**	**1.8**	**1.6**	**1.8**	**1.6**	**2.2**	**2.4**	**1.8**	**1.2**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	S (3)	M (2)	L (1)	L (1)
CO 2	M (2)	S (3)	M (2)	M (2)	M (2)
CO 3	S (3)	M (2)	L (1)	L (1)	M (2)
CO 4	L (1)	M (2)	M (2)	M (2)	L (1)
CO 5	M (2)	L (1)	M (2)	L (1)	M (2)
W. AV	**2.1**	**2.1**	**1.8**	**1.2**	**1.6**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
Core 3	**Course code :542103**	**Electronics and Instrumentation**	**T**	**Credits: 4**	**Hours: 4**

Unit - I

Objective 1	**To understand the concept of analog electronics**

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.

Outcome 1	**Getting Knowledge in analog amplifiers and their functions**	**K1, K2**

Unit - II

Objective 2	**To gain knowledge in advanced concepts of digital electronics**

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.

Outcome 2	**Learn the operational principle of digital amplifiers and their functions**	**K2, K3**

Unit - III

Objective 3	**To learn concepts of optoelectronics**

OPTOELECTRONICS- LEDs – semiconductor lasers – photodiodes – solar cells – photodetectors – optical fibers – communication – optoelectronic modulation and switching devices – optocoupler– optical data storage devices.

Outcome 3	**Knowing the optical applications of semiconductors and their functions**	**K5**

Unit - IV

Objective 4	**To understand knowledge in designing electronic instruments**

ELECTRONIC INSTRUMENTATION - Basics of instrumentation system – transducers – types of transducers – strain gauges – RTDs – LVDT – piezoelectric transducers – load cell – flow meters – signal conditioning – data acquisition and conversion – data transmission.

Outcome 4	**Getting detailed idea on material applications in instrumental development**	**K3, K4**

Unit - V

Objective 5	**To study basic concepts of nanoelectronics in materials perspective**

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.

Outcome 5	**Knowing the recent advancement in transistor applications**	**K1, K6**

Suggested Readings

Bhattacharya P. (2019). *Semiconductor Optoelectronic Devices*. Pearson Education.
Chua L.O. Desoer C. AandKuh 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.
Horowitz Pand Hill W. (2006). *Art of electronics*. Cambridge Univ. Press.
Kalsi H.S. (2017). *Electronic Instrumentation*. McGraw Hill Education.

Online resources

All About Circuits (https://www.allaboutcircuits.com/)

Electronics Hub (https://www.electronicshub.org/) Electronics Hub offers a wide range of electronics tutorials, projects, and guides, including instrumentation-related content.

Adafruit Blog (https://blog.adafruit.com/) Adafruit is a prominent electronics manufacturer, and their blog features tutorials, project ideas, and product reviews related to electronics and instrumentation.

K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**

Course designed by: Dr. C. Sekar

Course Outcome

CO 1	Analyze and design circuits for signal processing and amplification	**K1, K2**
CO 2	Design and implement digital circuits using logic components.	**K2, K3**
CO 3	Understand and design optoelectronic devices and systems.	**K5**
CO 4	Apply electronic measurement techniques and design data acquisition systems.	**K3, K4**
CO 5	Explore nanoscale electronic devices, fabrication techniques, and design principles.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
Core 4	**Course code:542104**	**Electromagnetic Theory and Optics**	**T**	**Credits: 4**	**Hours: 4**
Unit - I					
Objective 1	**To know the fundamentals of Maxwell's equations are their applications in different situations.**				
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.					
Outcome 1	**Derive Maxwell's equations and apply them to study the electrostatics and magneto statics.**				**K1, K2**
Unit - II					
Objective 2	**To get insight on fundamental laws of optics and its relation with Maxwell's Equation**				
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.					
Outcome 2	**Understand boundary conditions between different materials and reflection and refraction of light based on Maxwell's equations**				**K2, K3**
Unit - III					
Objective 3	**To Study the novel calculus of tensors and illustrate their usage in different Material properties**				
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.					
Outcome 3	**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.**				**K3, K4**
Unit - IV					
Objective 4	**Understand the various optical activities and their applications in material characterization**				
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.					
Outcome 4	**Elucidate how optical activities occur in materials and how they can be used to further characterize materials.**				**K2, K4**
Unit - V					
Objective 5	**To know the basics of non-linear optical effects and non-linear optical materials**				
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.					
Outcome 5	**Apprehend the fundamentals of Non-linear optical effects, the nature of materials exhibiting such properties, and their applications**				**K3, K5**

Suggested Readings:-

Corson D. and Lorrain P. (2013).*Introduction to Electromagnetic Fields and Waves*, Literary Licensing, LLC.
FleischD. (2008). *A student's Guide to Maxwell's Equations*. Cambridge University Press.
Griffiths D.J. (2015). *Introduction to Electrodynamics*. Pearson Education.
JordanE.Cand Balmain K.G (2015). *Electromagnetic Waves and Radiating Systems*. Pearson Education.
New G. (2014). *Introduction to Nonlinear Optics*, Cambridge University Press.

Online resources:-

Walter Lewin's MIT Lectures on Electricity and Magnetism (https://www.youtube.com/playlist?list=PLyQSN7X0ro203puVhQsmCj9qhlFQ-As8e)
NPTEL - Electromagnetic Theory (https://nptel.ac.in/courses/115/105/115105132/)
Optics 101 - Crash Course Physics (https://www.youtube.com/watch?v=8Jr-8_pgnq8)

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. S. Saravana kumar

Course Outcome

CO 1	Attain proficiency in theory of magnetism and magnetic induction.	**K1, K2**
CO 2	Understand the boundary behavior and condition of EM waves.	**K2, K3**
CO 3	Appreciate the advanced properties of materials.	**K3, K4**
CO 4	Elucidate optical activities occur in materials.	**K2, K4**
CO 5	Learn about the nonlinear optics theory and materials.	**K3, K5**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)	S (3)
CO 2	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)
CO 5	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)
W. AV	**2.6**	**2.8**	**3**	**2.8**	**2.6**	**3**	**2.8**	**2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	M (2)	S (3)	L (1)	L (1)	L (1)
CO 2	M (2)	S (3)	M (2)	L (1)	L (1)
CO 3	M (2)	S (3)	M (2)	M (2)	M (2)
CO 4	S (3)	S (3)	S (3)	M (2)	M (2)
CO 5	M (2)	S (3)	M (2)	M (2)	M (2)
W. AV	**2.2**	**3**	**2.0**	**1.8**	**1.8**

S –Strong (3), M-Medium (2), L- Low (1)

Core 5	Course code 542105	LAB I Electrical and Optical Characterization	P	Credits: 4	Hours: 8
Objectives	The main objective of the course is to impart knowledge on design and methodology for investigation of various optical and electrical properties of materials. In addition, the course is designed a. To make the students realise the importance of investigating material properties b. To introduce the concepts of various optical techniques. c. To introduce the students about various electrical materials and their application. d. To expose the students to magnetic materials and their properties. e. To educate electrochemical behaviour of materials and their characterization				
	1. Optical band gap determination. UV-visible spectrometric method 2. Photoluminescence properties of metal oxides 3. UV – visible characterization of polymers 4. Fluorescence spectral behavior of organic polymers 5. Fluorescence properties of carbon materials 6. Fluorescence properties of metal composites 7. Electrical conductivity of metals and alloys with temperature-four probe method. 8. Hall effect - Determination of Hall co-efficient, charge carrier density and mobility. 9. Magnetic susceptibility-Quincke's method. 10. Crystal Growth-Solution technique. 11. Crystal Growth-Gel technique. 12. Ferroelectricity – Hysteresis loop - coercivity, retentivity and saturation magnetization. 13. Fraunhofer diffraction - using laser 14. Cyclic voltammetric characterization of electrode materials 15. Electrochemical impedance characterization of electrode/electrolyte interface 16. Chronoamperometric technique for analyte detection using sensor materials 17. Differential pulse voltammetric analysis of analyte using sensor materials				
Outcome	After the completion of the course, students come familiar with various experiments to investigate the optical and electrical properties of materials. With the hand on training, they understand the importance of investigating material properties to decide about the materials quality and potential application of the materials.				

I-SEMESTER					
DSE	**Course code :542501**	**Biomaterials**	**T**	**Credits: 3**	**Hours: 3**

Unit I		
Objective 1	**To introduce the response of biomaterials to host environment, and host response to biomaterials.**	
BIOLOGICAL PERFORMANCE OF MATERIALS -Biocompatibility- introduction to the biological environment – material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear – host response: the inflammatory process - coagulation and hemolysis- approaches to thrombo- resistant materials development.		
Outcome 1	**Understand the response of biomaterials environment conditions, biocompatibility of the material, and host response to biomaterials.**	**K1/ K5**
Unit II		
Objective 2	**To introduce various materials used in bone and joint replacement**	
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, bioglass and glass ceramics – polymers: PMMA, UHMWPE/HDPE, PTFE – bone cement – composites		
Outcome 2	**Understand the biomaterials of metals/alloys used in bone and joint replacement.**	**K3/K4**
Unit III		
Objective 3	**To gain knowledge about materials used in cardiovascular implants.**	
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.		
Outcome 3	**Understand fundamentals of nano-electronic devices and MEMS**	**K3/K5**
Unit IV		
Objective 4	**To know about dental materials and dental implants.**	
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.		
Outcome 4	**Understand the mechanical properties of dental implants.**	**K1/K5**
Unit V		
Objective 5	**To impart knowledge on soft tissue and drug delivery materials.**	
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.		
Outcome 5	**Understand the biomaterials used for ophthalmology.**	**K2/K5**

Suggested Readings:-

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.

Online Resources:- http://acikerisim.btu.edu.tr/xmlui/handle/20.500.12885/1157#:~:text=https%3A//hdl.handle.net/20.500.12885/1157. https://mme.deu.edu.tr/wp-content/uploads/2017/10/biomaterials.pdf.					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**

Course Outcome

CO 1	Analyze the response of biomaterials to host environment, Biocompatibility of the material, and host.	**K1/ K3**
CO 2	Design and understand the biomaterials of metals and alloys used in bone and joint replacement.	**K3/ K4**
CO 3	Understand the fundamentals of nano-electronic devices and MEMS and selection of materials.	**K3/K5**
CO 4	Analyze the mechanical properties of impression material for dental implants.	**K1/ K5**
CO 5	Explore the biomaterials used for ophthalmology.	**K2/ K5**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
DSE	**Course code :542502**	**Molecular Electronics**	**T**	**Credits: 3**	**Hours: 3**

Unit I

Objective 1	**To understand the molecular nanotechnology and its applications in electronic devices.**

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.

Outcome 1	**Understand the molecular and atomic size of nanoparticles, top down and bottom-up approaches of nanomaterials.**	**K1, K5/K6**

Unit II

Objective 2	**To introduce various materials used in bone and joint replacement**

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.

Outcome 2	**Select different carbon materials for required applications.**	**K3/K6**

Unit III

Objective 3	**To gain knowledge about materials used in cardiovascular implants.**

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

Outcome 3	**Understand fundamentals of nano-electronic devices and MEMS and selection of materials**	**K1/K3/K5**

Unit IV

Objective 4	**To know about dental materials and dental implants.**

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

Outcome 4	**Select molecules to construct conducting wires, rectify, switches and DNA conductors and their role in molecular computer and DNA molecular devices.**	**K1/K5/K6**

Unit V

Objective 5	**To impart knowledge on soft tissue and drug delivery materials.**

FLEXIBLE ELECTRONIC DEVICES - Electroactive organic molecules, Plastic Electronics, Electrical conduction in ploymers, Donor molecules, Acceptor molecules, Optoelectronic devices: OLEDs, OTFTs.

Outcome 5	**Students select polymeric materials with suitable electrical and physical characteristics for desired electronic flexible devices in optoelectronics.**	**K2/K5/K6**

Suggested Readings :-

Swal 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.

Online Resources:-

Flexible Electronics - an overview | ScienceDirect Topics

Flexible Electronics: Stretchable Electrodes and Their Future - Huang - 2019 – Advanced Functional Materials - Wiley Online Library

Frontiers | Flexible Electronics and Healthcare Applications (frontiersin.org)

Flexible Electronic Devices for Biomedical Applications | SpringerLink

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Understand the molecular and atomic size of nanoparticles,	**K1, K2**
CO 2	Select the different carbon materials for required applications.	**K2, K3**
CO 3	Understand the fundamentals of nano-electronic devices and MEMS and selection of materials	**K5**
CO 4	Select molecules to construct conducting wires, rectify, switches and DNA conductors and their role in molecular computer and DNA molecular devices.	**K3, K4**
CO 5	Impart knowledge on soft tissue and drug delivery materials.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.2***	***2.2***	***2.2***	***2.6***	***3***

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
DSE	**Course code:542503**	**Non-Destructive Testing**	**T**	**Credits: 3**	**Hours: 3**

Unit I

Objective 1	**To introduce the students to liquid penetrant and magnetic particle inspection.**

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.

Outcome 1	**Students learn about liquid penetrant and magnetic particle inspection.**	**K1, K5/K6**

Unit II

Objective 2	**To make the students understand the principle, working and uses of radiographic testing**

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 – non imaging detectors – film radiography – calculation of exposure for X-ray and gamma rays – quality factors – Image quality indications and their use in radiography – neutron radiography.

Outcome 2	**Students understand the principle, working and uses of radiographic testing.**	**K3/K6**

Unit III

Objective 3	**To impart knowledge about the ultrasonic testing**

ULTRASONIC TESTING - Ultrasonic waves – velocity, period, frequency and wavelength – reflection and transmission – near and far field effects and attenuation – generation – piezoelectric and magnetostriction 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.

Outcome 3	**Students gain knowledge on ultrasonic testing.**	**K1/K3/K5**

Unit IV

Objective 4	**To make the students understand the principle, working and application of eddy current technique.**

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.

Outcome 4	**Students able to apply their knowledge on eddy current technique.**	**K1/K5/K6**

Unit V

Objective 5	**To expose the thermal and optical methods used in NDT.**

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.

Outcome 5	**Students able to analyze the thermal and optical methods used in NDT.**	**K2/K5/K6**

Suggested Readings :-

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.

Online Resources:-

Flexible Electronics - an overview | ScienceDirect Topics

Flexible Electronics: Stretchable Electrodes and Their Future - Huang - 2019 – Advanced Functional Materials - Wiley Online Library

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Learn about liquid penetrant and magnetic particle inspection.	**K1, K2**
CO 2	Understand the principle, working and uses of radiographic testing.	**K2, K3**
CO 3	Gain knowledge on ultrasonic testing.	**K5**
CO 4	Apply their knowledge on eddy current technique.	**K3, K4**
CO 5	Analyze the thermal and optical methods used in NDT.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
DSE	**Course code:542504**	**Nonlinear Optics and Materials**	**T**	**Credits: 3**	**Hours: 3**

Unit I		
Objective 1	**To introduce the concepts of electromagnetic theory and refractive index of materials.**	
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.		
Outcome 1	**Understand the concept of electromagnetic theory.**	**K1, K5/K6**

Unit II		
Objective 2	**To expose the students, the concept of optical susceptibility.**	
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.		
Outcome 2	**Appreciate the importance of optical susceptibility and nonlinear optical susceptibilities.**	**K3/K6**

Unit III		
Objective 3	**To make the students to understanding the concept of second order non linearity.**	
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).		
Outcome 3	**Reveal the origin of second harmonic generation and other second nonlinear optical processes and techniques.**	**K1/K3/K5**

Unit IV		
Objective 4	**To introduce the processes of third order nonlinear optical effects.**	
THIRD-ORDER NONLINEARITIES - Third harmonic generation – four-wave mixing – Kerr nonlinearity – intensity dependent effect – self-phase modulation – crossphase 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.		
Outcome 4	**Understand the important third order optical nonlinearities, theory and applications.**	**K1/K5/K6**

Unit V		
Objective 5	**To make the students to understand the properties of non-linear optical materials.**	
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.		
Outcome 5	**Gain knowledge on the properties of non-linear optical materials and polymers.**	**K2/K5/K6**

Suggested Readings :-

loembergen 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.

Online Resources:-
Bobo Gu, Chujun Zhao, Alexander Baev, Ken-Tye Yong, Shuangchun Wen, and Paras N. Prasad, Molecular nonlinear optics: recent advances and applications, Vol. 8, Issue 2, pp. 328-369 (2016), https://doi.org/10.1364/AOP.8.000328.
Anton Autere, Henri Jussila, Yunyun Dai, Yadong Wang, Harri Lipsanen, Zhipei Sun, Nonlinear Optics with 2D Layered Materials, 25 March 2018 https://doi.org/10.1002/adma.201705963.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Understand the concept of electromagnetic theory.	**K1, K2**
CO 2	Appreciate the importance of optical susceptibility.	**K2, K3**
CO 3	Reveal the origin of second harmonic generation and other second nonlinear optical processes.	**K5**
CO 4	Understand the important third order optical nonlinearities.	**K3, K4**
CO 5	Gain knowledge on the properties of non-linear optical materials.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
DSE	**Course code :542505**	**Laser and Applications**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To make the students understand about theoretical studies on laser systems.**

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.

Outcome 1	**Students understand the principle involved in Einstein coefficients and action of laser.**	**K1**

Unit - II

Objective 2	**To impact the basic knowledge on laser system compound among the learners.**

OPTICAL RESONATORS- Resonant cavities, Gaussian beam characteristics, resonator modes, spot size – Types of resonators, geometries, quality factor of an optical resonator – Q-switching and Modelocking concepts and techniques.

Outcome 2	**Students gain knowledge on laser compound and Q switching mode focusing concepts.**	**K3**

Unit - III

Objective 3	**To introduce the knowledge about various laser systems among the students.**

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 – homojunction and heterojunction laser - Liquid Lasers: Dye lasers.

Outcome 3	**Learners make use of the basic knowledge about various laser systems working methods.**	**K2**

Unit - IV

Objective 4	**To know about laser system used for materials processing.**

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.

Outcome 4	**The students gain knowledge on various laser processing methods and advantages.**	**K4**

Unit - V

Objective 5	**To impart knowledge on the laser applications among the students**

APPLICATIONS Metrology - 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.

Outcome 5	**The students know the laser applications on industrial and medical fields.**	**K5**

Suggested Readings:-

Charchan S.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.

Online resources:-

Hunter JG, Bowers JH, Burt RW, Sullivan JJ, Stevens SL, Dixon JA. Lasers in endoscopic gastrointestinal surgery. Am J Surg. 1984;148(6):736–41 https://doi.org/10.1016/0002-9610(84)90427-6.

Khalkhal, E., Rezaei-Tavirani, M., Zali, M. R., & Akbari, Z. (2019). The Evaluation of Laser Application in Surgery: A Review Article. Journal of Lasers in Medical Sciences, 10(Supplement), S104-S111. Retrieved from https://journals.sbmu.ac.ir/jlms/article/view/27719.

Jill Canin Endres MD, Randolph M. Steinhagen MD, Lasers in Anorectal Surgery, https://doi.org/10.1016/S0039-6109(16)46490-X.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Understood the principle involved in Einstein coefficients and action of laser.	**K1, K2**
CO 2	Gain knowledge on laser compound and Q switching mode focusing concepts.	**K2, K3**
CO 3	Learners make use of the basic knowledge about various laser systems working methods.	**K5**
CO 4	Gain knowledge on various laser processing methods and advantages.	**K3, K4**
CO 5	Know the laser applications on industrial and medical fields.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
DSE	**Course code:542506**	**Python Programming**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To make the students understand and to introduce the concepts of algorithms and developing them.**

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.

Outcome 1	**Students understand the principle involved in Developing algorithms.**	**K2**

Unit - II

Objective 2	**To make the students to understand different types of data, expressions and statements in Python environment.**

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.

Outcome 2	**Students understand various types of things in Python environment.**	**K4**

Unit - III

Objective 3	**To introduce the knowledge about various laser systems among the students.**

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.

Outcome 3	**Learners make use of control flow and functions in Python environment.**	**K1**

Unit - IV

Objective 4	**To introduce the concepts of lists, tuples and dictionaries in Python environment.**

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.

Outcome 4	**Students understand to use Python environment.**	**K5**

Unit - V

Objective 5	**To make the students to use files, modules and packages.**

Files, Modules, Packages -Files and exception: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file.

Outcome 5	**The students use Python programming environment.**	**K2**

Suggested Readings:-

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.

Online resources:-					
A Bogdanchikov et al, Python to learn programming, 2013 J. Phys.: Conf. Ser. 423 012027, DOI 10.1088/1742-6596/423/1/012027. Calico: A multi-programming-language, multi-context framework designed for computer science education, D Blank, JS Kay, JB Marshall, K O'Hara, M Russo					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**

Course Outcome

CO 1	Understand the principle involved in Developing algorithms.	**K1, K2**
CO 2	Understand different types of data, expressions and statements in Python environment.	**K2, K3**
CO 3	Make use of control flow and functions in Python environment.	**K5**
CO 4	Understand and use lists, tuples and dictionaries in Python environment.	**K3, K4**
CO 5	Use files, modules and packages of Python programming environment.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

II-SEMESTER					
Core 6	**Course code:542201**	**Materials Chemistry**	**T**	**Credits: 4**	**Hours: 4**
Unit - I					
Objective 1	**To elucidate fundamental chemical aspects of materials' composition-structure-property relationships**				
BONDING IN SOLIDS- Introduction Bonding in Elemental Solids, Covalent Bonding, Metallic Bonding, van der Waals Bonding, Bonding in Multielement Crystals. Ionic Bonding, Mixed Ionic–Covalent Bonding and Ionicity, Hydrogen Bonding, Cohesive Energies, Summary of Some Atomic Properties and Parameters Ionization Energy and Electron Affinity, Electronegativity, Atomic Radii: Ionic, Covalent, Metallic, and van der Waals. Problems					
Outcome 1	**Learners recognize different bonding nature forming crystals or materials in their structure.**				**K1**
Unit II					
Objective 2	**To know various types of band structure in different materials, electrical and optical properties**				
CLASSES OF MATERIALS-Characteristic Properties of Semiconductors- Microscopic Properties. Energy-Band Structure and Energy Gaps. Dynamics of Electron Motion. Excited States of Electrons. Doping and Defects Dimensionality and Quantum Confinement Macroscopic Properties. Electrical Conductivity and Mobility. Effects of Magnetic Fields. Optical Properties. Examples of Semiconductors - Elemental Semiconductors and Their Compounds and Alloys. Compound, Semiconductors and Their Alloys; Applications of Semiconductors.					
Outcome 2	**Able to identify different classes of material based on their physical and electronic properties.**				**K1/K4**
Unit III					
Objective 3	**To identify different polymers based on chemical and physical properties**				
POLYMERS: Structure and Geometry of Polymers. Polymer Crystals. Defects in Polymers Mechanical Properties. Polymers Under Tension. Viscoelasticity Thermal Properties. Thermal Properties of Polymers Applications. Structural Plastics. Polymeric Ionic Conductors. Photoresists Piezoelectric Polymers. Liquid Crystals					
Outcome 3	**Gain knowledge on polymer properties pertaining to material applications.**				**K1/K5**
Unit IV					
Objective 4	**To understand the Surface behaviors of solid materials, defects, property change by modification**				
SURFACE AND THIN FILMS INTERFACES: Ideal Surfaces. Real Surfaces. Relaxation.Reconstruction. Surface Defects Electronic Properties of Surfaces. Work Function Thermionic Emission Field Emission Photoemission Surface States Surface Modification Anodization Passivation Surface Phonons Surface Processes Adhesion and Friction Surface Plasmons Dispersion Forces. Friction					
Outcome 4	**Learn the tailor surface properties by altering surface defects, surface modifications with other material surfaces.**				**K1/K2/K5**

Unit V		
Objective 5	**To provide the knowledge need to design and produce materials with tailored properties from first principles.**	
SYNTHESIS AND PROCESSING OF MATERIALS: Introduction Issues in Synthesis and Processing. Thermodynamic and Chemical Effects. Kinetic Effects. Crystal Growth. Synthesis and Processing of Metals. Synthesis and Processing of Steels. Synthesis and Processing of Stainless Steels Synthesis and Processing of Ceramics and Glasses. Powder Synthesis. Sol–Gel Synthesis Synthesis and Processing of Polymers and Carbon Molecules. Polymerization. Catalysts in Polymer Synthesis. Synthesis of Carbon Nanotubes		
Outcome 5	**Familiar with synthesize of materials with required characteristics by selecting different synthesis methods.**	**K3/K5/K6**
Suggested Readings - Joel I. Gersten Frederick W. Smith The Physics And Chemistry Of Materials, John Wiley & Sons, Inc., ISBN 0-471-05794-0, 2001 Leonard V. Interrante, editor, Lawrence A. Casper, editor, Arthur B. Ellis, editor, Materials chemistry: an emerging discipline, Advances in chemistry series, ISSN 0065-2393; 245) ISBN 0-8412-2809-4		
Online Resource Nanomaterials: a review of synthesis methods, properties, recent progress, and challenges - Materials Advances (RSC Publishing) DOI:10.1039/D0MA00807A Materials Chemistry and Physics (scimagojr.com)		
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**
Course designed by: Dr. V. Dharuman		

Course Outcome

CO 1	Recognize different bonding nature forming crystals or materials in their structure.	**K1**
CO 2	Identify different classes of material based on their physical and electronic properties.	**K1, K4**
CO 3	Gain knowledge on polymer properties pertaining to material applications.	**K1, K5**
CO 4	Tailor surface properties by altering surface defects, surface modifications with other material surfaces.	**K1, K2, K5**
CO 5	Familiar with synthesize of materials with required characteristics by selecting different synthesis methods.	**K3, K5, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	M (2)	L (1)	L (1)	M (2)	M (2)
CO 2	M (2)	L (1)	M (2)	L (1)	M (2)	M (2)	M (2)	S (3)	L (1)	L (1)
CO 3	M (2)	S (3)	M (2)	M (2)	L (1)	M (2)	S (3)	M (2)	S (3)	M (2)
CO 4	M (2)	S (3)	S (3)	S (3)	M (2)	L (1)	S (3)	M (2)	L (1)	M (2)
CO 5	M (2)	M (2)	S (3)	S (3)	M (2)	M (2)	M (2)	L (1)	M (2)	M (2)
W. AV	**2.2**	**2.2**	**2.6**	**2.1**	**1.8**	**1.8**	**2.1**	**1.8**	**1.8**	**1.8**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	L (1)	L (1)	M (2)
CO 2	M (2)	S (3)	M (2)	S (3)	M (2)
CO 3	M (2)	S (3)	M (2)	L (1)	M (2)
CO 4	S (3)	M (2)	S (3)	S (3)	M (2)
CO 5	S (3)	S (3)	M (2)	M (2)	M (2)
W. AV	**2.6**	**2.6**	**2**	**2**	**2.0**

S –Strong (3), M-Medium (2), L- Low (1)

II-SEMESTER					
Core 7	**Course code:542202**	**Characterization of Materials**	**T**	**Credits: 4**	**Hours: 4**

Unit - I		
Objective 1	**To make the students understand some important thermal analysis techniques.**	
Thermal analysis - Introduction – thermogravimetric analysis (TGA) – instrumentation – determination of weightloss and decomposition products – differential thermal analysis (DTA)- cooling curves - differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements – determination of thermomechanical parameters.		
Outcome 1	**Students understand the concept of image formation in Optical microscope and other specialized microscopes.**	**K2**
Unit II		
Objective 2	**To make the students familiarize with image formation in an optical microscope and learn other specialized microscopic techniques.**	
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.		
Outcome 2	**Students learn the working principle and operation of SEM, TEM, STM and AFM.**	**K4**
Unit III		
Objective 3	**To make the students learn the principle of working of electron microscopes and scanning probe microscopes**.	
Electron microscopy and Scanning probe microscopy- SEM-FESEM- EDAX,- HRTEM: working principle and Instrumentation – sample preparation – scanning probe microscopy - STM – AFM - working principle, Instrumentation andmodes of operation.		
Outcome 3	**Students understand the necessary theory of Hall measurement, four – probe resistivity measurement, C-V, I-V, Electrochemical, Photoluminescence and electroluminescence techniques.**	**K4**
Unit IV		
Objective 4	**To make the students understand some important semiconductor characterization techniques.**	
Electrical methods and Optical characterization- 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.		
Outcome 4	**Students understand the necessary theory of Hall measurement, four –probe resistivity measurement, C-V, I-V, Electrochemical, Photoluminescence and electroluminescence techniques.**	**K2**
Unit V		
Objective 5	**To introduce the students the basics of some important spectroscopic techniques.**	
Spectroscopy- Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy,Raman spectroscopy, ESR, NMR, NQR, mass spectroscopy – Bain bridge-Jordan Mass spectroscope – application.		
Outcome 5	**Students learn basics and necessary theory of some important spectroscopic techniques and its applications.**	**K5**

Suggested Readings :-

Banwell C.N.and McCashE.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.

Stradling R.A. and Klipstain P.C. (1990). *Growth and Characterization of semiconductors*. Adam Hilger, Bristol.

Online resources:-

Characterization of Nanomaterials by Physical Methods, Annual Review of Analytical Chemistry 2009 2:1, 435-462, 10.1146/annurev-anchem-060908-155236.

Chapter 11 - Characterization of Nanomaterials: Tools and Challenges, 2019, Pages 313-353, 10.1016/B978-0-12-814130-4.00011-7.

Novel Synthesis and Characterization of Nanostructured Materials, 10.1007/978-3-642-41275-2.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. J. Wilson

Course Outcome

CO 1	Gain basic knowledge on various spectroscopy being used in scientific area for different applications	**K1**
CO 2	Characterization of materials using SEM, TEM and Microscopy analysis	**K2/K6**
CO 3	Investigate the different properties and characterization of nanomaterials for suitable applications	**K3**
CO4	Understand and applying the gained skill to develop a sustainable material for suitable application	**K2/K6**
CO5	Develop novel material by spectroscopic knowledge for specified applications and to providing a functional device	**K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)	S (3)	L (1)	S (3)	M (2)
CO 2	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	L (1)
CO 3	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	M (2)	S (3)	S (3)	L (1)
CO 4	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	S (3)	M (2)
CO 5	M (2)	M (2)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)
W. AV	**2.8**	**2.6**	**2.6**	**2.4**	**2.6**	**2.4**	**2.6**	**2.4**	**2.6**	**1.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	M (2)
CO 3	S (3)	S (3)	S (3)	M (2)	L (1)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)
CO 5	M (2)	S (3)	S (3)	M (2)	M (2)
W. AV	**2.8**	**2.8**	**2.8**	**2.4**	**2**

S –Strong (3), M-Medium (2), L- Low (1)

II-SEMESTER					
Core 8	**Course code:542203**	**Quantum Mechanics**	**T**	**Credits: 4**	**Hours: 4**

Unit I

Objective 1	**To know the fundamentals relations of Quantum Mechanics with Mathematical Physics**

MATHEMATICS FOR QUANTUM MECHANICS (QM) AND QM POSTULATES- Coordinate systems, Complex numbers, Functions (odd & even, orthogonality and normalization), Differential equations, Operators: linear, differential, and Hermitian and Hamiltonian operators, Eigen functions and Eigen values, Failure of Classical Mechanics and the need for QM, Postulates of QM, time-dependent and time-independent Schrodinger wave equations

Outcome 1	**Students understand the basic information of Operators, Eigen functions and Eigen values and Postulates of QM.**	**K1, K2**

Unit II

Objective 2	**To learn properties and applications of Quantum models**

QM MODELS AND THEIR APPLICATIONS–Particle in a box (1D, 2D & 3D), degeneracy and its application to linear conjugated molecular systems, free particle. Bohr's correspondence principle. QM tunnelling, Rigid Rotor: wave equation and solution calculation of rotational constants and bond length, Harmonic Oscillator: wave equation and solution, anharmonicity force constant and its significance

Outcome 2	**Learners understand the important of QM applications in 3D and harmonicity.**	**K2, K3**

Unit III

Objective 3	**To gain knowledge on single and multi-electrons system usage**

APPLICATION OF OM TO H-ATOM AND MULTI-ELECTRON ATOMS –The Hydrogen atom and H-like ions: Solution to H and H-like wave equation, radial and angular functions, quantum numbers n, l and m and their importance. the radial distribution functions and H-like orbitals and their representation, Approximation Methods: The variation method - trial variation function and variational integral (examples of variational calculations from particle in a box)

Outcome 3	**Students analyze the important and uses of H atom and variation methods**	**K3, K4, K5**

Unit IV

Objective 4	**To familiarize angular momentum and tools for derivation**

QUANTUM MECHANICAL TREATMENT OF ANGULAR TTMOMENTUM – simultaneous

measurement of several properties: evaluation of commutators such as [x, px), (x, px 2), (Lx, Ly] and (Lx2, Lx] and their significance. He atom: The electron spin, Pauli exclusion principle and Slater determinant for He **atom**. Atomic term symbols: LS and JJ coupling

Outcome 4	**Students get expertized on QM problems solving methods**	**K4, K5**

Unit V

Objective 5	**To learn more regarding the importance of bonding crystals**

MOLECULAR QM AND CHEMICAL BONDING – Hydrogen molecule ion - the use of linear variation function, the LCAO method, Hydrogen molecule: Molecular orbital theory and Heitler-London treatment, electronic structure of conjugated systems: Huckel method applied to ethylene. Allyl system butadiene and benzene.

Outcome 5	**Students understand the significance of molecular bonding crystals**	**K2, K5**

Suggested Readings -

A.K. Chandra, Introductory Quantum Chemistry, 4thed. Tata McGraw Hill 1994.

I.N. Levine, Quantum Chemistry, 5thedn, Prentice Hall, 2000.

P.W. Atkins, Molecular Quantum mechanics, Clarendon Press New York, 1973.

R.K. Prasad, Quantum Chemistry, New Age International Publishers, New Delhi, 1997.

R.P. Rastogi and V.K. Srivastava. An Introduction to Quantum Mechanics of Chemical Systems. Oxford &: IBH Publishing Co. New Delhi_ 1986

Donald A. McQuarrie, Quantum Chemistry. Viva Books PW. Ltd. New Delhi. 2003

P.W. Atkins and Julio de Paula. Atkins' Physical Chemistry, VII ed. Oxford University Press. 2002.

Online resources:

https://www.cambridge.org/highereducation/books/quantummechanics/C114CA0F4A218733CEEC8759DFA4661C#overview

https://onlinelibrary.wiley.com/doi/book/10.1002/0471654817.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. J. B. Arul Joseph Helen Therese

Course Outcomes

CO1	Comprehend the modern theory and issues with quantum materials.	**K1, K2**
CO2	Apply quantum theory in confined maters.	**K2, K3**
CO3	Analyze the physical behavior of electrons in atoms.	**K3, K4, K5**
CO4	Recognize the angular moment and the particle coupling mechanism.	**K4, K5**
CO5	Learn about the solutions for bonding in quantum particles.	**K2, K5**

Course outcome Vs Programme outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)
CO 4	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)	M (2)	S (3)
CO 5	S (3)	M (2)	S (3)	M (2)	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)
W. AV	**3**	**2.8**	**2.6**	**2.8**	**2.6**	**2.4**	**2.4**	**2.2**	**2.2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	M (2)
CO 3	S (3)	S (3)	S (3)	M (2)	L (1)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)
CO 5	M (2)	S (3)	S (3)	M (2)	M (2)
W. AV	**2.8**	**2.8**	**2.8**	**2.4**	**2**

S –Strong (3), M-Medium (2), L- Low (1)

II-SEMESTER					
Core 9	**Course code:542204**	**Crystal Growth**	**T**	**Credits: 4**	**Hours: 4**
Unit -I					
Objective 1	**To understand the concepts of nucleation and types of nucleation.**				
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.					
Outcome1	**Familiar with the concepts of nucleation and its theory**				**K1**
Unit II					
Objective 2	**To learn the theoretical aspects of crystal growth.**				
THEORIES OF CRYSTAL GROWTH - Two-dimensional nucleation theory – Temkins model of crystal growth – limitations of Temkin model – BCF surface diffusion theory – solution of BCF surface diffusion equation. Atmospheric nucleation.					
Outcome 2	**Gain knowledge about theories of crystal growth.**				**K2, K3**
Unit III					
Objective 3	**To learn various methods of melt growth.**				
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.					
Outcome 3	**Familiar with what is melt growth and various methods of melt growth.**				**K4, K5**
Unit IV					
Objective 4	**To acquire knowledge on the growth of crystals by solution growth.**				
SOLUTION GROWTH - Measurement of supersaturation – Low temperature solution growth – High temperature solution growth – Accelerated crucible rotation technique (ACRT) – Electro crystallization – Crystal growth in gel – Growth of biological crystals – Hydrothermal technique – Sol-gel growth					
Outcome 4	**Expert in the solution growth method.**				**K4, K5**
Unit V					
Objective 5	**To understand various methods of growing crystals from vapour phase.**				
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.					
Outcome 5	**Gain knowledge on growth of crystals from their vapor phase.**				**K6**

Suggested Readings:-

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 Barraclough K.G. (1986). Advance Crystal Growth. Prentice Hall, London.

Ohara M. And ReidR.C. (1973). Modelling Crystal Growth Rates from Solution.

ZxettlemoyerA.C. (1969). Nucleation. Marcel-Dekker Publishers.

Online resources:-

Crystal Growth Online (http://crystalgrowthonline.com/): This website provides a collection of resources, articles, and information on crystal growth techniques and research.

American Association for Crystal Growth (AACG) (http://www.crystalgrowth.org/): AACG is a professional organization focused on crystal growth and provides access to conference proceedings, publications, and educational resources.

https://www.youtube.com/@veritasium This channel covers various science topics, including crystal growth and material science.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. C. Sekar

Course Outcome

CO1	Understand nucleation mechanisms and its role in material formation	**K1, K2**
CO2	Analyze various theories explaining crystal growth phenomena	**K2**
CO3	Gain proficiency in techniques and principles of crystal growth from melts	**K3, K5**
CO4	Explore the fundamentals and different methods of crystal growth from solutions	**K2, K4**
CO5	Comprehend vapor-phase crystal growth methods and their practical applications	**K1, K2, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	S (3)	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	S (3)	M (2)	S (3)	L (1)	M (2)	M (2)	M (2)	L (1)
CO 3	S (3)	S (3)	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)	S (3)
CO 5	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
W. AV	**3**	**3**	**2.8**	**2.2**	**1.8**	**2.2**	**2.8**	**2.8**	**2.8**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	S (3)	S (3)	M (2)
CO 2	M (2)	L (1)	S (3)	S (3)	M (2)
CO 3	S (3)	M (2)	S (3)	S (3)	M (2)
CO 4	S (3)	M (2)	S (3)	S (3)	S (3)
CO 5	S (3)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.8**	**1.6**	**3**	**3**	**2.4**

S –Strong (3), M-Medium (2), L- Low (1)

II-SEMESTER					
Core 10	**Course code: 542205**	**LAB II Materials synthesis and characterization**	**P**	**Credits: 4**	**Hours: 8**
Objectives	The objective of the course is to make the students • gain practical knowledge on preparation of polymers and properties • understand the physical and chemical processes of polymers • familiarize with polymer characterization methods • familiarize with use of polymer materials in different application • develop the ability to design a hypothesis driven research project and design and execute experiments to evaluate the stated hypothesis				
Experiments	1. High temperature synthesis of materials 2. Sol-gel synthesis of metal oxide composites 3. Hydrogel synthesis of oxide composites 4. Electrochemical characterization of material behaviour 5. Synthesis of nanocarbon materials 6. FTIR characterization of materials 7. TG-DTA studies of nanomaterials 8. Powder X-ray diffraction- indexing, lattice parameters and unit cell volume calculation 9. Composite of metal oxides preparation 10. Composites of carbon and metal 11. Composites of polymer and carbon 12.Composites of polymer and metal oxide 13. Alloy formation and confirmation 14. Electrochemical sensing of glucose 15. Electrochemical preparation of thin films 16. Thin film formation on metal surfaces 17. Differential pulse voltammetry technique				
Outcomes	After completion of this course, students synthesize different types of nanomaterials including metal oxides, carbon nanostructures, composites and polymers. Students perform preliminary characterization for confirming the formation of the target material either as single phase or as composites.				

II-SEMESTER					
DSE	**Course code :542507**	**Molecular Spectroscopy**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To recall the basic nature of Bonding's of materials**	

SYMMETRY ASPECTS OF MOLECULAR ORBITALS -Valence bond theory – Molecular orbital theory- Heitler London theory for Hydrogen molecule - Hybridization – SP – SP^2 & SP^3 Hybrids.

Outcome 1	**Students understand the basic information of band theory and its applications.**	**K1, K2**

Unit - II

Objective 2	**To learn on properties and important conditions of rotational molecules**	

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.

Outcome 2	**Learners discuss the formation and properties of rotating diatomic and polyatomic molecules.**	**K2, K3, K5**

Unit - III

Objective 3	**To gain knowledge on vibrational and Raman spectroscopy**	

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.

Outcome 3	**Students analyze the importance and use of vibrating molecules.**	**K3, K4**

Unit - IV

Objective 4	**To familiarize Non-linear effects and modern tools for characterization**	

NON-LINEAR SPECTROSCOPIC PHENOMINA - Non-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.

Outcome 4	**Students expertise on NLO crystals and analysing methods**	**K4, K5**

Unit - V

Objective 5	**To learn more regarding the resonance functions and their spectroscopy techniques**	

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.

Outcome 5	**Students understand of the resonance and resonance spectroscopy.**	**K5, K6**

Suggested Readings:-

Aruldhass G. (2001). Molecular structure and spectroscopy. Prentice Hall of India, New Delhi.

Colin N Banwell. (2019). Fundamentals of Molecular Spectroscopy, McGraw Hill.

Dogra S.K. (2015). Atomic and Molecular Spectroscopy. Pearson Publications.

Mchale, Jeanne L. (2008). Molecular Spectroscopy. Pearson Publications.

Willard et al. (2005). Instrumental methods of analysis. CBS publishers

Online resources:-

Fundamental Concepts of Molecular Spectroscopy – https://www.routledge.com/book/9781032274850.

Nuclear Magnetic Resonance Spectroscopy an Introduction to principles, Applications and experimental methods -https://www.wiley.com/book/978111929580.

Shaffner, T. J. (1986) "A Review of Modern Characterization Methods for Semiconductor Materials," Scanning Electron Microscopy: Vol. 1986: No. 1, Article 2, https://digitalcommons.usu.edu/electron/vol1986/iss1/2

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. S. Saravana Kumar

Course Outcome

CO1	Learn basic principles of many molecule structures.	**K1, K2**
CO2	Analyze and apply the various molecular characterization techniques.	**K2, K3, K5**
CO3	Discover the various movements of molecule.	**K3, K3, K4**
CO4	Analytical expertise with non-linear spectroscopic materials.	**K4, K5**
CO5	Learn about resonance spectroscopy and apply it on materials.	**K5, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	M (2)
CO 2	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)
CO 3	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	M (2)	S (3)	M (2)
CO 4	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)	S (3)	M (2)
CO 5	M (2)	S (3)	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	M (2)	S (3)
W. AV	**2.6**	**2.8**	**2.6**	**2.8**	**2.8**	**2.2**	**2.4**	**2.2**	**2.6**	**2.2**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	S (3)	M (2)	M (2)	M (2)
CO 2	S (3)	M (2)	M (2)	S (3)	M (2)
CO 3	S (3)	M (2)	M (2)	M (2)	M (2)
CO 4	S (3)	M (2)	M (2)	M (2)	M (2)
CO 5	S (3)	S (3)	M (2)	M (2)	M (2)
W. AV	**3**	**2.4**	**2.0**	**2.2**	**2.0**

S –Strong (3), M-Medium (2), L- Low (1)

II-SEMESTER					
DSE	**Course code:542508**	**Semiconductor Materials and Devices**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To introduce the concepts of various semiconductor principles, properties and their functions.**

INTRODUCTION -Introduction: Properties of semiconductors –Free electron Theory - Transport properties. Bonds and Bands in Semiconductor: -Electronic band 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 with donors and acceptors at low temperatures - Quantum theory of junction devices - Generation of recombination processes in junction devices.

Outcome 1	**The students gain knowledge on energy band structures.**	**K2**

Unit - II

Objective 2	**To introduce the students about various optical properties and their application.**

OPTICAL PROPERTIES - Optical properties of semiconductors - Optical constants - Light absorption spectrum – Light absorption edge - Effect of free charge carriers on the absorption edge - Fundamentals of absorption 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.

Outcome 2	**Students understand the basic and optical properties of materials.**	**K4**

Unit - III

Objective 3	**To expose the students to basic transport properties in semiconductor devices.**

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.

Outcome 3	**Learners understand fundamentals to Understand on transport properties in materials.**	**K4**

Unit - IV

Objective 4	**To study the properties and fabrication of various transistors and their characteristics.**

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.

Outcome 4	**Learners gain knowledge on fabrication of semiconductor devices.**	**K2**

Unit - V

Objective 5	**To make the students about fabrication of LED's and Sensors in photonic device applications.**

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.

Outcome 5	**Learners understand different fabrication steps in optoelectronic devices.**	**K5**

Suggested Readings:-

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.

Online resources

M. J. Deen & F. Pascal, Electrical characterization of semiconductor materials and devices—review, Journal of Materials Science: Materials in Electronics volume 17, pages549–575 (2006), https://link.springer.com/article/10.1007/s10854-006-0001-8.

International Technology Roadmap for Semiconductors—ITRS 2005 Edition, http://www.itrs.net/Common/2005ITRS/Home2005.htm.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Gain knowledge on energy band structures.	**K1, K2**
CO 2	Understood the basic principles and optical properties of materials.	**K2, K3**
CO 3	Make use of fundamental to Understand the principles of transport properties in materials.	**K5**
CO 4	Gain knowledge on fabrication of semiconductor devices.	**K3, K4**
CO 5	Understand different fabrication steps involved in optoelectronic devices.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

II SEMESTER					
DSE	**Course code:542509**	**Physical Metallurgy**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To make the students understand about phase diagram of metallurgy.**

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, peritectic and peritectoid 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.

Outcome 1	**Students understand the principle involved in Einstein coefficients and action of laser.**	**K1**

Unit - II

Objective 2	**To impact knowledge about iron carbon phase equilibrium diagram and alloys**

SOLID SOLUTION - Types of solid solution – solid solution factors governing substitutional solubility – Hume-Rothery rules- intermediate phases -solid solution alloys –Vegard's law – Lever rule - mechanical mixtures-- Iron-Carbon equilibrium diagram – Aluminum alloys – Copper alloys – Effect of alloying elements.

Outcome 2	**The students gain knowledge on Iron-Carbon phase equilibrium diagram.**	**K3**

Unit - III

Objective 3	**To expose the students to various heat treatment processes those are employed**

HEAT TREATMENT – Recovery, recrystallisation and grain growth: property changes, annealing twins, textures in cold worked and annealed alloys,-TTT diagrams – CCT diagrams – heat-treatment processes – annealing, normalizing, quenching and tempering – baths used in heat treatment – hardenability – Jominy's end quench test – martempering and austempering – case hardening – induction, flame, laser - carburizing,
cyaniding, nitriding, carbo nitriding.

Outcome 3	**Students apply the various heat treatment processes**	**K2**

Unit - IV

Objective 4	**To make the students to understand about various phase transformations**

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.

Outcome 4	**Students gain knowledge on phase transformations**	**K4**

Unit - V

Objective 5	**To introduce various engineering alloys and their applications.**

ENGINEERING ALLOYS - Low carbon steels – mild steels – high strength structural steels – tool materials – stainless steels – super alloys – light alloys – shape memory alloys – applications.

Outcome 5	**Analyze the various properties of engineering alloys and apply them**	**K5**

Suggested Readings:-

Avner S.H. (2019). Introduction to Physical Metallurgy. Mc Graw Hill Education.

Guy A.G. and HrenJ. (1984). Elements of Physical Metallurgy. Oxford Univ. Press.

Lakhtin Y. (2005). Engineering Physical Metallurgy. CBS Publishers & Distributors.

Polmear I. S. (1995). Light Alloys. Metallurgy and Materials Science.

Raghavan V. (2015). Physical Metallurgy: Principles and Practice. PHI Learning Private Limited, New Delhi.

Online resources:-

Phase transformation of precipitated TiO2 nanoparticles, Y Hu, H.-L Tsai, C.-L Huang, Materials Science and Engineering: A, Volume 344, Issues 1–2, 2003, Pages 209-214, https://doi.org/10.1016/S0921-5093(02)00408-2.

Semi-solid processing of engineering alloys by a twin-screw rheo-moulding process, S Ji, Z Fan, M.J Bevis, Materials Science and Engineering: A, Volume 299, Issues 1–2, 2001, Pages 210-217, https://doi.org/10.1016/S0921-5093(00)01373-3.

Synergistic effect of cavitation erosion and corrosion of various engineering alloys in 3.5% NaCl solution, C.T Kwok, F.T Cheng, H.C Man, Materials Science and Engineering: A, Volume 290, Issues 1–2, 2000, Pages 145-154, https://doi.org/10.1016/S0921-5093(00)00899-6.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Construct phase diagrams.	**K1, K2**
CO 2	Gain knowledge on Iron-Carbon phase equilibrium diagram.	**K2, K3**
CO 3	Apply the various heat treatment processes.	**K5**
CO 4	Gain knowledge on phase transformations	**K3, K4**
CO 5	Analyze the various properties of engineering alloys and apply them	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.2***	***2.2***	***2.2***	***2.6***	***3***

S –Strong (3), M-Medium (2), L- Low (1)

II SEMESTER					
DSE	**Course code:542510**	**Materials Processing**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To understand the basic concepts of manufacturing processes of materials.**

BASIC MANUFACTURING PROCESSES -Fundamental analysis of Manufacturing processes, casting, casting processes, forging, methods of forging, extrusion, rolling, spinning, turning, planning and shaping, milling, grinding.

Outcome 1	**The students gain the knowledge about the basics of various manufacturing processes involved in manufacturing materials.**	**K2**

Unit - II

Objective 2	**To impart the knowledge about surface treatment processes.**

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.

Outcome 2	**The students learn the various surface treatment processes.**	**K4**

Unit - III

Objective 3	**To understand various welding processes.**

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.

Outcome 3	**Learners make use of the processes involved in different welding techniques.**	**K4**

Unit - IV

Objective 4	**To teach the students about mechanical working of metals.**

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.

Outcome 4	**Learners gain a better knowledge with mechanical working of metals.**	**K2**

Unit - V

Objective 5	**To make the students understand the knowledge about powder metallurgical processes.**

POWDER METALLURGICAL PROCESS -Production of powders, powder mixing, compacting, types of presses, sintering, soaking, finishing process, limitations and advantages of powder metallurgy, applications, production of cemented carbide cutting tools, self-lubricating bearings, magnets, cermet's, ultrasonic ceramic transducers.

Outcome 5	**Learners understand the powder metallurgical process.**	**K5**

Suggested Readings:-

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.

Online resources:-

M. B. Uday,M. N. Ahmad Fauzi,H. Zuhailawati &A. B. Ismail, Advances in friction welding process: a review, Pages 534-558 | Published online: 04 Dec 2013, https://doi.org/10.1179/136217110X12785889550064.

Montasser Marasy Dewidar, Ho-Chel Yoon & Jae Kyoo Lim, Mechanical properties of metals for biomedical applications using powder metallurgy process: A review, Metals and Materials

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Gain knowledge about the basics of various manufacturing processes involved in manufacturing materials.	**K1, K2**
CO 2	Learn the various surface treatment processes	**K2, K3**
CO 3	Understand the processes involved in different welding techniques.	**K5**
CO 4	Gain a better knowledge with mechanical working of metals.	**K3, K4**
CO 5	Understand the powder metallurgical process.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.2***	***2.2***	***2.2***	***2.6***	***3***

S –Strong (3), M-Medium (2), L- Low (1)

II SEMESTER					
DSE	**Course code:542511**	**Corrosion Science and Engineering**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To introduce the students to corrosion process and corrosion control.**	
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.		
Outcome 1	**The students learn various corrosion process and control.**	**K2**

Unit - II

Objective 2	**To make the students understand the methods used for testing corrosion.**	
CORROSION TESTING - Materials and specimens – surface preparation – measuring and weighing – linear polarization – AC impedance – in vivo corrosion – paint tests – seawater tests.		
Outcome 2	**The students understand the methods for testing corrosion.**	**K4**

Unit - III

Objective 3	**To introduce the different methods used for coating.**	
COATING MANUFACTURE – Electrodeposition; flame and plasma spraying; thermal, HV of detonation gun, physical vapour deposition; chemical vapour deposition; HIP surface treatments.		
Outcome 3	**Students analyze and apply the different methods for coating.**	**K4**

Unit - IV

Objective 4	**To impart knowledge on various types of corrosion with respect to corrosion.**	
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.		
Outcome 4	**The students gain knowledge on corrosion type with respect to environment.**	**K2**

Unit - V

Objective 5	**To expose the students to various application of coating.**	
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.		
Outcome 5	**The students learn about the various concepts and applications of coating.**	**K5**

Suggested Readings:-

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.

Online resources:-

Sukanchan Palit, Recent Advances in Corrosion Science: A Critical Overview and a Deep Comprehension, Direct Synthesis of Metal Complexes, 2018, Pages 379-41, https://doi.org/10.1016/B978-0-12-811061-4.00011-6.

D. Féron, 2 - Overview of nuclear materials and nuclear corrosion science and engineering, Nuclear Corrosion Science and Engineering Woodhead Publishing Series in Energy, 2012, Pages 31-56, https://doi.org/10.1533/9780857095343.1.31.

Vincent Maurice, Philippe Marcus, Progress in corrosion science at atomic and nanometric scales.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Learn various corrosion process and corrosion control.	**K1, K2**
CO 2	Understand the methods used for testing corrosion.	**K2, K3**
CO 3	Analyze and apply the different methods for coating.	**K5**
CO 4	Gain knowledge on corrosion type with respect to environment.	**K3, K4**
CO 5	Learn about the various concepts and applications of coating.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

II SEMESTER					
DSE	**Course code:542512**	**Solid State Ionics**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To introduce the basic aspects of solid-state physics.**

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-Ionic and electronic conductivities.

Outcome 1	**The students learn the basic aspects of solid-state physics.**	**K2**

Unit - II

Objective 2	**To impart knowledge on solid state ionics, hydrogen storage and nano-ionic materials.**

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.

Outcome 2	**Gain knowledge on solid state ionics, hydrogen storage.**	**K4**

Unit - III

Objective 3	**To introduce the students to micro batteries, super capacitors and their applications.**

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.

Outcome 3	**Learn about microbatteries, fuel cells, super capacitors.**	**K4**

Unit - IV

Objective 4	**To familiarize various characterization techniques for new cathode materials.**

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.

Outcome 4	**Learn about the various characterization techniques available for cathode materials.**	**K2**

Unit - V

Objective 5	**To expose the students to the various application of ionic materials.**

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.

Outcome 5	**The students familiar with various applications of ionic materials**	**K5**

Suggested Readings:-

Chandra S. (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,Ozin A.& Andre C Arsenault, (2008).Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry.

Online resources:-

Fan Wu a b c d e, Lilu Liu a, Shuo Wang d, Jieru Xu d, Pushun Lu d, Wenlin Yan d, Jian Peng d, Dengxu Wu d, Hong Li, Solid state ionics – Selected topics and new directions, Progress in Materials Science, Volume 126, May 2022, 100921, https://doi.org/10.1016/j.pmatsci.2022.100921.

J. Schoonman, Nanostructured materials in solid state ionics, Solid State Ionics Volume 135, Issues 1–4, 1 November 2000, Pages 5-19, https://doi.org/10.1016/S0167-2738(00)00324-6.

C. Julien, Technological applications of solid state ionics, Materials Science and Engineering: B, Volume 6, Issue 1, May 1990, Pages 9-28, https://doi.org/10.1016/0921-5107(90)90109-O.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Learn the basic aspects of solid-state physics.	**K1, K2**
CO 2	Gain knowledge on solid state ionics, hydrogen storage.	**K2, K3**
CO 3	Learn about microbatteries, fuel cells, super capacitors.	**K5**
CO 4	Learn about the various characterization techniques available for cathode materials.	**K3, K4**
CO 5	Familiar with various applications of ionic materials	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.2***	***2.2***	***2.2***	***2.6***	***3***

S –Strong (3), M-Medium (2), L- Low (1)

III-SEMESTER					
Core 11	**Course code:542301**	**Nanomaterials**	**T**	**Credits: 4**	**Hours: 4**

Unit -I

Objective 1	**To introduce the basic aspects of preparation of nanomaterials and their related characterization techniques.**

BASIC PROPERTIES OF NANOPARTICLES - Size effect and properties of nanoparticles - particle size - particle shape - melting point, surface tension, wettability - specific surface area and pore size – Reason for change in optical properties, electrical properties, and mechanical properties – advantages.

Outcome 1	**Familiarize the properties of nanoparticles and its advantages.**	**K1, K2**

Unit II

Objective 2	**To study the synthesis and purification Single walled and Multi walled Nanotubes (SWNT and MWNT).**

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.

Outcome 2	**The students apply ideas on enlightenment of Nanowires.**	**K2, K6**

Unit III

Objective 3	**To impart the concepts behind 1 dimensional nanowires and nanofibers.**

NANOWIRES AND NANOFIBERS – Semiconductor and oxide nanowires –preparation –solvothermal – electrochemical –PVD –Pulse laser deposition – template method (qualitative)- nanofibers –electro spinning technique.

Outcome 3	**Gain the idea of ID nanostructures.**	**K4, K6**

Unit IV

Objective 4	**To acquire knowledge on the growth of crystals by solution growth.**

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).

Outcome 4	**The students able to understand its application.**	**K4, K5**

Unit V

Objective 5	**To inspire the knowledge of nanodevices for magnetic storage.**

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.

Outcome 5	**The students understand the principle involved in preparation and characterization of nanostructures and fabrication of nanodevice.**	**K2, K3**

Suggested Readings

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). Handbook of Nanostructured Materials and Technology, Vol.1-5. Academic Press, USA.

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

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

Online resources

Nanowerk (https://www.nanowerk.com/) - covers a wide range of nanotechnology topics, including the fundamentals of nanomaterials, research developments, and industry news.

Nanotechnology Now (http://www.nanotech-now.com/) - features articles, blogs, and news related to nanotechnology, including the basics of nanomaterials and their applications.

ACS Nano Blog (https://axial.acs.org/category/acs-nano/) - affiliated with the American Chemical Society, offers insights into nanotechnology research, including the fundamental aspects of nanomaterials.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. C. Sekar

Course Outcome

CO 1	Understand basic properties of nanomaterials	**K1, K2**
CO 2	Identify properties and synthesis mechanisms of various nanotubes	**K2, K6**
CO 3	Examine properties and preparation methods for nanowires and nanofibers.	**K4, K6**
CO 4	Understand characterization techniques like FESEM, HRTEM, PL & UV spectra, electrophoresis, and microscopy	**K4, K5**
CO 5	Analyze nanodevices such as MRAMs, magnetic disks, magnetic data storage, and nanomaterial sensors.	**K2, K3**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
CO 3	S (3)	S (3)	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 4	M (2)	S (3)	L (1)	S (3)	S (3)	S (3)	M (2)	L (1)	S (3)	L (1)
CO 5	S (3)	S (3)	S (3)	M (2)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)
W. AV	**2.8**	**3**	**2.6**	**2.6**	**2.6**	**2.8**	**2.6**	**2.6**	**3**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	L (1)	L (1)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)
CO 3	S (3)	S (3)	M (2)	S (3)	S (3)
CO 4	L (1)	L (1)	L (1)	S (3)	L (1)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.4**	**2.2**	**2**	**2.4**	**2.2**

S –Strong (3), M-Medium (2), L- Low (1)

III-SEMESTER					
Core 12	**Course code: 542302**	**Polymer and Composite Materials**	**T**	**Credits: 4**	**Hours: 4**

Unit - I

Objective 1	**To introduce polymers, their synthesis and polymerization techniques.**

Introduction to polymers - Classification of polymers – copolymers – tacticity –geometric isomerism – molecular weight distribution and averages – Measurement of molecular weight – synthesis of polymers – step growth polymerization – chain growth polymerisation – polymerisation techniques.

Outcome 1	**Understand the basic properties of polymers, their synthesis and various polymerization techniques.**	**K2**

Unit - II

Objective 2	**To impart knowledge on the various properties of polymers.**

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

Outcome 2	**Students learn the conformation, glass transition temperature, crystallinity and mechanical behavior of polymers.**	**K4**

Unit - III

Objective 3	**To gain knowledge of various polymer processing techniques, and applications.**

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.

Outcome 3	**Students analyze the different polymer processing methods, and various applications of polymers.**	**K4**

Unit - IV

Objective 4	**To introduce the fundamentals of composites and their mechanical behavior.**

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.

Outcome 4	**Learners acquire knowledge on classification of composites, matrix and reinforcement, and mechanical behavior of composites.**	**K2**

Unit - V

Objective 5	**To impart knowledge on the fabrication of different types of composites.**

Fabrication of composites- Polymer matrix composites – liquid resin impregnation routes, pressurized consolidation of resin pre-pregs, consolidation of resin moulding compounds, injection moulding of thermoplastics, hot press moulding of thermoplastics – metal composites – squeeze infiltration, stir casting, powder blending – ceramic composites – powder-based routes, layered ceramic composites, carbon/carbon composites.

Outcome 5	**Learners critically evaluate the fabrication techniques of composites and apply them in practice.**	**K5**

Suggested Readings:-

Crawford R.J. (2014). *Plastics Engineering*. Elsevier India.

Gowarikar V.R, Viswanathan N.V. &Sreedhar J. (2019). *Polymer Science*. New Age International. Hull D. & Clyne T.W. (2008). *An Introduction to Composite Materials*. Cambridge University Press.Joel R. Fried. (2014). *Polymer Science and Technology*. Pearson Prentice Hall.

Mallick P.K. (2008). *Fiber-Reinforced Composites: Materials*, Manufacturing and Design. CRC Press, Boca Raton.

Online resources:- Polymer-Based Composites: An Indispensable Material for Present and Future Applications: Volume 2020 | Article ID 8834518 | https://doi.org/10.1155/2020/8834518 Polymeric composites for powder-based additive manufacturing: Materials and applications, 91, 2019, 141-168, 10.1016/j.progpolymsci.2018.11.001.					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**
					Course designed by: Dr. J. Wilson

Course Outcome

CO 1	Gain basic knowledge on various polymers being used in both day today and scientific applications	**K1**
CO 2	Explore the fundamental properties of polymers to expand the knowledge of polymeric material	**K2/K6**
CO 3	Apply the basic knowledge to synthesizing the polymer by varies techniques	**K3**
CO 4	Understand and apply the gained skill to develop a polymeric composite for suitable application	**K2/K6**
CO 5	Develop novel material polymeric composite to enhance the functional properties for specified applications	**K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)	S (3)	L (1)	S (3)	M (2)
CO 2	S (3)	S (3)	L (1)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	L (1)
CO 3	S (3)	M (2)	M (2)	S (3)	M (2)	M (2)	M (2)	S (3)	S (3)	L (1)
CO 4	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 5	M (2)	M (2)	S (3)	M (2)	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)
W. AV	**2.8**	**2.6**	**2.6**	**2.4**	**2.6**	**2.4**	**2.6**	**2.4**	**2.2**	**1.8**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	M (2)	S (3)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	M (2)
CO 3	S (3)	S (3)	S (3)	M (2)	L (1)
CO 4	M (2)	L (1)	S (3)	L (1)	M (2)
CO 5	M (2)	S (3)	M (2)	M (2)	M (2)
W. AV	**2.6**	**2.4**	**2.6**	**2.0**	**2.0**

S –Strong (3), M-Medium (2), L- Low (1)

III-SEMESTER					
Core 13	**Course code :542303**	**Solid state Physics**	**T**	**Credits: 4**	**Hours: 4**

Unit - I

Objective 1	**To recall the basic nature of Bonding's of crystals**

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.

Outcome 1	**Students understand the basic information of bonding of solids and its applications.**	**K1, K2, K3**

Unit - II

Objective 2	**To understand the conductivity of Solid materials**

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.

Outcome 2	**Learners understand the properties and applications of conducting materials.**	**K2, K3**

Unit - III

Objective 3	**To analyze the lattice and thermal resistance of crystalline materials**

LATTICE DYNAMICS - Mono atomic and diatomic lattices – an harmonicity and 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 and Umklapp processes - scattering experiments.

Outcome 3	**Students analyze the use of lattice dynamics.**	**K3, K4**

Unit - IV

Objective 4	**To analyze the importance of periodic potentials of bands**

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.

Outcome 4	**Students get expertise on Periodic potentials and tight binding approximation methods**	**K2, K4**

Unit - V

Objective 5	**To evaluate types of semi and superconductors**

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 tunnelling – SQUID - High temperature superconductors - applications.

Outcome 5	**Students understand the significance of semi and superconducting materials.**	**K3, K5**

Suggested Readings:-

Ali Omar M. (2002). Elementary Solid-State Physics. Pearson Education.

Ashcroft N.W and Mermin N.D. (2003). Solid State Physics, Cengage Learning.

James D. Patterson and Bernad C. Bailey. (2018). Solid State Physics: Introduction to the Theory. Springer.

Rogalski M.S. and Palmer S.B. (2000). Solid State Physics. Gordon Breach Science Publishers. Wahab M.A. (2019). Solid State Physics: Structure and Properties of Materials. Narosa Publishing House Pvt. Ltd.					
Online resources:- Solid State Physics – https://www.e booksdirectory.com/details.php?ebook=10489 Lecture Notes for Solid State Physics – https://www.e-booksdirectory.com/details.php?ebook=9717					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**
Course designed by: Dr. S. Saravana kumar					

Course Outcome

CO 1	Understand the basics of crystal structure and bonding of materials	**K1, K2, K3**
CO 2	Learn theoretical aspects of moving electrons in solid.	**K2, K3**
CO 3	Utilize thermal energy transition in material lattice dynamics.	**K3, K4**
CO 4	Become familiar with the energy diagrams for various conducting materials.	**K2, K4**
CO 5	Examine the underline concept and choose advanced conducting materials for practical application.	**K3, K5**

Course outcome Vs Programme outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	M (2)	S (3)	S (3)	M (2)	S (3)	M (2)
CO 3	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	M (2)	M (2)	M (2)
CO 4	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)	M (2)
CO 5	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)	S (3)
W. AV.	**3**	**2.6**	**2.8**	**2.6**	**2.4**	**2.6**	**2.8**	**2.4**	**2.6**	**2.2**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	S (3)	S (3)	M (2)	M (2)
CO 2	S (3)	S (3)	M (2)	M (2)	M (2)
CO 3	S (3)	M (2)	M (2)	M (2)	M (2)
CO 4	S (3)	M (2)	M (2)	M (2)	M (2)
CO 5	S (3)	S (3)	S (3)	S (3)	M (2)
W. AV.	**3**	**2.6**	**2.4**	**2.2**	**2.0**

S –Strong (3), M-Medium (2), L- Low (1)

III-SEMESTER					
Core 14	**Course code: 542304**	**Ceramic Materials**	**T**	**Credits: 4**	**Hours: 4**

Unit I

Objective 1	**To introduce the concepts of ceramic materials processing.**

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.

Outcome 1	**Understand the concept of ceramic processing.**	**K1, K5/K6**

Unit II

Objective 2	**To expose the students, the concept of structural ceramics.**

STRUCTURAL CERAMICS - Oxide ceramics – zirconia, alumina, silica, mullite, magnesia and titania – carbides – silicon carbide, boron carbide, tungsten carbide, titanium carbide – nitrides – silicon nitride, boron nitride, titanium nitride, borides, silicides, - sialon – bio ceramics.

Outcome 2	**Appreciate the importance of ceramics and its processing techniques.**	**K3/K6**

Unit III

Objective 3	**To understand the concept of electrical properties of ceramic materials.**

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

Outcome 3	**Reveal the electronic properties of ceramic materials.**	**K1/K3/K5**

Unit IV

Objective 4	**To introduce the processes of refectories of ceramic materials.**

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.

Outcome 4	**Understand the processes of refectories of ceramic materials and applications.**	**K1/K5/K6**

Unit V

Objective 5	**To understand the preparation and properties of glass ceramics**

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.

Outcome 5	**Gain knowledge on the importance of glass ceramics in practical reliance.**	**K2/K5/K6**

Suggested Readings:-

CableM. And Parker 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.
Reed J.S. (2008). Principles of Ceramic Processing. Wiley-Interscience.
Richerson D.W. Lee W.E. (2018). Modern Ceramic Engineering: Properties, Processing and Use in design. CRC Press.

Online Resources:-

Automotive and industrial applications of structural ceramics in Japan, Akira Okada, Journal of the European Ceramic Society, Volume 28, Issue 5, 2008, Pages 1097-1104, https://doi.org/10.1016/j.jeurceramsoc.2007.09.016.

Development of refractory ceramics from residual silica derived from rice husk ash, F.Z. Sobrosa, N.P. Stochero, E. Marangon, M.D. Tier, Ceramics International, Volume 43, Issue 9, 2017, Pages 7142-7146, https://doi.org/10.1016/j.ceramint.2017.02.147.

Characterization of different starch types for their application in ceramic processing, Eva Gregorová , Willi Pabst, Ivan Bohačenko, Journal of the European Ceramic Society, Volume 26, Issue 8, 2006, Pages 1301-1309, https://doi.org/10.1016/j.jeurceramsoc.2005.02.015.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. J. Wilson

Course Outcome

CO 1	Understand the concept of ceramic materials processing.	**K1, K2**
CO 2	Appreciate the importance of ceramics and its processing techniques.	**K2, K3**
CO 3	Reveal the electronic properties of ceramic materials.	**K5**
CO 4	Understand the processes of refectories of ceramic materials and applications.	**K3, K4**
CO 5	Gain knowledge on the importance of glass ceramics in practical reliance.	**K1, K6**

Course outcome Vs Programme Outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	**2.2**	**2.2**	**2.2**	**2.6**	**3**

S –Strong (3), M-Medium (2), L- Low (1)

III-SEMESTER					
Core 15	**Course Code: 542305**	**Lab III: Device Characterization**	**P**	**Credits: 4**	**Hours: 8**
Objectives	The objective of the course is to equip the students with adequate experimental skill which includes design and testing of electronic components, devices and sensors. Students shall also perform thermal and mechanical properties of select materials				
Experiments	1. Characteristics of PN junction diode 2. Zener diode Characteristics Regulator using Zener diode 3. Common Emitter input-output Characteristics 4. Common Base input-output Characteristics 5. FET and SCR Characteristics 6. Clipper and clamper circuits 7. Verifications of Thevenin & Norton theorem 8. Verifications of Kirchhoff's Voltage Law and Kirchhoff's Current Law 9. Verifications of Super position theorem 10. Verifications of maximum power transfer & reciprocity theorem 11. Determination of resonance frequency of series & parallel RLC circuits 12. Transient analysis of RL and RC circuits 13. Resistive sensors 14. Stress and strain study (tensile strength, compression & bending moment) 15. Thermal properties of materials 16. Impact test and surface roughness study 17. Corrosion studies				
Outcome	At the end of the course work, students gain adequate training and skills in the design and testing of electronic components, devices and sensors. In addition, they also become familiar about testing mechanics and thermal properties of select materials.				

III SEMESTER					
DSE	**Course code:542513**	**Biosensors**	**T**	**Credits: 3**	**Hours: 3**

Unit - I

Objective 1	**To understand basic characteristics, types of biosensing devices.**

BASICS OF BIOSENSORS - Biosensor – definition-Historical perspective; Sensor characteristics - calibration, dynamic Range, signal to noise, sensitivity, selectivity, interference- examples - applications – Problems.

Outcome 1	**Become knowledgeable in the field of biosensors.**	**K1/K2**

Unit - II

Objective 2	**To understand different methods for attaching recognition molecule on the sensor surface.**

TYPES OF TRANSDUCERS- Transducer – definition- types – optical, electrochemical, Electrochemical transducers (Amperometric, potentiometric,conductimetric), thermal, Mass – piezoelectric – acoustic wave with examples.

Outcome 2	**Ability to select different types of sensors based on type of requirement and applications.**	**K3/K6**

Unit - III

Objective 3	**To identify different recognition molecules for different biosensing applications**

BIORECOGNITION SYSTEMS– Enzymes; Microorganism based biosensor, immobilization of microorganism - botanical biosensors-Biosensors using cultured cells-intact tissues-receptor elements.

Outcome 3	**Ability to select the biorecognition system to detect particular type of analytes.**	**K1/ K5/K6**

Unit - IV

Objective 4	**To understand the working principles of electronic and optical sensor devices.**

DNA ELECTRONIC APPLICATIONS- Molecular wires and switches Biomolecular computer, molecular arrays as memory stores, DNA for molecular devices - moleculesbetween nanofabricated electrodes.

Outcome 4	**Understand molecular conductivity towards constructing conducting wires, rectifiers switches by semiconductor interfacing with biomolecules towards bioelectronics devices.**	**K2, K4, K6**

Unit - V

Objective 5	**To learn origin of biosensors, glucose biosensor, different generations and recent trends**

GLUCOSE SENSORS - Definition- Historical developments – generations of glucose sensing -types of glucose monitoring – invasive and non-invasive – sensor market-Indian status.

Outcome 5	**Familiar with history and recent development of glucose sensors.**	**K2/K4/K6**

Suggested Readings:-

Cooper J. 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.

Mulchandani A. Rogers K.R. (1998). Enzyme and Microbial Biosensors Techniques and Protocols. Humana Press, Totowa, New Jersey.

Online resources:- Basics of Biosensors and Nanobiosensors - Nanobiosensors - Wiley Online Library Biosensors: Design, Development and Applications | IntechOpen Biosensors: components, mechanisms, and applications - ScienceDirect					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**
					Course designed by: Dr. V. Dharuman

Course Outcome

CO 1	Understand basic characteristics, types of biosensing devices	**K1/K2**
CO 2	Understand different methods for attaching recognition molecule on the sensor surface.	**K3/K6**
CO 3	Identify different recognition molecules for different biosensing applications	**K1/ K5/K6**
CO 4	Understand the working principles of electronic and optical sensor devices.	**K2, K4, K6**
CO 5	Learn the origin of biosensors, glucose biosensor, different generations and recent trends	**K2/K4/K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	M (2)	M (2)	M (2)	L (1)
CO 2	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	M (2)	M (2)	L (1)	M (2)
CO 3	S (3)	M (2)	M (2)	M (2)	S (3)	M (2)	S (3)	S (3)	M (2)	M (2)
CO 4	S (3)	M (2)	S (3)	M (2)	S (3)	L (1)	S (3)	M (2)	S (3)	M (2)
CO 5	M (2)	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)	M (2)	M (2)	M (2)
W. AV	**2.8**	**2.1**	**2.6**	**2.0**	**2.4**	**2.2**	**2.2**	**2.2**	**2.0**	**1.8**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	S (3)	M (2)	M (2)	M (2)
CO 2	S (3)	M (2)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	M (2)	M (2)	M (2)	S (3)	M (2)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.4***	***2.2***	***2.2***	***2.4***	***2.6***

S –Strong (3), M-Medium (2), L- Low (1)

III SEMESTER					
DSE	**Course code:542514**	**Bioelectronics**	**T**	**Credits: 3**	**Hours: 3**

Unit - I		
Objective 1	**To impart knowledge on bioelectronic devices and their applications in various fields.**	
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.		
Outcome 1	**Familiarize with basic semiconducting properties of metal oxide semiconductors and its structure.**	**K1/K4/K6**
Unit - II		
Objective 2	**To understand basics of biosensor devices, metal oxide semiconductors in biosensor field and types of biosensor devices.**	
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 potentiometric sensors (LAPS).		
Outcome 2	**Selection of metal oxides, ion selective electrodes field effect transducers for the required biosensing applications**	**K1/K2/K6**
Unit - III		
Objective 3	**To learn on molecules as electronic components for developing molecular electronic devices**	
MOLECULAR ELECTRONICS – Molecular wires and switches; molecular arrays as memory stores biomolecular computer, Properties of DNA and its potential applications in molecular electronics.		
Outcome 3	**Understand molecular conductivity towards constructing conducting wires, rectifiers switches by semiconductor interfacing with biomolecules towards bioelectronics devices.**	**K2, K4, K6**
Unit - IV		
Objective 4	**To learn on the microelectrode types, polarizable and non-polarizable electrodes and their applications in biomedical field.**	
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.		
Outcome 4	**Selection of micro electrodes for applications in medical field**	**K3/K4/K6**
Unit - V		
Objective 5	**To understand the conduction in neurons, their electrical properties and circuit models**	
BIOELECTRICITY AND BIOELECTRIC PHENOMENON -Biology of the Neuron, Biophysical Description of the Action Potential, The Neuron as the threshold device – Synapses, Networks, Neuro-bioengineeringNeuroelectronic Junctions, Silicon Neurons Neurons - Equivalent Circuit Model for Cell Membrane - Hodgkin & Huxley and Equivalent Circuits.		
Outcome 5	**Learn about neuronal network and mechanism of signal transmission in biological system and to develop equivalent circuits**	**K2/K4/K6**

Suggested Readings:-

Andreas Offenhausser and Ross Rinaldi. (2009). *Nanobioelectronics-for electronics, biology andmedicine*.

Chad A. Mirkin and Christ of Niemeyer M. (2007). *Nanobiotechnology II More Concepts and Applications*.

Christ of Niemeyer M and Chad A. Mirkin. (2004). *Nanobiotechnology Concepts, Applications and Perspectives.*

David S. Good sell. (2004). *Bionanotechnology*.

Jason J Davis. (2009). *Engineering the bioelectronic interface*.

Online resources:-

PPT – Metal-Oxide-Semiconductor (MOS) PowerPoint presentation | free to view - id: 3e1ae5-MTIzY (powershow.com)

Advances in Molecular Electronics: A Brief Review - ScienceDirect

Introduction To Bioelectric Phenomena [d4pqq1zv79np] (idoc.pub)

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. V. Dharuman

Course Outcome

CO 1	Familiarize with basic semiconducting properties of metal oxide semiconductors and its structure.	**K1/K4/K6**
CO 2	Selection of metal oxides, ion selective electrodes field effect transducers for the required biosensing applications	**K1/K2/K6**
CO 3	Understand molecular conductivity towards constructing conducting wires, rectifiers switches by semiconductor interfacing with biomolecules towards bioelectronics devices.	**K2, K4, K6**
CO 4	Selection of micro electrodes for applications in medical field	**K3/K4/K6**
CO 5	Learn about neuronal network and mechanism of signal transmission in biological system and to develop equivalent circuits	**K2/K4/K6**

Course outcome Vs Programme outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	M (2)	L (1)	M (2)	M (2)
CO 2	S (3)	M (2)	M (2)	S (3)	M (2)	M (2)	M (2)	M (2)	S (3)	M (2)
CO 3	M (2)	S (3)	M (2)	L (1)	M (2)	S (3)	M (2)	S (3)	M (2)	L (1)
CO 4	M (2)	M (2)	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	M (2)
CO 5	S (3)	M (2)	L (1)	M (2)	M (2)	S (3)	M (2)	M (2)	M (2)	L (1)
W. AV.	**2.6**	**2.2**	**2.0**	**2.0**	**2.2**	**2.8**	**2.1**	**2.0**	**2.2**	**1.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)
CO 2	S (3)	M (2)	M (2)	S (3)	M (2)
CO 3	M (2)	M (2)	M (2)	M (2)	M (2)
CO 4	S (3)	S (3)	S (3)	M (2)	L (1)
CO 5	M (2)	M (2)	M (2)	S (3)	M (2)
W. AV.	**2.6**	**2.2**	**2.4**	**2.0**	**1.8**

S –Strong (3), M-Medium (2), L- Low (1)

III SEMESTER					
DSE	**Course code:542515**	**Chemical Sensors**	**T**	**Credits: 3**	**Hours: 3**

Unit I

Objective 1	**To introduce the concept of sensors with its principle and definition.**	
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.		
Outcome 1	**Understand the concept of sensors with its principle and definition.**	**K1/ K5**

Unit II

Objective 2	**To introduce various physico-chemical methods in sensor and the sensor materials used for fabrication.**	
PHYSICO-CHEMICAL SENSORS AND TRANSDUCERS - 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.		
Outcome 2	**Understand the materials used in sensors and different types of physico-chemical sensors in recent years.**	**K3/K4**

Unit III

Objective 3	**To gain knowledge about materials used for biosensors.**	
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.		
Outcome 3	**Understand fundamentals of bio- electronic devices and how to select the materials for biosensors.**	**K3/K5**

Unit IV

Objective 4	**To know about fabrication of sensors using modern technology.**	
SENSOR ENGINEERING - Methods for sensors fabrication: self-assembled monolayers, screen printing, photolithography, microcontact printing, MEMS. Engineering concepts for mass production.		
Outcome 4	**Understand the device fabrication strategies used in sensor preparation.**	**K1/K5**

Unit V

Objective 5	**To impart knowledge on advanced sensor materials used in practical application**	
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.		
Outcome 5	**Understand the various sensor materials used for health care monitoring.**	**K2/K5**

Suggested Readings:-

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

Frieder Schelfer And 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.

Online Resources:-

Infrared optical sensors for water quality monitorin, B. Mizaikoff, Water Sci Technol (2003) 47 (2): 35–42. https://doi.org/10.2166/wst.2003.0079

Biochemical sensors based on polymer microrings with sharp asymmetrical resonance, Chung-Yen Chao; L. Jay Guo, Appl. Phys. Lett. 83, 1527–1529 (2003), https://doi.org/10.1063/1.1605261.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Understand the concept of sensors with its principle and definition.	**K1/ K3**
CO 2	Understand the materials used in sensors and different types of physico-chemical sensors in recent years.	**K3/ K4**
CO 3	Understand fundamentals of bio- electronic devices and how to select the materials for biosensors	**K3/ K5**
CO 4	Understand the device fabrication strategies used in sensor preparation	**K1/ K5**
CO 5	Understand the various sensor materials used for health care monitoring.	**K2/ K5**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	3
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.2***	***2.2***	***2.2***	***2.6***	***3***

S –Strong (3), M-Medium (2), L- Low (1)

III SEMESTER					
DSE	**Course code:542516**	**Thin Film Science and Technology**	**T**	**Credits: 3**	**Hours: 3**

Unit I

Objective 1	**To understand the film growth technology and structural defects in formed film.**	
GROWTH AND STRUCTURE OF FILMS -Introduction to thin films and applications - General features - Nucleation theories - Post-nucleation growth – Thin film structures- Structural defects.		
Outcome 1	**Understand the general features and film growth techniques used.**	**K1, K5/K6**

Unit II

Objective 2	**To introduce various measurement and monitoring techniques used for thin films analysis**	
THICKNESS MEASUREMENT AND MONITORING - Multiple beam interference - quartz crystal - ellipsometric - stylus techniques. Characterization: X-ray diffraction - electron microscopy - high and low energy electron diffraction.		
Outcome 2	**Study the various measurement and monitoring techniques.**	**K3/K6**

Unit III

Objective 3	**To gain knowledge about preparation techniques used for film formation.**	
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.		
Outcome 3	**Understand fundamentals of preparation methods**	**K1/K3/K5**

Unit IV

Objective 4	**To know about properties of thin film.**	
PROPERTIES OF THIN FILMS - Optical - reflection and anti-reflection coatings - interference filters - thin film solar cells - electrophotography. Electrical and dielectric behaviour of 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 and tribological coatings.		
Outcome 4	**Understand the properties and analysis the results obtained from thin film.**	**K1/K5/K6**

Unit V

Objective 5	**To impart knowledge on high vacuum production in sample preparation.**	
HIGH VACUUM PRODUCTION- Mechanical pumps - Diffusion pump - measurement of vacuum - gauges - production of ultra-high vacuum - thin film vacuum coating unit		
Outcome 5	**Students understand the necessity of high vacuum production in sample preparation.**	K2/K5/K6

Suggested Readings:-

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.

Online Resources:- Synthesis of ZrO2 thin films by atomic layer deposition: growth kinetics, structural and electrical properties, Michel Cassir, Fabrice Goubin, Cécile Bernay, Philippe Vernoux, Daniel Lincot, Applied Surface Science, Volume 193, Issues 1–4, 2002, Pages 120-128, https://doi.org/10.1016/S0169-4332(02)00247-7. Mechanical properties of thin films, William D. Nix , Metallurgical Transactions A volume 20, pages2217–2245 (1989), https://doi.org/10.1007/BF02666659					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**

Course Outcome

CO 1	Understand the general features and film growth techniques used	**K1, K2**
CO 2	Study the various measurement and monitoring techniques	**K2, K3**
CO 3	Understand fundamentals of preparation methods	**K5**
CO 4	Understand the properties and analysis the results obtained from thin film	**K3, K4**
CO 5	Understand the necessity of high vacuum production in sample preparation.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.2***	***2.2***	***2.2***	***2.6***	***3***

S –Strong (3), M-Medium (2), L- Low (1)

III SEMESTER					
DSE	**Course code 542517**	**Superconducting Materials and Applications**	**T**	**Credits: 3**	**Hours: 3**

Unit - I		
Objective 1	**To introduce the basic experimental aspects of the superconductivity.**	
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.		
Outcome 1	**The students understand the basic concepts of superconductivity**	**K2**
Unit - II		
Objective 2	**To know about superconducting materials and its alloys.**	
SUPERCONDUCTING MATERIALS - Elemental superconductors –superconducting compounds and its alloys – A-I5 compounds – chevral phase compounds.		
Outcome 2	**Gain knowledge in superconducting materials.**	**K4**
Unit - III		
Objective 3	**To make the students to understand the experimental studies of superconducting materials.**	
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.		
Outcome 3	**Understand the experimental studies of superconducting materials**	**K1**
Unit - IV		
Objective 4	**To inspire the theoretical aspects of superconductivity.**	
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.		
Outcome 4	**Apply the theoretical aspects of superconductivity.**	**K5**
Unit - V		
Objective 5	**To learn various application in superconductivity**	
APPLICATIONS - Superconducting magnets – power generators, motors, transformers, power storage, power transmission – Josephson junction devices – IR sensors – SQUIDS –SLUGS – magnetically leviated trains – computer storage elements		
Outcome 5	**The students able to understand various technological application of the superconductivity.**	**K2**

Suggested Readings:-

Blundell S. (2009). Superconductivity: A Very Short Introduction. Oxford University Press.

KowkH.S. and ShawD.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.

Online resources:-

High-Tc superconducting materials for electric power applications, David Larbalestier, Alex Gurevich, D. Matthew Feldmann & Anatoly Polyanskii , Nature volume 414, pages368–377 (2001), https://doi.org/10.1038/35104654.

Development of a superconducting magnet for nuclear magnetic resonance using bulk high-temperature superconducting materials, Takashi Nakamura, Yoshitaka Itoh, Masaaki Yoshikawa, Tetsuo Oka, Jun Uzawa, Volume31B, Issue2, April 2007, Pages 65-70, https://doi.org/10.1002/cmr.b.20083.

Materials science challenges for high-temperature superconducting wire, S. R. Foltyn, L. Civale, J. L.

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course Outcome

CO 1	Understand the basic concepts of superconductivity	**K1, K2**
CO 2	Gain knowledge in superconducting materials.	**K2, K3**
CO 3	Understand experimental studies of superconducting materials	**K5**
CO 4	Apply the theoretical aspects of superconductivity.	**K3, K4**
CO 5	Understand various technological application of the superconductivity.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S (3)	M (2)	S (3)	M (2)	M (2)	S (3)	L (1)	M (2)	L (1)	M (2)
CO 2	S (3)	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	S (3)	S (3)	S (3)
CO 3	M (2)	M (2)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	L (1)	S (3)
CO 4	S (3)	S (3)	S (3)	S (3)	M (2)	M (2)	L (1)	M (2)	M (2)	M (2)
CO 5	M (2)	S (3)	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)
W. AV	**2.6**	**2.6**	**3**	**2.8**	**2.6**	**2**	**1.4**	**2.2**	**2**	**2.6**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	M (2)	M (2)	S (3)	S (3)
CO 2	S (3)	S (3)	M (2)	M (2)	S (3)
CO 3	M (2)	M (2)	S (3)	M (2)	S (3)
CO 4	L (1)	M (2)	M (2)	S (3)	S (3)
CO 5	M (2)	M (2)	M (2)	S (3)	S (3)
W. AV	***2.2***	***2.2***	***2.2***	***2.6***	***3***

S –Strong (3), M-Medium (2), L- Low (1)

IV-SEMESTER					
Core 16	**Course Code: 542999**	**Project Dissertation work/Internship Programme**		**Credits: 15**	**Hours: 30**
Objectives	The overall aim of the research project/internship is • To allow students to demonstrate the personal abilities and skills required to produce and present an extended piece of work. • To engage in personal inquiry, action and reflection on specific topics and issues. • To focus on, and demonstrate an understanding of, the areas of interaction. • To reflect on learning and share knowledge, views and opinions. Specific objectives for allowing one full semester to carry out research project and/or to undergo are internship training programme are as follows; A) Planning and Development Students should: • Identify a clear and achievable goal • Describe and justify a focus on the chosen area(s) of interaction • Describe the steps followed to achieve the stated goal • Adhere to the stated goal throughout the project. B) Literature/data collection Students should: • Select and utilize adequate, varied resources • Identify and use relevant information critically • Acknowledge sources of information appropriately. C) Choice and Application of Techniques Students should: • Choose experiment/techniques relevant to the project's goal • Justify this selection • Apply the chosen techniques consistently and effectively. • Acquire sufficient data relevant to the goal D) Data analysis Students should: • Analyse the data in terms of the goal and the focus of the project • Express personal thought • Support arguments with evidence • Respond thoughtfully to ideas and inspiration. E) Organization of the Dissertation Students should: • Organize their work in a coherent manner according to the required structure • Present information clearly • Present references, bibliography and symbolic representations appropriately. F) Analysis of the Process and Outcome Students should: • Identify the strengths and weaknesses of the project at different stages of development • Where appropriate, suggest ways in which the project could have been tackled differently • Assess the achieved results in terms of the initial goal and the focus on the chosen area(s) of interaction • Show awareness of the overall perspectives related to the chosen topic or piece of work.				

I-SEMESTER					
NME 1	**Course code :542701**	**Electronics For Daily Life**	**T**	**Credits: 2**	**Hours: 3**
Unit -I					
Objective 1	**To get basics of electrical and electronics home appliances**				
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.					
Outcome 1	**Get familiar with the principle of electrical safety.**				**K1, K2**
Unit II					
Objective 2	**To learn about electrical accessories.**				
ELECTRICAL ACCESSORIES AND EARTHING - Switches – holders – sockets – ceiling rose – plugs – main switch – fuse – circuit breaker – Earthing/grounding – importance – components of earthing system – types of earthing – pipe, plate and rod earthing – SI specifications of earthing.					
Outcome 2	**Get familiar in handling electrical appliances and electronics gadgets.**				**K3, K4**
Unit III					
Objective 3	**To get familiar with smart electronics**				
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.					
Outcome3	**Students learn about smart electronics.**				**K2**
Unit IV					
Objective 4	**To understand the concept of energy and energy devices**				
ENEGRY DEVICES- Energy density vs Power density – Primary, Secondary Batteries- Wet Cell, Dry Cell- Alkaline-Lithium ion –Flow battery- Supercapacitor- Fuel Cell.					
Outcome4	**Get familiar with energy devices.**				**K5**
Unit V					
Objective 5	**To get knowledge on energy conservation**				
ENERGY CONSERVATION- Renewable Energy Source- Photovoltaic Cell – Energy Efficient lamps (CLF, LED)- Green Computing-Home appliance- Energy efficiency in Vehicles – Solar car.					
Outcome 5	**Get familiar with how to conserve electricity by opting for renewable energy sources and energy efficient home appliances.**				**K5, K6**

Suggested Readings:-

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.

Online resources:-

https://www.khanacademy.org/science/electrical-engineering

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. C. Sekar

Course Outcome

CO1	Acquire knowledge of electrical safety principles, preventing electric shock, and addressing safety concerns with emerging energy sources.	**K1**
CO2	Learn about electrical accessories and earthing systems, their significance, components, types, and adherence to SI specifications.	**K2, K3**
CO3	Comprehend the history of processors, memory storage and apply smart electronics in devices, while understanding human-computer interaction.	**K2, K4**
CO4	Gain comprehensive understanding of various energy storage technologies, along with the concepts of energy density and power density.	**K2, K5**
CO5	Learn about renewable energy sources, energy-efficient lighting, green computing, eco-friendly appliances, and solar-powered vehicles.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)	L (1)	S (3)
CO 2	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	L (1)	M (2)	L (1)	S (3)
CO 3	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	S (3)	S (3)	S (3)	S (3)
CO 4	S (3)	S (3)	S (3)	M (2)	L (1)	M (2)	L (1)	M (2)	S (3)	M (2)
CO 5	S (3)	S (3)	S (3)	M (2)	L (1)	M (2)	S (3)	L (1)	M (2)	S (3)
W. AV	**3**	**3**	**3**	**1.4**	**1**	**2.2**	**2.2**	**2.2**	**2**	**2.8**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/ CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	S (3)	M (2)	S (3)	S (3)
CO 2	S (3)	M (2)	M (2)	S (3)	M (2)
CO 3	S (3)	S (3)	L (1)	M (2)	M (2)
CO 4	S (3)	L (1)	S (3)	M (2)	M (2)
CO 5	S (3)	M (2)	S (3)	M (2)	M (2)
W. AV	**3**	**2.2**	**2.2**	**2.4**	**2.2**

S –Strong (3), M-Medium (2), L- Low (1)

I-SEMESTER					
NME 2	**Course code:542702**	**Food Chemistry**	**T**	**Credits: 2**	**Hours: 3**
Unit -I					
Objective 1	**To enable the students to acquire knowledge on the macro and micro constituents of the food**				
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.					
Outcome 1	**Know about the factors governing the food**				**K1, K2**
Unit II					
Objective 2	**To know the structure and chemical characteristics of constituents of food**				
ELECTRICAL ACCESSORIES AND EARTHING - Switches – holders – sockets – ceiling rose – plugs – main switch – fuse – circuit breaker – Earthing/grounding – importance – components of earthing system – types of earthing – pipe, plate and rod earthing – SI specifications of earthing.					
Outcome2	**Able to name and describe the general chemical structures of the major components of foods and selected minor components**				**K3, K4**
Unit III					
Objective 3	**To demonstrate the knowledge of food chemistry and applying, the principles and concepts of chemistry as they apply to food systems**				
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.					
Outcome 3	**Know about the techniques involved in food processing and preservation**				**K2**
Unit IV					
Objective 4	**To familiarize the student with the relationship between water and food**				
ENEGRY DEVICES- Energy density vs Power density – Primary, Secondary Batteries- Wet Cell, Dry Cell- Alkaline-Lithium ion –Flow battery- Supercapacitor- Fuel Cell.					
Outcome4	**Learn food additives and their function in preservation**				**K5**
Unit V					
Objective 5	**To explain the rationale for certain food processes and preservation**				
ENERGY CONSERVATION- Renewable Energy Source- Photovoltaic Cell – Energy Efficient lamps (CLF, LED)- Green Computing-Home appliance- Energy efficiency in Vehicles – Solar car.					
Outcome 5	**Familiarize with the nature of packed food from industrial processes**				**K5, K6**

Suggested Readings: -

Belitz, H-D., Grosch, W. & Schieberle, P. (2004) Food Chemistry 3rd Ed. (translation of fifth German edition), Springer

Damodaran, S., Parkin, K. L., and Fennema, 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.

Online resources:-

https://www.britannica.com/technology/food-processing

https://byjus.com/biology/food-processing/

https://www.ift.org/policy-and-advocacy/advocacy-toolkits/food-processing

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. C. Sekar

Course Outcome

CO1	Know about the factors governing the food quality and chemical constituents	**K1**
CO2	Able to name and describe the general chemical structures of the major components of foods and selected minor components	**K2, K3**
CO3	Know about the techniques involved in food processing and preservation	**K2, K4**
CO4	Learn food additives and their function in preservation	**K2, K5**
CO5	Familiarize with the nature of packed food from industrial processes	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)	L (1)	S (3)
CO 2	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	L (1)	M (2)	L (1)	S (3)
CO 3	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	S (3)	S (3)	S (3)	S (3)
CO 4	S (3)	S (3)	S (3)	M (2)	L (1)	M (2)	L (1)	M (2)	S (3)	M (2)
CO 5	S (3)	S (3)	S (3)	M (2)	L (1)	M (2)	S (3)	L (1)	M (2)	S (3)
W. AV	**3**	**3**	**3**	**1.4**	**1**	**2.2**	**2.2**	**2.2**	**2**	**2.8**

S –Strong (3), M-Medium (2), L- Low (1) Course

Outcome Vs Programme Specific Outcome

PSO/CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	S (3)	M (2)	S (3)	S (3)
CO 2	S (3)	M (2)	M (2)	S (3)	M (2)
CO 3	S (3)	S (3)	L (1)	M (2)	M (2)
CO 4	S (3)	L (1)	S (3)	M (2)	M (2)
CO 5	S (3)	M (2)	S (3)	M (2)	M (2)
W. AV	**3**	**2.2**	**2.2**	**2.4**	**2.2**

S –Strong (3), M-Medium (2), L- Low (1)

III-SEMESTER					
NME 3	**Course code :542703**	**Nanomaterials Biosensors**	**T**	**Credits: 2**	**Hours: 3**

Unit - I

Objective 1	**To understand different methods for attaching recognition molecule on the sensor surface. understand basic characteristics of biosensors, nanoparticles and hybrids**

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.

Outcome 1	**Ability to Select different types of sensors based on type of requirement and applications. Understanding the hybrid of nanomaterials and biomolecules**	**K3/K6**

Unit - II

Objective 2	**To learn about Synthetic methods of nanoparticles in presence of biological molecules.**

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.

Outcome 2	**Get familiar with green synthesis of metal/oxide nanoparticles using bacteria, fungi and plant extracts**	**K4/K5/K6**

Unit - III

Objective 3	**To identify different recognition molecules for different biosensing applications**

MOLECULAR RECOGNITION ELEMENTS IN NANOSENSING – Transducers- bio-recognizing elements – Enzymes, Antibodies; Nucleic acids; Methods of Immobilization - Co-valent and non-covalent, self-assembly.

Outcome 3	**Ability to select biorecognition system to detect particular type of analytes.**	**K1/ K5/K6**

Unit - IV

Objective 4	**To know electrical and optical techniques in biosensing.**

ELECTRICAL AND OPTICAL BIOSENSORS - Principles – Conductometric, amperometric and Impedimetric biosensors; Glucose biosensors - Optical Biosensors: Principles – Absorbance, Chemi-luminescence - Fluorescence, Phosphorescence; Colorimetric sensors.

Outcome 4	**Learn different biosensing techniques, glucose biosensors, principles of electrochemical and optical biosensors**	**K1/ K2/K5/K6**

Unit - V

Objective 5	**To get familiar nanotechnology applications in medical and food industries.**

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.

Outcome 5	**Familiarize with applications of nanosensors in medical and food industries and able to identify the materials for both applications**	**K1/ K2/K5/K6**

Suggested Readings:-

Charles P. Poole, Jr., Frank J. 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.

Kourosh Kalantar, 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 and Nanosystems, New Jersey.

Online resources:-

Nanotechnologies in Food Science: Applications, Recent Trends, and Future Perspectives | SpringerLink
Frontiers | Application of Nanotechnology in Food Science: Perception and Overview (frontiersin.org)

K1-Remember	K2-Understand	K3-Apply	K4-Analyse	K5-Evaluate	K6-Create

Course designed by: Dr. V. Dharuman

Course Outcome

CO 1	Ability to Selectin different types of sensors based on type of requirement and applications. Understanding the hybrid of nanomaterials and biomolecules	**K1, K2**
CO 2	Familiarize with green synthesis of metal/oxide nanoparticles using bacteria, fungi and plant extracts	**K3, K6**
CO 3	Ability to selecting biorecognition system to detect analytes	**K4, K5, K6**
CO 4	Learn different biosensing techniques, glucose biosensors, principles of electrochemical and optical biosensors	**K1, K5, K6**
CO 5	Familiarize with applications of nano sensors in medical and food industries and able to identify the materials for both applications	**K1, K2, K5, K6**

Course outcome Vs Programme outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)	L (1)	L (1)	M (2)	L (1)
CO 2	S (3)	M (2)	M (2)	M (2)	M (2)	S (3)	M (2)	M (2)	M (2)	M (2)
CO 3	M (2)	S (3)	M (2)	L (1)	M (2)	M (2)	S (3)	S (3)	M (2)	M (2)
CO 4	M (2)	M (2)	S (3)	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	M (2)
CO 5	M (2)	M (2)	M (2)	M (2)	M (2)	S (3)	L (1)	L (1)	M (2)	L (1)
W. AV.	**2.4**	**2.0**	**2.2**	**1.8**	**2.0**	**2.4**	**1.8**	**1.8**	**2.2**	**1.6**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/ CO	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO 1	S (3)	S (3)	M (2)	M (2)	M (2)
CO 2	S (3)	M (2)	S (3)	S (3)	M (2)
CO 3	M (2)	M (2)	M (2)	M (2)	S (3)
CO 4	M (2)	M (2)	S (3)	S (3)	M (2)
CO 5	S (3)	S (3)	M (2)	M (2)	M (2)
W. AV.	**2.6**	**2.4**	**2.4**	**2.4**	**2.2**

S –Strong (3), M-Medium (2), L- Low (1)

III-SEMESTER					
NME 4	**Course code :542704**	**Green Chemistry**	**T**	**Credits: 2**	**Hours:3**

Unit -I

Objective 1	**To introduce the basic concept and principles of green chemistry for environmental management.**

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**.**

Outcome 1	**Familiarize with basic concepts of green chemistry and apply to them in various field.**	**K1, K2**

Unit II

Objective 2	**To make the students know about green reagents and its importance to the environment**

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).

Outcome 2	**Recognize the catalytic reaction with green reagents and its importance.**	**K3, K4**

Unit III

Objective 3	**To acquaint green solvents and its impacts in green chemistry**

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.

Outcome 3	**Recognize the preparations of materials with green process and its application to the environment.**	**K2**

Unit IV

Objective 4	**To familiarize the synthesis of materials using green methods**

GREEN SYNTHESES - Microwave induced green synthesis (Hoffmann Elimination and Oxidation of alcohols) – Ultra sound assisted green synthesis (Esterification, Saponification and Cannizaro reaction) – Solid state green synthesis Dehydration of alcohols to alkenes, Grignard reaction)- Solid supported organic synthesis (Synthesis of furans and pyrrole).

Outcome 4	**To gain knowledge of preparation of various drugs using green synthesis methods**	**K5**

Unit V

Objective 5	**To impart the knowledge on applications of green synthesis technology**

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.

Outcome 5	**Obtain skills and technology towards green chemistry and apply in industry.**	**K5, K6**

Suggested Readings:-

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.					
Online resources:- https://www.khanacademy.org/science/electrical-engineering https://www.electronics-tutorials.ws/ https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/					
K1-Remember	**K2-Understand**	**K3-Apply**	**K4-Analyse**	**K5-Evaluate**	**K6-Create**
				Course designed by: Dr. C. Sekar	

Course Outcome

CO1	Familiarize with basic concepts of green chemistry and apply to them in various field.	**K1**
CO2	Recognize the catalytic reaction with green reagents and its importance. To identify available green solvents and apply them to various synthesis process	**K2, K3**
CO3	Recognize the preparations of materials with green process and its application to the environment.	**K2, K4**
CO4	Gain the knowledge of preparation of various drugs using green synthesis methods	**K2, K5**
CO5	Obtain skills and technology towards green chemistry and apply in industry.	**K1, K6**

Course outcome Vs Programme outcomes

PO/CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	S (3)	S (3)	S (3)	L (1)	L (1)	S (3)	S (3)	S (3)	L (1)	S (3)
CO 2	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	L (1)	M (2)	L (1)	S (3)
CO 3	S (3)	S (3)	S (3)	L (1)	L (1)	M (2)	S (3)	S (3)	S (3)	S (3)
CO 4	S (3)	S (3)	S (3)	M (2)	L (1)	M (2)	L (1)	M (2)	S (3)	M (2)
CO 5	S (3)	S (3)	S (3)	M (2)	L (1)	M (2)	S (3)	L (1)	M (2)	S (3)
W. AV	**3**	**3**	**3**	**1.4**	**1**	**2.2**	**2.2**	**2.2**	**2**	**2.8**

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome Vs Programme Specific Outcome

PSO/CO	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**	**PSO 5**
CO 1	S (3)	S (3)	2	S (3)	S (3)
CO 2	S (3)	M (2)	M (2)	S (3)	M (2)
CO 3	S (3)	S (3)	L (1)	M (2)	M (2)
CO 4	S (3)	L (1)	S (3)	M (2)	M (2)
CO 5	S (3)	M (2)	S (3)	M (2)	M (2)
W. AV	***3***	***2.2***	***2.2***	***2.4***	***2.2***

S –Strong (3), M-Medium (2), L- Low (1)

SCIENCE CAMPUS