தமிழ்நாடு மத்தியப் பல்கலைக்கழகம்

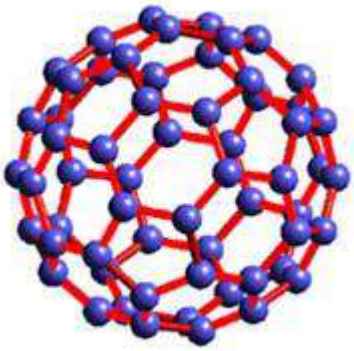
CENTRAL UNIVERSITY OF TAMIL NADU

तमिलनाडु केन्द्रीय विश्वविद्यालय

ESTABLISHED BY AN ACT OF PARLIAMENT IN 2009

DEPARTMENT OF
MATERIALS SCIENCE

SCHOOL OF TECHNOLOGY



B.Tech. (Bachelor of Technology)

Materials Science and Technology

CURRICULUM AND SYLLABUS

R2026 (Regulations: 2026)

A. OVERVIEW

Central University of Tamil Nadu (CUTN) is an institution of higher education established by an Act of Parliament in 2009. The University aims at the forming of an enlightened society founded on a relentless pursuit of excellence through innovation in teaching-learning process, interdisciplinary studies and research. With a host of diversified integrated postgraduate, postgraduate and doctoral programmes, the University has been keen to stay abreast of the ever expanding academic frontiers. Within a brief period CUTN has established itself as a frontrunner in the pursuit of excellence.

1. SCHOOL OF TECHNOLOGY

The School of Technology aims to be in the forefront of teaching, research, and extension activities. This School presently comprises the Department of Materials Science, offering the following courses.

1. **B.Tech.** (Materials Science and Technology) - 4 year Programme
2. **M.Tech.** (Materials Science and Technology) - 2 year Programme
3. **Ph.D.** (Materials Science)

2. DEPARTMENT OF MATERIALS SCIENCE

The Department of Materials Science is an interdisciplinary engineering science department that currently offering M.Tech. (Materials Science and Technology) and Ph.D. in (Materials Science). From academic year 2026 – 27, it offers the B.Tech. programme in Materials Science and Technology.

The department was started in the academic year 2016-17. The department is equipped with six faculty members with doctorates and they are actively involved in research besides teaching.

The curriculum is designed to meet the standards expected from the industry and also facilitates to aspire research. The department offers a choice-based credit system. The students are evaluated through a continuous assessment system. The department is equipped with a smart class room and materials science labs that cater the needs of students. The department have a six research labs headed by faculty members that cater the needs of faculty and research scholars to pursue high quality research.

3. VISION OF THE DEPARTMENT

To evolve into a globally recognized department in the frontiers areas of Materials Science and Technology

4. MISSION OF THE DEPARTMENT

- To produce Materials Science and Technology graduates having professional excellence.
- To carry out quality research having social and industrial relevance.
- To provide technical support to budding entrepreneurs and existing industries.

5. PROGRAM SPECIFIC OBJECTIVES

PSO1	**MATERIALS DESIGN AND PROCESSING:** Graduates will be able to understand the structure–property–processing relationships of materials. They will gain skills to design and synthesize metals, ceramics, polymers, and composites. They will apply modern techniques to develop advanced and sustainable materials.
PSO2	**CHARACTERIZATION AND ANALYSIS:** Graduates will develop proficiency in material characterization using advanced analytical tools. They will interpret microstructural, thermal, mechanical, and chemical properties of materials. They will apply data analysis to solve real-world materials engineering problems.
PSO3	**APPLICATION AND INNOVATION IN MATERIALS ENGINEERING:** Graduates will apply materials science principles in industries like energy, electronics, and healthcare. They will engage in research, innovation, and product development using emerging materials. They will demonstrate professional ethics, teamwork, and lifelong learning in technological advancement.

6. PSO TO MISSION MAPPING

	M1	M2	M3
PSO1	3	3	2
PSO2	2	3	3
PSO3	1	2	3

7. PROGRAM EDUCATION OBJECTIVES

PEO 1	**PROFESSIONAL COMPETENCE AND CAREER GROWTH:** Graduates will establish successful careers in materials-related industries, research organizations, or higher education. They will apply core principles of materials science to solve engineering problems effectively. They will adapt to evolving technologies and industry demands.
PEO 2	**INNOVATION, RESEARCH, AND LIFELONG LEARNING:** Graduates will engage in research, innovation, and development of advanced materials and technologies. They will pursue higher studies, certifications, or entrepreneurial ventures. They will demonstrate continuous learning to stay relevant in emerging scientific fields.
PEO 3	**ETHICAL PRACTICE AND SOCIETAL CONTRIBUTION:** Graduates will practice engineering with strong professional ethics and social responsibility. They will contribute to sustainable development through eco-friendly materials and processes. They will work effectively in multidisciplinary teams and serve the needs of society.

8. PEO TO MISSION MAPPING

	M1	M2	M3
PEO1	3	2	1
PEO2	2	3	2
PEO3	1	2	3

9. GRADUATE ATTRIBUTES

G1. Apply fundamental knowledge of materials science to solve engineering problems.
G2. Analyze and interpret material properties using scientific and engineering principles.
G3. Design and develop materials and processes to meet specific industrial needs.
G4. Use modern tools and techniques for material synthesis and characterization.
G5. Conduct experiments, analyze data, and draw meaningful conclusions.
G6. Function effectively as an individual and as a member of multidisciplinary teams.
G7. Communicate technical information clearly in oral and written forms.
G8. Understand professional ethics and responsibilities in engineering practice.
G9. Consider environmental and sustainability aspects in materials development.
G10. Engage in lifelong learning to adapt to emerging technologies and innovations.

10. DISCIPLINE GRADUATE ATTRIBUTES FOR MATERIALS SCIENCE TECHNOLOGY

1. **STRUCTURE–PROPERTY CORRELATION**
   Ability to relate atomic/microstructure to mechanical, electrical, thermal, and optical properties of materials.
2. **MATERIALS PROCESSING EXPERTISE**
   Knowledge of synthesis and processing techniques such as casting, powder metallurgy, thin films, and additive manufacturing.
3. **CHARACTERIZATION PROFICIENCY**
   Skill in using tools like X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and spectroscopy to analyze materials.
4. **MATERIALS SELECTION AND DESIGN**
   Ability to select appropriate materials based on performance, cost, and environmental constraints for specific applications.
5. **FAILURE ANALYSIS AND RELIABILITY**
   Competence in identifying failure mechanisms such as corrosion, fatigue, and wear, and improving material reliability.
6. **COMPUTATIONAL MATERIALS SCIENCE**
   Understanding of simulation and modelling tools to predict material behaviour and optimize performance.
7. **NANOMATERIALS AND ADVANCED MATERIALS**
   Knowledge of synthesis, properties, and applications of nanomaterials, biomaterials, and smart materials.
8. **SUSTAINABILITY AND GREEN MATERIALS**
   Ability to develop eco-friendly materials and processes considering recycling, lifecycle, and environmental impact.
9. **INDUSTRIAL AND MANUFACTURING AWARENESS**
   Understanding of industrial practices, quality control, and scale-up processes in materials production.
10. **RESEARCH AND INNOVATION SKILLS**
    Ability to conduct independent research, analyse scientific literature, and contribute to innovation in materials technology.

11. PROGRAM OBJECTIVES

On successful completion of the program, the students will be able to

PO1	**Strong Fundamental Knowledge** Develop a solid foundation in physics, chemistry, and materials science principles. Enable understanding of structure–property–processing relationships.
PO2	**Materials Synthesis and Processing** Provide knowledge of techniques for synthesis and processing of diverse materials. Enable fabrication of metals, ceramics, polymers, and composites.
PO3	**Characterization Skills** Train students in modern characterization methods for analyzing materials. Enable interpretation of structural, mechanical, and chemical properties.
PO4	**Problem-Solving Ability** Develop analytical skills to identify and solve materials-related engineering problems. Encourage logical reasoning and scientific approach.
PO5	**Design and Development** Enable students to design materials and processes for specific applications. Promote innovation in developing advanced and functional materials.
PO6	**Modern Tool Usage** Provide exposure to advanced tools, software, and instrumentation. Enable effective use of computational and experimental techniques.
PO7	**Research and Innovation** Encourage participation in research and development activities. Develop ability to analyze literature and generate new ideas.
PO8	**Industrial and Practical Exposure** Provide knowledge of industrial practices and real-world applications. Enhance employability through internships and hands-on training.
PO9	**Environmental and Sustainability Awareness** Promote the use of eco-friendly materials and sustainable processes. Encourage responsibility toward environmental protection.
PO10	**Ethics and Professional Responsibility** Instill ethical values and professional conduct in engineering practice. Prepare graduates to work responsibly in society.
P011	**Communication and Teamwork** Develop effective communication and interpersonal skills. Enable collaboration in multidisciplinary and diverse teams.

12. PO TO PSO MAPPING

	PSO1	PSO2	PSO3
PO1	3	3	3
PO2	3	3	2
PO3	3	3	3
PO4	2	3	2
PO5	3	3	3
PO6	1	2	2
PO7	1	2	2
PO8	1	2	3
PO9	2	2	2
PO10	2	2	2
PO11	2	2	3

B. REGULATIONS

1. PREAMBLE

The B.Tech. (Materials Science and Technology) programme of Central University of Tamil Nadu is offered under the Choice Based Credit System (CBCS). These regulations guide all academic and administrative processes pertaining to admission, curriculum structure, teaching–learning, assessment, evaluation, and award of the degree.

2. ADMISSION REQUIREMENTS AND SANCTIONED INTAKE

A candidate seeking admission to the B.Tech. Degree Programme shall have passed the Higher Secondary Examination (10+2 pattern) with Physics, Chemistry and Mathematics as mandatory subjects under Part III or any Examination recognized as equivalent, fulfilling eligibility norms of the University and Government of India. Admissions shall be made through ranking obtained by the candidate in national-level examinations such as JEE (Main) or CUET-UG**,** subject to policy decisions of CUTN. For the academic year 2026-27, the sanctioned intake is 24.

3. DURATION OF THE PROGRAMME

The programme shall extend over eight semesters (four academic years) with two semesters in each academic year.

4. MEDIUM OF INSTRUCTION

English shall be the medium of instruction for all courses, seminars, examinations, laboratory work, and project reports.

5. PROGRAMME STRUCTURE

The curriculum consists of the following categories of courses:

- Humanities and Social Sciences (HSMC)
- Basic Sciences (BSC)
- Engineering Sciences (ESC)
- Professional Core (PCC)
- Professional Electives (PEC)
- Lab Courses (LC)
- Open Electives (OEC)
- Industrial Training / Internship Courses / Certification
- MOOC
- Project Work

5. PROGRAMME STRUCTURE

5.1 CREDIT SYSTEM

The assignment of credits follows standard norms:

- 1 Credit = 1 hour of Lecture/Tutorial per week
- 1 Credit = 2 hours of Laboratory / Practical work per week
- MOOCs / Self-Learning**:** Credit as per equivalence approved by the BoS.

5.2 TOTAL CREDITS

To qualify for the award of the B.Tech. MST degree, a student must earn **172 credits**, as specified in the curriculum.

5.3 INTERNSHIP / INDUSTRIAL TRAINING / CERTIFICATION

Every student should undergo industrial training or do an internship (as prescribed in the curriculum) in industry, R&D organization or in any recognized institution for a minimum of four to six weeks, normally during the summer vacation. These Industrial

Training/Internships should be carried out at Centrally Funded Institutes (CFIs)/IITs/NITs/Industries/Govt. Universities & Govt. Research organisations/Labs. Evaluation will be made a credits will be awarded in the subsequent semester. Credits shall be awarded based on

- Internship report
- Certificate from the organization / institution
- Evaluation by the faculty committee

A student can be permitted to do a certification course instead of internship or industrial training. In this case, the certificate will be validated by the faculty committee and the credits will be awarded in the seventh semester.

5.4 NCC / NSS /SPORTS AND YOGA

The activities will include Practical / field activities / Extension lectures and shall be carried out outside class hours. The evaluation of these audit courses will be done as per CUTN norms.

6. ACADEMIC CALENDAR

Each semester shall normally consist of 90 working days. The University shall notify the academic calendar every year, indicating:

- Course registration dates
- Commencement and last date of classes
- Examination dates
- Vacation periods

7. COURSE REGISTRATION

Every student must register for courses at the beginning of each semester.

- A student may register for a maximum number of credits permissible for any semester as dictated in the curriculum.
- Late registration / enrolment will be permitted with a fine as per CUTN norms.

8. FACULTY ADVISOR

To provide guidance on academic matters as well as other related activities, the Head of the Department shall, at the beginning of each academic year, assign a group of first-semester students to a faculty member designated as the Faculty

Advisor. The same Faculty Advisor shall continue to mentor the assigned students throughout the duration of the programme, until they complete all degree requirements.

9. CLASS COMMITTEE

A Class Committee shall be constituted for every class in each semester to monitor the academic progress and teaching–learning processes. The Class Committee shall be chaired by a senior faculty member of the department who preferably does not teach the class, and shall include all faculty handling courses for that class. In addition, there will be four student representatives nominated, as per the norms given by the Department, by the students and approved by the Head of the Department. The Class Committee shall meet three times during the semester: once within two weeks of the commencement of the semester to discuss the nature and structure of the internal assessment tests and the overall assessment methodology; the second time two weeks after the first internal assessment test; and the third time two weeks after the second internal assessment test. The meetings are aimed at reviewing student performance and enhancing the teaching–learning process.

10. ASSESSMENT PROCEDURES

Student performance is assessed continuously through internal evaluation and a final end-semester examination.

10.1 THEORY COURSES

In every theory course, the pattern of assessment shall be as follows: Assignments shall be issued at least one week prior to each cycle test and the end-semester examination. These assignments will include both theoretical and problem-solving components from the portions covered for the respective cycle test.

- **CONTINUOUS INTERNAL ASSESSMENT (CIA): 40 MARKS**
  - Test 1: (for 30 marks, CIA test will be conducted)
  - Test 2: (for 30 marks, CIA test will be conducted
  - Test 3: Full Syllabus (for 60 marks, CIA test will be conducted)
  - **Best two CIA test marks will be considered as an average.**
  - Assignments/Quiz/Attendance (Mandatory) – 10 marks
    CIA test marks will be calculated for 40 marks in total.

- **END-SEMESTER EXAMINATION (ESE): 60 MARKS**

10.2 LAB COURSES

The continuous assessment in laboratory courses shall be based on the supervision of the student's performance, the quality of work carried out, their participation in viva-voce examinations and group discussions and other components as prescribed. The end-semester practical examination shall consist of an experiment and/or a written test. For every practical course, the assessment pattern shall be as follows:

- **CONTINUOUS ASSESSMENT: 75%**
- **END-SEMESTER PRACTICAL EXAMINATION: 25%**

10.3 PROJECT WORK

For the project work, the continuous assessment shall be carried out by a committee comprising the Project Coordinator, appointed by the Head of the Department, and the project guide. The assessment shall be based on a minimum of two periodic reviews. If the Project Coordinator or the Head of the Department is also serving as a project guide, the Head of the Department shall nominate another faculty member to participate in the continuous assessment for those students to avoid any conflict of roles.

Upon submission of the project report, the end-semester evaluation shall consist of a detailed project assessment and a viva-voce examination. This evaluation shall be conducted by a panel comprising the Project Coordinator, the project guide, and either a faculty member from a related department or an external examiner from an academic institution or industry.

The distribution of marks between continuous assessment and the end-semester examination shall be as follows:

- Periodic reviews and continuous assessment: **40%**
- Final evaluation and viva voce: **60%**
  - **External Examiner – 30%**
  - **Project Guide – 30%**

10.4 SUPPLEMENTARY EXAMINATIONS

The Supplementary Examinations will be conducted as per CUTN norms.

10.5 RETEST

Students who are absent for the cycle tests on genuine grounds (with the condition that the student reports to the Head of the Department within two days of re-joining) or participation in Institute-approved activities with prior permission—may be permitted to appear for a retest. Permission for the retest shall be granted by the Head of the Department. The retest shall not be considered or used as an improvement test under any circumstances.

11. ATTENDANCE REGULATIONS AND ELIGIBILITY CRITERIA FOR APPEARING IN END SEMESTER EXAMINATION

A minimum of **75% attendance** is required in each course to appear for the End-Semester Examination (ESE). Attendance shortage is handled as per CUTN norms.

12. PASSING REQUIREMENTS

A student shall secure at least 50% in the End-Semester Examination and a minimum of 50% overall (CIA + ESE) to pass the course.

13. GRADING SYSTEM

A 10-point letter grading scheme shall be used as follows:

Range of Marks	**90 – 100**	**80 – 89**	**70 – 79**	**60 – 69**	**50 – 59**	**< 50**
Letter Grade	O	A+	A	B+	B	RA
Grade Point	10	9	8	7	6	0

RA - Reappear

FA - Failure due to lack of attendance

AU - Audit Course

AE - Absent in the end semester examination

13.1 CALCULATION OF CGPA

The Semester Grade Point Average (SGPA) for a given semester shall be calculated only for those students who have passed all the courses prescribed in that semester. Likewise, the Cumulative Grade Point Average (CGPA) up to any semester shall be

computed only for students who have successfully completed all the courses up to that point.

The SGPA is defined as the ratio of the sum of the products of the credits assigned to each course C_i and the grade points earned in that course GP_i, to the sum of the credits of all courses taken in that semester:

$$\boldsymbol{SGPA} = \frac{\sum_{i=1}^{n} \boldsymbol{\Sigma}\, \boldsymbol{C_i} \times \boldsymbol{GP_i}}{\sum_{i=1}^{n} \boldsymbol{\Sigma}\, \boldsymbol{C_i}}$$

where n denotes the total number of courses registered in that semester.

Upon successful completion of the entire programme, the CGPA shall be calculated using the following formula:

$$\boldsymbol{CGPA} = \frac{\sum_{i=1}^{N} \boldsymbol{\Sigma}\, \boldsymbol{C_i} \times \boldsymbol{GP_i}}{\sum_{i=1}^{N} \boldsymbol{\Sigma}\, \boldsymbol{C_i}}$$

where C_i represents the credit assigned to the *i*-th course, GP_i denotes the grade point secured in that course, and N is the total number of courses prescribed for the programme.

Formula for Conversion of CGPA to Percentage is as follows:

$$\%\, \boldsymbol{of\ marks} = \boldsymbol{CGPA} \times \mathbf{10}$$

14. ELIGIBILITY FOR THE DEGREE

A candidate shall be eligible for the award of the degree of Bachelor of Technology (B.Tech.) only if he or she satisfies the following conditions:

- The candidate has successfully completed the prescribed programme of study and has earned the minimum number of credits specified in the curriculum of the relevant programme within the maximum permitted duration of eight years.
- The candidate has cleared all dues to the Institution, including those pertaining to the Library, Hostels and any other University facilities.
- No disciplinary proceedings or actions are pending against the candidate at the time of award of the degree.

15. ACADEMIC GOVERNANCE

Academic governance shall be carried out through the:

- **Class Committee**
- **Department Consultative Committee**
- **Board of Studies (BoS)**
- **School Board**
- **Academic Council**

These bodies shall oversee curriculum revision, academic audits, student progress, and policy compliance.

16. STUDENT WELFARE AND CONDUCT

Students shall abide by:

- CUTN Code of Conduct
- Anti-Ragging Regulations
- POSH (Prevention of Sexual Harassment) guidelines
- Guidelines issued by statutory bodies

The University shall provide counselling services and assign faculty advisors for academic guidance.

17. AMENDMENTS TO THE REGULATIONS

The University reserves the right to modify these regulations in part or whole, subject to approval of the Academic Council. Amendments shall be applicable to all students from the date of notification unless specified otherwise.

PROGRAM STRUCTURE

S. No	Course Code	Course Title	Course Type	Credit	Hours per Week	Marks	
						Int.	Ext.
INDUCTION PROGRAMME							
SEMESTER – I							
1		Mathematics –I	BSC	4	4	40	60
2		Engineering Physics	BSC	3	3	40	60
3		English for Technical communication	HSMC	2	2	40	60
4		Computer Programming and Problem Solving	ESC	3	3	40	60
5	**MSN5011**	Introduction to Materials Science	PCC	3	3	40	60
6		Engineering Physics Lab	BSC	2	4	100	
7	**MSN5012**	Materials Science Lab	PCC	2	4	100	
8	**MSN5013**	Engineering Mechanics	ESC	3	3	40	60
9		Indian Constitution	MC	0			
TOTAL				**22**	**26**		
SEMESTER – II							
1		Mathematics –II	BSC	4	4	40	60
2		Chemistry	BSC	3	3	40	60
3	**MSN5021**	Basic Engineering	ESC	4	4	40	60
4	**MSN5022**	Engineering Graphics	ESC	3	3	40	60
5		Chemistry Lab	BSC	3	3	40	60
6		Cyber Security	ESC	2	4	100	
7	**MSN5023**	Workshop/Manufacturing Practices	ESC	2	4	100	
8		NSS/NSS/Sports and Yoga	MC	1	2	100	
TOTAL				**22**	**27**		
SEMESTER – III							
1	**MSN5031**	Structure of Materials	PCC	4	4	40	60
2	**MSN5032**	Physics and Chemistry of Materials	PCC	4	4	40	60
3	**MSN5033**	Mechanics of Solids	ESC	4	4	40	60
4		Mathematics-III	BSC	3	3	40	60
5	**MSN5034**	Fluid Mechanics	ESC	4	4	40	60
6	**MSN5035**	Metallic and Non-metallic Materials	PCC	3	3	40	60
7	**MSN5036**	Mechanical and Metallographic Lab	PCC	2	4	100	
8		Environmental Science		0			
TOTAL				**24**	**26**		
SEMESTER – IV							

1	**MSN5041**	Thermodynamics	PCC	3	3	40	60
2		Mathematics-IV	BSC	3	3	40	60
2	**MSN5042**	Ceramics, Glasses and Composites	PCC	4	4	40	60
3	**MSN5043**	Manufacturing Technology	ESC	3	3	40	60
4	**MSN5044**	Fundamental of Nanomaterials	PCC	3	3	40	60
5	**MSN5045**	Materials Characterization	PCC	3	3	40	60
6	**MSN5046**	Materials Synthesis	PCC	3	3	40	60
7	**MSN5047**	Materials Synthesis and Characterisation Lab	PCC	2	4	100	
TOTAL				**24**	**28**		
#Industrial Training/Internship-I has to be done by the students at end of the 4th semester (during summer vocation, for 4 to 6 weeks' duration). These Industrial Training/Internships should be carried out at CFIs/IITs/NITs/Industries/Govt. Universities & Govt. Research organisations/Labs. Two credits will be offered for it and the same will be accounted in 5th Semester mark sheet.							
SEMESTER – V							
1	**MSN5051**	Polymer Science and Technology	PCC	3	3	40	60
2	**MSN5052**	Mechanical Behaviour of Materials	PCC	3	3	40	60
3	**MSN5053**	Principles and Applications of Spectroscopic Methods	PCC	3	3	40	60
4	**MSN5054**	Heat Treatment of Materials	PCC	3	3	40	60
5	**MSN5055**	Clean Energy Technology	PCC	3	3	40	60
6	**MSNECXX**	Professional Elective -1 / MOOCS/NPTEL course	PEC	3	3	100	
7		Principles of Management	HSMC	3	3	40	60
8		Internship-I/Industrial Training /Certification, towards Skill Development		2		100	
9		Foreign Language	HSMC	1		100	
TOTAL				**24**	**21**		
SEMESTER – VI							
1	**MSN5061**	Semiconductor Materials and Devices	PCC	3	3	40	60
2	**MSN5062**	Biomaterials	PCC	3	3	40	60
3	**MSN5063**	Computational Methods and AI in Materials Science	PCC	4	4	40	60
4	**MSN5064**	Magnetic and Optical Properties of Materials	PCC	3	3	40	60
5	**MSN5065**	Physical Metallurgy	ESC	3	3	40	60
6	**MSNECXX**	Professional Elective -2 / MOOCS/NPTEL course	PEC	3	3	40	60
7		Industrial Psychology	HSMC	3	3	40	60
8	**MSN5066**	Functional Materials Lab -I	PCC	2	4	100	

TOTAL				**24**	**26**		
#-Industrial Training/Internship-II has to be done by the students at end of the 6th semester (during summer vocation, for 4 to 6 weeks' duration). These Industrial Training/Internships should be carried out at CFIs/IITs/NITs/Industries/Govt. Universities & Govt. Research organisations/Labs. Two credits will be offered for it and the same will be accounted in 7th Semester mark sheet.							
SEMESTER – VII							
1	**MSN5071**	Corrosion Science and Technology	PCC	3	3	40	60
2	**MSN5072**	Energy Materials and Technology	PCC	3	3	40	60
3	**MSNECXX**	Professional Elective -3	PEC	3	3	40	60
4	**MSNECXX**	Professional Elective -4	PEC	3	3	40	60
5	**MSNECXX**	Professional Elective -5	PEC	3	3	40	60
6	**MSN5073**	Functional Materials Lab- II	PCC	2	4	100	
7		Internship-II/Industrial Training / Certification, towards Skill Development		2		100	
8		Industrial Economics	HSMC	3	3	40	60
9		Industrial Lectures×		0	0		
TOTAL				**22**	**26**		
×-Three to five special lectures will be arranged from Industrial Experts during this semester.							
SEMESTER – VIII							
1	**MSN5081**	Seminar on Project Area		2	4	100	
2	**MSN5082**	Project Work/ Dissertation	PROJ	8	16	100	
TOTAL				**10**	**20**		

CREDITS PER SEMESTER									Total Credits
Sem#	I	II	III	IV	V	VI	VII	VIII	
CREDITS	**22**	**22**	**24**	**24**	**24**	**24**	**22**	**10**	**172**

PROFESSIONAL ELECTIVE COURSES (PEC):

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
Theory						
		Professional Elective Courses*				
1	**MSNEC01**	Smart Materials and Applications	**3**	**0**	**0**	**3**
2	**MSNEC02**	Advanced Nanofabrication Techniques	**3**	**0**	**0**	**3**
3	**MSNEC03**	Symmetry and group theory and its application in spectroscopy	**3**	**0**	**0**	**3**
4	**MSNEC04**	Industrial Applications of Quantum Materials	**3**	**0**	**0**	**3**
5	**MSNEC05**	Electron Microscopy for Imaging of Materials	**3**	**0**	**0**	**3**
6*	**MSNEC06**	X-ray Diffraction Theory and Technique	**3**	**0**	**0**	**3**
7	**MSNEC07**	Advanced Crystal Growth	**3**	**0**	**0**	**3**
8	**MSNEC08**	Non-destructive Testing & Evaluation	**3**	**0**	**0**	**3**
9	**MSNEC09**	Principles and applications of fluorescence spectroscopy	**3**	**0**	**0**	**3**
10	**MSNEC10**	Porous Materials	**3**	**0**	**0**	**3**
11	**MSNEC11**	Organic Light Emitting Diode (OLED)	**3**	**0**	**0**	**3**
12	**MSNEC12**	Thin film Science and Technology	**3**	**0**	**0**	**3**
13	**MSNEC13**	Metal Casting Technology	**3**	**0**	**0**	**3**
14	**MSNEC14**	Powder Metallurgy	**3**	**0**	**0**	**3**
15	**MSNEC15**	Surface Engineering	**3**	**0**	**0**	**3**
16	**MSNEC16**	Applications of Materials	**3**	**0**	**0**	**3**
17	**MSNEC17**	Mechanical Metallurgy	**3**	**0**	**0**	**3**
18	**MSNEC18**	Metal Extraction Technology	**3**	**0**	**0**	**3**
19	**MSNEC19**	Materials Optimization	**3**	**0**	**0**	**3**
20	**MSNEC20**	Optimization Techniques and Applications	**3**	**0**	**0**	**3**
21	**MSNEC21**	Welding Technology	**3**	**0**	**0**	**3**
22	**MSNEC22**	Iron and Steel Technology	**3**	**0**	**0**	**3**
23	**MSNEC23**	Failure Analysis	**3**	**0**	**0**	**3**
24	**MSNEC24**	Fatigue and Fracture	**3**	**0**	**0**	**3**
25	**MSNEC25**	Failure Mechanism and analysis	**3**	**0**	**0**	**3**

*New electives will be appended based on the availability of course instructors.

Electives will be offered based on the availability of expert faculty at the respective semester and the syllabus will be provided at the time of teaching the courses.

SEMESTER - I

SEMESTER - I					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5011	**INTRODUCTION TO MATERIALS SCIENCE**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	**LEVEL**
CO1	The students will be able to understand the fundamental concepts of materials science in the aspects of the structure of atoms, quantum states, bonding characteristics	Understand
CO2	broad view of crystal structure classification, their types, close packing such FCC and HCP	Remember
CO3	knowledge of semiconducting materials, classification into extrinsic and extrinsic to their application in microelectronic devices	Understand
CO4	Understand the mechanical properties, stress-strain behaviour including the optical properties and their applications as LASERS	Analyze
CO 5	Magnetic properties of materials, properties of materials, classification of magnetic materials	Analyze

b. Syllabus

Units	**Content**	**Hrs.**
I	**Classification of Materials:** Metals, Ceramics, Polymers, Composites, Advanced Materials of the future. Structure of atoms - Quantum States-Atomic bonding in Solids Imperfection in solids: Point defects, line defects, surface imperfection, grain boundaries, surface energy and equilibrium shapes of crystals- Importance of defects.	**12**
II	Fundamental concepts - Unit cells- **Crystal systems-** Crystallographic Points, Directions and Planes -Crystalline and non-crystalline materials: Single crystals-polycrystalline Materials Anisotropy- Noncrystalline solids- Metallic Crystal structures: FCC, BCC and HCP crystal structures, atomic arrangements-Polymorphism and Allotropy. Diffraction: Fundamentals of Diffraction, X-rays - production - white and monochromatic X-rays, Laue diffraction -Reciprocal lattice - Ewald sphere construction - Bragg's law - Structure Factor - indexing diffraction pattern, calculation of lattice parameters - Determination of strain - particle size.	**12**

III	Introduction to semiconducting materials - Bonding in Semiconductors -Classification of semiconductors: Carrier concentrations in intrinsic, extrinsic semiconductors- P-N junction: Application of voltage across P-N Junction - Hall effect: Hall coefficients for intrinsic and extrinsic semiconductors - Hall Effect devices - Fermi level: Variation of conductivity, mobility with temperature- Insulators: Dielectric polarisation and mechanism- Dielectric properties.	**12**
IV	**Types of mechanical properties**- Factors affecting mechanical properties of metals -Elasticity and Plasticity of materials- Stress-strain behavior for metallic, ceramic, polymer materials ductile, low carbon steels and for different materials-Yield strength, tensile strength and modulus of elasticity-Hardness, toughness, Fatigue, creep and fracture. **Optical properties**: Light interaction with solids - absorption, refraction, diffraction, transmission, luminescence effects- Atomic, electronic interaction, Non-radiative transition, electro-optic materials, solid state LASERs.	**12**
V	Introduction -**Classification of magnetism** -Domain wall structure- Domain theory- Magnetic Hysteresis- Magnetic Anisotropy- High frequency application of ferrites -Types of magnetic materials: hard magnetic and soft magnetic materials, Super-para magnetic materials - Magneto-optic materials and their properties.	**12**

Books:

1. William D. Callister, "Materials Science and Engineering: An Introduction", 8thEdition, John Wiley & Sons, 2010.
2. C. Kittel, "Introduction to Solid State Physics" 8th Edition, Wiley Eastern Ltd, 2018.
3. V. Raghavan, “Materials Science and Engineering: A First Course", Prentice Hall, 6thEdition, 2015.
4. Elements of X-ray Diffraction - B.D. Cullity

References:

1. S. O. Pillai, Solid State Physics, New Age International; Eighth edition (2018), ISBN-10: 9789386070920, ISBN-13: 978- 9386070920
2. A. J. Dekker, "Solid State Physics”, Macmillan & Co, (2000, ISBN:978-0-333-10623-5

Leonid V. Azaroff, Introduction to Solids, McGraw-Hill Inc.,US, ISBN-10: 0070026688 and ISBN-13: 978- 0070026681

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	**3**	**1**	**3**	**3**	**3**	**3**
CO2	**3**	**1**	**3**	**3**	**3**	**3**
CO3	**3**	**1**	**3**	**3**	**3**	**3**
CO4	**3**	**1**	**3**	**3**	**3**	**3**
CO5	**3**	**1**	**3**	**3**	**3**	**3**

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

SEMESTER - I					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5012	**MATERIALS SCIENCE LAB**	**-**	**-**	**8**	**2**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

Experiment Nos.	Experiment (Content)	Hrs.
I	Indexing powder X-ray diffraction (XRD) pattern of a given cubic crystal.	6
II	Estimation of particle size from given XRD data of powder sample using Scherer formula.	6
III	To calculate strain produced in a material using Williamson-Hall plot from given XRD data.	6
IV	Determination of band gap using Tauc's plots for given UV-Visible spectra.	6
V	Hall Effect Measurement – Determination of Conductivity, resistivity and carrier density if semiconductors.	6
VI	Study of Dielectric Constant – Dielectric and curie temperature Measurement.	6
VII	Specimen Preparation and Study of Metallurgical Microscope.	6
VIII	Preparation and Study of Microstructure of Aluminium and Copper.	6
IX	To the study of Microstructure Non-Ferrous alloys.(Brass & Bronze).	6
X	Grain refinement studies using polarization microscope	6
XI	To determine the Young's Modulus of the material of the bar subjected to non-uniform bending by measuring the depression at the centre using optical lever.	6
XII	Electrical characterization of p-n junction diodes.	6

References:

1. Elements of X-ray Diffraction – B. D. Cullity & S. R. Stock
2. X-ray Diffraction Procedures – Harold P. Klug & Leroy E. Alexander
3. Optical Properties of Solids – Mark Fox
4. Solid State Physics – Neil W. Ashcroft & N. David Mermin
5. Semiconductor Physics and Devices – Donald A. Neamen
6. Solid State Electronic Devices – Ben G. Streetman & Sanjay Kumar Banerjee.
7. Materials Science and Engineering – William D. Callister Jr.
8. Metallography: Principles and Practice – George F. Vander Voort.
9. Mechanical Behavior of Materials – Norman E. Dowling.

SEMESTER - I					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5013	**ENGINEERING MECHANICS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	The students will be able to understand the fundamental concepts and principles of statics related to forces acting on particles and rigid bodies	Analyze
CO 2	Understand to formulate and apply equilibrium equations for particles and rigid bodies in two and three dimensions	Understand
CO 3	Broad view of Properties of surfaces and Virtual work.	Understand
CO 4	Analyze the force systems through vector resolution and calculation of moments and couples.	Understand
CO 5	Study the concepts of Kinematics and Dynamics of Particles.	Remember

b. Syllabus

Units	Content	Hrs.
I	**Basic Concepts of Mechanics:** Idealizations of mechanics, vector and scalar quantities, equality and equivalence of vectors, laws of mechanics, elements of vector algebra. Important vector quantities: position vector, moment of a force about a point, moment of a force about an axis, the couple and couple moment, couple moment as a free vector, moment of a couple about a line. Equivalent force systems: translation of a force to a parallel position, resultant of a force system, simplest resultant of special force systems, distributed force systems, reduction of general force system to a wrench.	9
II	**Static Equilibrium**: free-body diagram, free bodies involving interior sections, general equations of equilibrium, problems of equilibrium, static indeterminacy. Applications of equations of equilibrium: Trusses: solution of simple trusses using method of joints and method of sections; Friction forces: laws of Coulomb friction, simple contact friction problems; Cables and chains.	9
III	**Properties of surfaces**: first moment and centroid of plane area, second moments and product of area for a plane area, transfer theorems, rotation of axes, polar moment of area, principal axes. Method of virtual work: principles of virtual work for rigid bodies and its applications.	9

IV	**Kinematics of a particle**: introduction, general notions, differentiation of a vector with respect to time, velocity and acceleration calculations in rectangular coordinates, velocity and acceleration in terms of path variables and cylindrical coordinates, simple kinematical relations and applications.	9
V	**Dynamics of a particle**: introduction, Newton's law for rectangular coordinates, rectilinear translation, Newton's law for cylindrical coordinates, Newton's law for path variables, energy and momentum methods: introduction, conservative force field, conservation of mechanical energy, alternative form of work-energy equation, impulse and momentum relations, moment-of-momentum equation.	9

References:

1. I. H. Shames, *Engineering Mechanics—Statics and Dynamics*, 4th Edition, Prentice Hall of India, 1996.
2. F.P. Beer and E.R. Johnston, *Vector Mechanics for Engineers – Statics*, McGraw Hill Book Company, 2000.
3. J.L. Meriam and L.G. Kraige, *Engineering Mechanics – Statics*, John Wiley & Sons, 2002.
4. R.C Hibbler, Engineering Mechanics—Statics and Dynamics, 11th Edition, Pearson, India, 2009

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

SEMESTER - II

SEMESTER - II					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5021	**BASIC ENGINEERING**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	To provide the students an illustration of the significance of the Civil Mechanical Engineering Profession in satisfying the societal needs.	Analyze
CO 2	To help students acquire knowledge in the basics of surveying and the materials used for construction and manufacturing.	Understand
CO 3	Students will gain knowledge regarding the various laws and principles associated with electrical systems	Understand
CO 4	Students will gain knowledge of Analog electronics.	Understand
CO 5	Students will gain knowledge on Digital electronic systems.	Remember

b. Syllabus

Units	Content	Hrs.
I	Civil Engineering contributions to the welfare of Society – Specialized sub disciplines in Civil Engineering – Structural, Construction, Geotechnical, Environmental, Transportation and Water Resources Engineering – National building code – terminologists: Plinth area, Carpet area, Floor area, Build-up area, Floor space index – Types of buildings: Residential buildings, Industrial buildings.	**12**
II	Overview of Mechanical Engineering – Mechanical Engineering Contributions to the welfare of Society –Specialized sub disciplines in Mechanical Engineering – Manufacturing, Automation, Automobile and Energy Engineering – Interdisciplinary concepts in Mechanical Engineering	**12**
III	DC Circuits: Circuit Components: Conductor, Resistor, Inductor, Capacitor – Ohm's Law – Kirchhoff's Laws - Nodal Analysis, Mesh analysis Introduction to AC Circuits – Steady state analysis of RLC circuits. Electrical machines: DC Separately and Self excited Generators, Types and Applications; DC motors, Types and Applications. Construction, working principle and Applications of Transformer, Three phase Alternator, Synchronous motor and Three Phase Induction Motor	**12**

IV	Analog electronics: Semiconductor Materials: Silicon &Germanium – PN Junction Diodes, Zener Diode –Characteristics Applications – Bipolar Junction Transistor-Biasing, JFET, SCR, MOSFET, IGBT – Types, I-V Characteristics and Applications, Rectifier and Inverters	**12**
V	Digital Electronics: Review of number systems and Boolean algebra, Logic Gates and Truth Tables, Simplification of Boolean functions using Karnaugh map (upto 4 variable K-maps), Implementation of Simple combinational circuits (Adder, Code Converters, 7-Segment Drivers, Comparators, Priority Encoders, etc) T and D flip-flops, counters and registers using D flip flops.	**12**

References:

1. G Shanmugam, M S Palanichamy, Basic Civil and Mechanical Engineering, McGraw Hill Education; First edition, 2018
2. N.Mittle "Basic Electrical Engineering". Tata McGraw Hill Edition, New Delhi, 1990.
3. A.K. Sawhney, 'A Course in Electrical & Electronic Measurements & Instrumentation', Dhanpat Rai and Co, 2004.
4. Jacob Millman and Christos C-Halkias, "Electronic Devices and Circuits", Tata McGraw Hill

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

SEMESTER - II					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5022	**ENGINEERING GRAPHICS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Prepare drawings as per standards (BIS).	Analyze
CO 2	Solve specific geometrical problems involving points and lines.	Understand
CO 3	Solve specific geometrical problems in plane geometry involving plane figures.	Understand
CO 4	Produce orthographic projection of engineering components working from pictorial drawings	Understand
CO 5	Understand the basic AUTOCAD commands	Remember

b. Syllabus

Units	Content	Hrs.
I	Introduction; drawing instruments and their uses; lines, lettering and dimensioning; geometrical construction; constructions of plain, diagonal and Vernier scales; orthographic projection—first and third angle projections;	9
II	orthographic projection of points on principal, profile, and auxiliary planes. Orthographic projection of straight line in simple and oblique positions; application of orthographic projection of line;	9
III	orthographic projection of planes in simple and oblique position on principal and profile planes; orthographic projection of lines and planes on auxiliary planes.	9
IV	Orthographic projection of solids in simple and oblique positions on principal and profile planes; orthographic projections of solids in oblique position using auxiliary plane method; orthographic projection of spheres;	9
V	Orthographic projection of solids in section; development of surfaces of solids; method of isometric projection.	9

References:

1. N. D. Bhatt, Engineering Drawing, 53rd ed. Anand, India: Charotar Publishing House, 2016.
2. Basant Agrawal and C M Agrawal, Engineering Drawing, 2nd ed. New Delhi, India: McGraw Hill Education (India), 2014.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

SEMESTER - II					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5023	**WORKSHOP/ MANUFACTURING PRACTICES**	**-**	**-**	**2**	**2**

LIST OF EXPERIMENTS
FOUNDRY Preparation of sand mould for the Flange, Hand Wheel
WELDING Exercise in arc welding for making Butt joint and Lap joint
FITTING Preparation of Joints, Markings, Cutting and filling for making a) Semicircle Part b) Dovetail Part
WIRING AND PLUMPING Exercise in electrical Wiring/House wiring/Plumping
Sheet metal / Carpentry experiments - if facility is available

SEMESTER - III

SEMESTER - III					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5031	**STRUCTURE OF MATERIALS**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Understanding the structural classification of materials	**Remember**
CO 2	Application of the concepts to identify the type of structures	**Understand**
CO 3	Understanding the role of defects and their types	**Analyze**
CO 4	Application of concepts to solve the problems related to identification of structures and defect types	**Understand**
CO 5	Applying knowledge of chemical structure and functions for predicting structure-property relationships.	**Apply**

b. Syllabus

Units	Content	Hrs.
I	Concept of Lattice, Basis, Symmetry Operations, 2-Dimensional and 3-Dimensional Lattices, Miller Indices, Crystal structure classes: Bravais Lattice, concept of Reciprocal lattice	**12**
II	Imperfections in solids, Point defects, Line defects, Surface defects, Volume defects, Volume defects, Classification of Point defects (substitutional, interstitial), Types: Frenkel and Schottky, concentration of defects, creating point defects, Dislocations, Types of dislocations: Edge, screw and mixed, Burgers vector, plastic deformation in crystals, concept of Grain boundary, and Stacking faults	**12**
III	Diffusion in crystals, Fick's laws, Application of Fick's laws, Unary and Binary phase diagram, Tie line and lever rule, Eutectic Phase diagram, Gibb's free energy plot for Eutectic system, Peritectic phase diagram, Examples, Phase transformations: First order, second order, Homogeneous and Heterogeneous nucleation during phase transformation, Time-Temperature-Transformation diagrams	**12**
IV	Formation of crystals: Crystallization mechanism, Nucleation and Growth kinetics, Solidification of metals and alloys, Role of time, cooling curves, Planar growth, Dendrtitic growth, Recovery, Recrystallization linked with grain growth, Concept of Solid-solution, Hume-Rothry rules, non-crystalline solids: Glasses, Concept of Glass transition temperature.	**12**

V	X-ray - electron and neutron diffraction techniques to determine the structure of materials, microscopic techniques for imaging microstructure and local crystal structure, Amorphous materials, Pair distribution function	**12**

Text Books:

1. J.F. Shackelford, Introduction to Materials Science for Engineers, Prentice-Hall, 1996.
2. V. Raghavan, Materials Science and Engineering: A First Course, Prentice Hall of India.
3. J. Wulff, The Structure and Properties of Materials, Wiley
4. B.D. Cullity, Elements of X-ray Diffraction, Prentice- Hall, 2001.
5. L.V. Azaroff, Introduction to Solids, Mc Graw Hill Education (2017) Paperback edition
6. Wahab, Essentials of Crystallography, Narosa Publishing house, 2nd edition (2014)

References:

1. M. De Graf and M.E. McHenry, Structure of Materials, Cambridge Univ. Press, 2007.

SWAYAM-NPTEL Courses:

1. An Introduction to Materials (Structure of Materials Part I) by Prof. Ashish Garg, IIT Kanpur

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2

Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza-tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - III					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5032	**PHYSICS AND CHEMISTRY OF MATERIALS**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Understanding the Classical and Quantum models for better understanding of Material properties	**Understand**
CO 2	Applying the quantum mechanical concepts to solve basic to advanced problems that helps in understanding the Materials properties	**Apply**
CO 3	Correlating the fundamental understanding of quantum mechanical principles to atomic structure and bonding	**Analyze**
CO 4	Understanding the origin of atomic and molecular structure, bonding, and properties.	**Understand**
CO 5	Applying knowledge of chemical structure and functions for predicting structure-property relationships.	**Apply**

b. Syllabus

Units	Content	Hrs.
I	Newton's laws, Classical treatment of electronic motion, Drude's Free electron theory, Conductivity of metals, Thermal conductivity, Widemann Franz law, Understanding of Hall effect, Plasmon absorption in metals, Nearly Free electron model, limitations	**12**
II	Wave-Particle Duality, Dirac's hypothesis, Schrodinger equation, concept of wave function, Born's statistical interpretation, Time independent Schrodinger equation, Stationary states, Particle in a box, Finite potential well and barrier, Multiple well problem	**12**
III	Quantum Mechanical model for metals, Concept of Fermi energy, Fermi Surface, Density of states, Understanding Quantum Confinement in 0D, 1D, 2D etc., Quantization of Angular momentum, Concept of spin, Atomic structure, Types of bonding, solving of Hydrogen atom problem, Quantum Numbers	**12**
IV	Chemical properties of elements, atomic orbitals, molecular orbitals, electronic displacements – Inductive and resonance effects, dipole moment, weak interactions in materials, symmetry and point group, chemical kinetics.	**12**
V	Classes of materials- inorganic and organic materials, bonding and reactivity, acid-base, surfaces, interfaces, soft materials, effects of synthesis and chemical compositions on the structure and properties of various materials, chemical and catalytic aspects of materials, materials design, and structure-properties	**12**

	relationships.	

Text Books:

1. Neil Ashcroft and N. David Mermin, Solid state Physics, Cengage (2021)
2. Arthur Beiser, Concepts in Modern Physics, Tata Mc Graw Hill, 5th edition (1995)
3. D.J. Griffiths, Introduction to Quantum Mechanics, Cambridge University Press (2017)
4. M.P. Anantram and Daryoush Shiri, Quantum Mechanics for Engineers and Materials Scientists, World Scientific Publishers (2024)
5. David A B Miller, Quantum Mechanics for Scientists and Engineers, Cambridge University Press (2008)
6. Gray, Harry B. 1994. Chemical Bonds: An Introduction to Atomic and Molecular Structure (version published). Mill Valley, CA: University Science Books. DOI: 10.7907/rt7h-8t44.
7. McQuarrie, J. D.; Simon, J. D., Physical Chemistry: A Molecular Approach; Viva Books: New Delhi, 1997 (reprint 2003); ISBN 81-764-9001-6.
8. Molecular symmetry and group theory, Robert L. Carter, Wiley: New York, 1998.
9. Chemical applications of group theory, F. Albert Cotton, 3rd edition, ISBN: 9788126519255.
10. Peter Sykes, A guidebook to mechanisms in organic chemistry, Pearson Education, 6th edition (2003), ISBN 8177584332.
11. R. P. Sarkar, General and Inorganic Chemistry, 3rd Revised edition (2011), New Central Book Agency, ISBN 81-7381-136-9.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1

Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza-tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - III					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5033	**MECHANICS OF SOLIDS**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Describe the mechanical behaviour of engineering materials subjected to various types of stresses and compute the resulting strain and strain energy.	Analyze
CO 2	Analyse the bending of various types of beams under static loading conditions and compute the shear stress distribution for different cross sections of beams.	Understand
CO 3	Show knowledge of principal planes, stresses and strains and analyse the elastic deformation of members and apply different theories of elsatic failures.	Understand
CO 4	Compute the torsion for the circular shaft and analyse the crippling load and equivalent length for various types of columns of different end conditions.	Understand
CO 5	Compute the deflection of beams and shafts under static loading and stresses in thin walled cylindrical and spherical vessels.	Remember

b. Syllabus

Units	Content	Hrs.
I	Introduction: Tension, compression and shear Types of external loads - self weight - internal stresses - normal and shear stresses - strain - Hooke‘s law - Poisson‘s ratio - relationship between elastic constants - stress strain diagrams - working stress - elongation of bars of constant and varying sections - statically indeterminate problems in tension and compression - assembly and thermal stresses - strain energy in tension, compression and shear.	**12**
II	Bending moment and shear force: Types of beams - shear force and bending moment diagrams for simply supported, overhanging and cantilever beams - relationship between intensity of loading, shear force and bending moment. - stresses in laterally loaded symmetrical beams.	**12**
III	Theory of simple bending: limitations - bending stresses in beams of different cross sections - moment of resistance - beams of two materials - shearing stresses in bending - principal stresses in bending - strain energy in bending Torsion: Torsion of circular solid and hollow shafts - strain energy in shear and torsion – open and close coiled helical springs.	**12**

IV	Analysis of stress and strain: Stress on inclined planes for axial and biaxial stress fields - principal stresses - Concept of shear flow and shear center. Mohr's circle of stress - principal stress problem as an eigenvalue problem - principal strains - strain rosette -thin cylinders (as an example to biaxial stresses)	**12**
V	Deflection of beams: Differential equation of elastic curve - slope and deflection of beams by successive integration - Macaulay's method - moment area method - conjugate beam method - deflection due to shear.	**12**

Text Books:

1. Gere, J.M., Mechanics of Materials, Thomson, Singapore, 2001.
2. Timoshenko, S.P., Young, D.H., Elements of Strength of Materials, East West Press, New Delhi, 2003.
3. Popov, E.P., Mechanics of Materials, Prentice Hall India, New Delhi, 2002.
4. Beer, F. P. and Johnston, E. R., Mechanics of Materials, Tata McGraw Hill, New Delhi, 2005
5. Nash, W.A., Strength of Materials, Schaum's Outline Series, McGraw Hill, New York, 1988

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - III					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5034	**FLUID MECHANICS**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Understand the properties of fluids	**Understand**
CO 2	Measurement of pressure, computations of hydrostatic forces on structural components and the concepts of Buoyancy.	**Analyze**
CO 3	Provide a first level exposure to the students to fluid kinematics and dynamics.	**Understand**
CO 4	Apply continuity, energy and momentum equations to engineering problems in the use of orifice, flow meters and notches and evaluate the head loss in pipes.	**Understand**
CO 5	Calculate surface resistance in laminar and turbulent flows and understand the basic concept of boundary layer theory.	**Analyze**

b. Syllabus

Units	Content	Hrs.
I	Introduction: continuum hypothesis; properties of fluids; viscosity, surface tension, capillarity, fluid statics; pressure at a point; variation of pressure in a static fluid; absolute and gauge pressures, pressure head; measurement of pressure: manometers, pressure gauges; hydrostatic forces on plane areas; centre of pressure, forces on curved surfaces, floating and immersed bodies in fluids, buoyant force.	**12**
II	Flow of fluids: classification of flows like steady flow, uniform flow, incompressible flow, ideal flow, laminar and turbulent flows etc.; basic physical laws applied to a fluid flow; equation of continuity for one dimensional steady flow, continuity, momentum and energy equations;	**12**
III	Bernoulli's equation; application to flow through pipes; head loss in pipes, Major and Minor losses, Darcy-Weisbach equation; pipes in series and parallel and U-Tube Manometry, Orifice meter and Venturimeter	**12**
IV	Fluid Machines: pumps and turbines; flow through turbo-machines; velocity diagrams; pumping machinery: Rotodynamic and positive displacement pumps; centrifugal pumps: head developed and power, specific speed of pumps, characteristics of centrifugal pumps; reciprocating pumps: indicator diagram, slip.	**12**

V	Turbines: classification like impulse and reaction turbines; Pelton turbine: constructional details, calculation of power; reaction turbines: principle of reaction turbines; radial, axial and mixed flow turbines; draft tubes; constructional details of Francis and Kaplan turbines; calculation of power; selection of turbines; cavitation.	**12**

Text Books:

1. J. B. Franzini and E. J. Finnemore, *Fluid Mechanics with Engineering Applications*. McGraw Hill International Edition, 1997.
2. V. Gupta and S. Gupta, *Fluid Mechanics and its Applications.* New Age International, 2005.
3. J. Lal, *Fluid mechanics and Hydraulics*. Metropolitan, 1975.
4. J. Lal, *Hydraulic Machines*. Metropolitan, 1975.
5. Y. A. Cengel and J. M. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, 3rd ed. McGraw Hill, 2014.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - III					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5035	**METALLIC AND NON METALLIC MATERIALS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Understand the different types of ferrous and non-ferrous alloys and their uses in engineering field.	**Understand**
CO 2	Analyze and illustrate the different polymer, ceramics and composites and their uses in engineering field.	**Analyze**
CO 3	To learn various thermo-plastics and thermo-setting plastics	**Understand**
CO 4	Analyze various Polymers and its Process, Properties and Applications	**Analyze**
CO 5	Understand the polymer manufacturing process and types, parts of moulding	**Understand**

b. Syllabus

Units	Content	Hrs.
I	Basic ferrous materials and its making-Effect of alloying additions on steel (Mn, Si, Cr, Mo, Ni, V, Ti & W) – stainless and tool steels – HSLA - Maraging steels – Grey, white, malleable, spheroidal – alloy cast irons.	**9**
II	Non-Ferrous materials: Copper and its alloys – Brass, Bronze and Cupronickel – Aluminium and its alloys; Al-Cu – precipitation strengthening treatment – Titanium alloys, Mg-alloys, Ni-based super alloys – shape memory alloys- Properties and Applications overview of materials standards.	**9**
III	Polymers – types of polymers, commodity and engineering polymers – Properties and applications of PE, PP, PS, PVC, PMMA, PET, PC, PA, ABS, PAI, PPO, PPS, PEEK, PTFE,	**9**
IV	Thermoset polymers – Processing, Properties and application of Urea and Phenol formaldehydes, Nylon, Epoxy, Silicon, Polyester, Polyurethanes - Ceramics-polymer composites.	**9**
V	Polymer manufacturing process : Polymer mixing devices, Additives and Mixing process, different types of mixing devices - calendering and extrusion - Processing methods - based on extruder – extrusion coating process - Injection moulding machines and its components – types -Blow Moulding - Thermoforming – vacuum forming, Pressure forming– Rotation moulding - Compression moulding- Transfer moulding	**9**

Text Books:
1. Kenneth G.Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of India Private Limited, 9th edition ,2018.
2. Sydney H.Avner, "Introduction to Physical Metallurgy", McGraw Hill Book Company, 1994
3. H.S. Ray and R.Sridhar, Extractive Metallurgy of Non ferrous metals
4. C.G. Krishnadas Nair, Non-ferrous Metals strategy cum source book, IIM publication.
5. R.Bhimarao, K. Srinivasrao and Vibhuti N. Mishra, Non-ferrous Metals in the New Millennium, 2001.
6. Plastics: Materials and Processing by A.Brent Strong
7. Shreve's Chemical Process Industries by George Austin
8. SPI Plastics Engineering Handbook by Micheal L. Berins

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3

Part – C **(Detailed answer- 5 x 7 = 35 marks)**	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza-tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - III					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5036	**MECHANICAL AND METALLOGRAPHIC LAB**	**-**	**-**	**4**	**2**

LIST OF EXPERIMENTS	
S. NO	**EXPERIMENTS**
1	Determination of hardness of materials using Vickers' Hardness Tester.
2	Determination of hardness of materials using Rockwell Hardness Tester.
3	Determination of Impact strength of Materials using Izod / Charpy Test.
4	Fatigue Test of a material.
5	Determination of Mechanical properties of metal specimen using Universal Testing Machine (UTM)
6	Determination of Corrosion rate of metal using electrochemical method, in acidic and alkaline environment.
7	Examination of defects in a metal plate sample using Magnetic Particle Inspection (MPI) method
8	Examination of defects in a metal plate sample using Ultrasonic Flaw Detector (UFD) method
9	Thermal analysis of a polymer material using simultaneous Thermal Gravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC)
10	Preparation and microstructure analysis of a metal/alloy specimen using optical Microscope.

SEMESTER - IV

SEMESTER - IV					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5041	**THERMODYNAMICS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	On completion of the course, students can explain the concepts of thermodynamics and special emphasis on metallurgical thermodynamics.	Remember
CO 2	Students may understand the laws of thermodynamics	Understand
CO 3	Students can apply the laws of thermochemistry to various types of materials.	Apply
CO 4	Students can solve the problems based on thermodynamics.	Analyze
CO 5	Students can handle the day-to-day problems associated with thermodynamics and provide solutions.	Skill

b. Syllabus

Units	Content	Hrs.
I	Basic concepts: Thermodynamic systems, properties, state and equilibrium, processes and cycles, continuum, classical thermodynamics; forms of energy; energy transfer by heat and work; temperature and zeroth law of thermodynamics; pure substance: phases, phase change processes of pure substances, property diagrams for phase change processes, property tables; ideal-gas: internal energy, enthalpy, compressibility factor, different equations of state.	9
II	First law of thermodynamics: First law of thermodynamics applied to closed system executing a process and cycle; energy transfer by mass; first law of thermodynamics applied to steady and unsteady flow processes: steady flow engineering devices; specific heats of ideal gases, thermodynamic processes executed by ideal gases.	9
III	Second law of thermodynamics: The second law of thermodynamics: limitations of first law, thermal energy reservoirs, heat engines, Kelvin-Planck statement, energy conversion efficiencies, refrigerators and heat pumps, Clausius statement, equivalence of the two statements, reversible and irreversible processes, irreversibilities.	9
IV	Carnot cycle, Carnot principles, thermodynamic temperature scale, Carnot heat engine, Carnot refrigerator and heat pump; entropy: increase of entropy principle, entropy change of pure substances, isentropic processes, property diagram involving entropy, the T-ds relations, entropy change of liquids and solids, entropy change of ideal gases.	9

V	Energy and property relations: Energy, reversible work and irreversibility, energy of fixed mass and flow stream, energy transfer by heat, work and mass, second law efficiency; thermodynamic property relations: Maxwell relations, Clapeyron equation, general relations for change in properties, Joule-Thomson coefficient, change in properties for real gases. Third law of thermodynamics.	9

Text Books:

1. Atkin's Physical Chemistry, by Peter Atkins and Julio De Paula, 8th Edition, Oxford Press,2018.
2. Physical Chemistry Through Problems, 2015, by Dogra S K, Publisher: New Age International Publisher.
3. Physical Chemistry 6th Ed, by Ira N Levine, 2011.
4. Gaskell, David R., Introduction to the thermodynamics of materials, 6th Ed, 2017, CRC press.
5. B. R. Puri, M. S. Pathania, L. R. Sharma, Principles of Physical chemistry, Vishal Pub. Co. Jalandhar. 48th Edition, 2020.
6. Y. A. Cengel and M. A. Boles, Thermodynamics: An Engineering Approach, 8th ed. Mc Graw- Hill, 2015.
7. R. E. Sonntag and C. Borgnakke, Fundamentals of Thermodynamics, 9th ed., John Wiley & Sons, 2016.
8. M. J. Moran and H. N. Shapiro, Fundamentals of Engineering Thermodynamics, 8th ed. John Wiley & Sons, 2017.
9. J. B. Jones and R. E. Dugon, Engineering Thermodynamics, 1st ed. Prentice Hall, 1996. 5. P. K. Nag, Engineering Thermodynamics, 5th ed. Tata Mc Graw Hill, 2013.

References:

1. Mohanty, A. K., "Rate Processes in Metallurgy", Revised Ed, 2009, Prentice Hall of India (EEE)
2. Problems in Metallurgical Thermodynamics and Kinetics: International Series on Materials Science (Materials Science & Technology Monographs), 2013, by G. S. Upadhyaya and R. K. Dube. Publisher: Pergamon.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3

2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communicated with sequences	Just Communicated	No coherent communication	Not Attended	CO3, CO4, CO5

SEMESTER - IV					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5042	**CERAMICS, GLASSES AND COMPOSITES**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	The student can recognize the crystal structures through the classification of ceramic crystal structures	Remember
CO 2	In-depth understanding on defects in ceramics, types, notations - frame defect reactions	Understand
CO 3	Understanding the parameters involved in ceramic processing and sintering	Apply
CO 4	Applying the concept of ceramic processing to optimize the industry ready products	Analyze
CO 5	Introduce the student to the world of Composites for their commercial production	Skill

b. Syllabus

Units	Content	Hrs.
I	**Introduction to Ceramics** and Ceramic material types, Applications, Pauling's five rules, Radius Ratio and Coordination polyhedral, Ceramic crystal structures, Rock Salt, Zinc Blende, Corrundum, Wurtzite, Flourite, Anti-Flourite, Perovskite, Spinel- normal and inverse	9
II	**Defects in Ceramics**, Defect reactions, Kroger-Vink Notation, Types of ceramic defects, Ceramic Phase equilibrium diagrams, determination of phase diagram, two component phase diagram, three component phase diagram, examples, Solid solutions of Zirconia with Yittria, Zirconia with Calcium Oxide, Silica with Calcium oxide, Silica with Magnesium oxide as important case studies	9
III	**Processing of Ceramics**, Primary re-crystallization, secondary recrystallization, Nucleation and Grain growth mechanisms, Parameters determining grain growth: Time, temperature, initial grain size etc., Ceramic sintering, Porosity in Ceramics, Microstructural Characterization in ceramics, Large scale processing of ceramics	9
IV	**Mechanical properties of ceramics**, Hardness and Brittle character, Toughening mechanism in ceramics, Thermal shock and thermal stress in ceramics, Ceramic Coatings, Glazes and Enamels, Dielectric properties of ceramics, Piezoelectric, Pyroelectric and Ferroelectric ceramics, Glasses, Glass transition temperature, type of glasses, short range order in Glasses, Characterization of Glasses using XRD, SAXS, SANS etc.,	9

V	**Composites** including nano-composites for structural, electrical and device applications; Fabrication and processing of metal matrix (MM), polymer Matrix (PM) and ceramic matrix (CM) composites and their characterization; Understanding the composite modulus, strength and fracture behaviour for structural applications.	9

Text Books:

1. Kingery W.D, H Kent Bowen, D R Uhlmann, Introduction to Ceramics, John Wiley and Sons (reprinted 1976)
2. David E Clark, Diana E Folz, Thomas D McGee, An Introduction to Ceramic Engineering and Design, The American Ceramic Society (2002)
3. William J Callister and David G Rethwisch, Materials Science and Engineering: An introduction,, John Wiley and Sons, 10th edition
4. William J Callister and David G Rethwisch, Fundamentals of Materials Science and Engineering: An integrated approach, John Wiley and Sons, 6th edition
5. Anthony.R.West, Solid state chemistry, John Wiley and Sons (2003) Reprinted 2007
6. M.N. Rahaman, Ceramic Processing and Sintering, CRC Press, Taylor and Francis (2003)

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - IV					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5043	**MANUFACTURING TECHNOLOGY**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	To understand different Manufacturing Processes	Understand
CO 2	Ability to design a mould for casting	Skill
CO 3	To understand the basics of Welding Metallurgy	Understand
CO 4	To have an overview of manufacturing by powder metallurgy	Remember
CO 5	To have the ability to have a practical concept of manufacturing objects.	Understand

b. Syllabus

Units	Content	Hrs.
I	Introduction to casting as a shaping technique; Characteristic and effects of sand, binders and additives; Different types of Molding and Machine molding; Special casting techniques. Design of Gating and Risering of casting ; Solidification	9
II	Melting furnace- Working principle, Advantages and disadvantages of cupola, rotary furnace, induction furnaces; Defects in casting and their remedy; Metallurgy of cast iron, Aluminium and copper based alloy.	9
III	Joining: Physics of welding, Process of different welding, common welding processes of shielded metal arc welding, gas metal arc welding, gas tungsten arc welding and submerged arc welding; Welding metallurgy, problems associated with welding of steels and aluminium alloys, defects in welded joints.	9
IV	Historical perspective of Powder Metallurgy; Reasons for using Powder Metallurgy; The Future of Powder Metallurgy; Powder Fabrication: Different powder fabrication techniques; Powder Characterization: Experimental methods for measuring particle size, shape, distribution, surface area; Significance of true, apparent and tap densities of powders; Flow rate of powders and its significance; compressibility and green strength	9
V	Powder Handling: Powder Packing; Mixing and Blending; Mixing with Binders and Lubricants; Powder Lubrication; Compaction: Phenomenology of Powder Compaction; Conventional Compaction; Fundamentals of Compaction; Influence of Material and Powder Characteristics; Sintering: Sintering fundamentals; Full Density Processing.	9

Text Books:

1.O. P. Khanna: Foundry technology, 17th Edition, DhanpatRai Publications,2011.

2.Rajender Singh: Introduction to Basic Manufacturing Processes & Workshop Technology, New Age International (P) Limited, Publishers, 2006.

3.R. A. Flinn: Fundamentals of Metal Casting, Addison-Wesley; Underlining edition,

4.Powder Metallurgy – AUpadhyaya and G S Upadhyaya.

5.Powder metallurgy: principles and applications- Fritz V. Lenel Reference Books:

6.P. L. Jain: Principles of Foundry Technology, 5th Edition, Tata Mcgraw Hill Education Private, 2009.

7.M. C. Flemings: Solidification processing, McGraw-Hill, 1974.

8.Metals Handbook, Casting, vol. 15, 10th Edition, ASM International, Materials Park, Ohio, USA, 1998.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - IV					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5044	**FUNDAMENTAL OF NANOMATERIALS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	The students will be able to understand the fundamental concepts of nanomaterials in the aspects of the size effects, quantum confinement effect and basic nanostructures	Analyze
CO 2	Understand the basic structures of nanomaterials and size dependent properties.	Understand
CO 3	Broad view of chemical bonds and forces and interpret in-depth knowledge on surface energy.	Understand
CO 4	Knowledge of diffusion in nanostructures and their classification	Understand
CO 5	Study the application of nanomaterials and check their use in various fields.	Remember

b. Syllabus

Units	Content	Hrs.
I	Introduction to nanomaterials: 1D, 2D, 3D and 0D materials - Surface to volume effect and Quantum confinement effect on properties of nanomaterials, quantum effects on the density of states, bandgap energy.	9
II	Basic nanostructures: Quantum dots, nanotubes, nanorods, nanowires, nanofilms, nanofibers, nanocrystals and carbon systems and their properties – Size dependent properties of chemical, electrical, electrical, magnetic, mechanical, and catalytic properties of nanomaterials.	9
III	Structure and Bonding in Nanomaterials : Chemical bonds and forces -Surface energy - Surface charge density- Intermolecular forces- Chemical Potential and Surface curvature - Ostwald Ripening process - Stabilization against agglomeration -Electrostatic and Steric Stabilization- Interaction between two particles DVLO theory.	9
IV	Diffusion in Nanostructures - Factors affecting diffusion, Surface, Volume and cross grain boundary diffusion , growth controlled by diffusion, diffusion kinetics, Kirkendall effect- Nanoparticles by homogeneous nucleation and heterogeneous nucleation- Particle size, strain and grain size of nanomaterials.	9
V	Nanomaterials Application: Nano-electronics (SET/FET) -Chemical and Biosensors. - Photovoltaic, fuel cells, batteries and energy-other applications in various fields.	9

Text Books:
1. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education, 2012.
2. C. P. Poole, Jr., F. J. Owens, "Introduction to Nanotechnology", Wiley, 2003.

References:
1. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), "Handbook of NanoSci, Eng. and Tech.", CRC Press, 2002.
2. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education, 2012.
3. C. P. Poole, Jr., F. J. Owens, "Introduction to Nanotechnology", Wiley, 2003.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - IV					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5045	**MATERIALS CHARACTERIZATION**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	To provide an introduction to materials characterization and its importance.	Analyze
CO 2	To discuss different types of characterization techniques and their uses.	Understand
CO 3	To review the topic of crystal structure and how structures can be determined using diffraction methods.	Understand
CO 4	To understand the properties and behaviour of X-rays and their use in materials characterization.	Understand
CO 5	To know the parameters, operation and use of a TEM and SEM	Remember

b. Syllabus

Units	Content	Hrs.
I	Characterization techniques in material science –X-ray diffraction, Electron Microscopy - instrumentation and application, Sample preparation techniques - contrast mechanisms - Scanning electron microscopy, Transmission electron microscopy and HRTEM, SAED, EELS, Electron back scattering (EBSD) - X-ray micro analysis (EDS, WDS).	9
II	Scanning probe microscopy, tapping mode, contact mode, MFM, EFM, I-AFM, DC- AFM, PFM, FMM, LFM, SCM, SThM, SKM, F-d spectroscopy, Nano indentation, Nano scratching, Scanning tunnelling microscopy, Scanning near field microscopy (SNOM). Spectroscopy techniques: IR, UV, NMR. Surface profilometry measurements - BET surface area analysis	9
III	Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo Gravimetric Analysis (TGA) -Measurement of coefficient of thermal expansion Temperature programme reduction. - Dynamic mechanical analysis (DMA)- Mechanical properties: Hardness measurement- Tensile testing – Impact strength- yield strength -Electrical properties – Electrical resistivity- Corrosion resistance.	9
IV	Temperature measurement techniques, Infrared thermography, Thermo reflectance thermography, Liquid crystal thermography. Interferometry- Electronic speckle pattern interferometry	9

V	Measurement of properties of Nano fluids -thermal conductivity- viscosity- Broke field viscometer. Stability of Nano fluids- Particle size distribution - Zeta potential - Dynamic light scattering system- Acoustic-Attenuation spectroscopy, Photo acoustic spectroscopy, Nano particle counters	9

Text Books & References:

1. Robert K, Ian H, Mark G, *Nanoscale Science and Technology*, john Wiley & sons Ltd., 2005.
2. Weilie Zhou and Zhong Lin Wang, *Scanning Microscopy for Nanotechnology*, Springer 2006.
3. David B. Williams, C. Barry Carter, *Transmission Electron Microscopy*, Springer 2009.
4. Nan Yaho and Zhong, *Hand book of Microscopy for Nanotechnology*, Kluwer Academic press, Boston, 2005.
5. K.S Birdi, *Scanning Probe Microscopy*, CRC Press, 2003.
6. C B Sobhan, G P Peterson, *Microscale and Nanoscale Heat Transfer-Fundamentals and Engineering Applications*, Taylor and Francis/CRC, 2008.
7. Ernest O Doeblin., *"Measurement Systems: Application and Design*", McGraw Hill (Int. Edition) 1990.
8. MIcheal E Brown, *Introduction to Thermal Analysis, Techniques and applications*, Kluwer Academic Publishers 2001.
9. C. Banwell and E. Mccash, *Fundamentals of molecular spectroscopy*, Mc Graw Hill, 1994.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza-tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

g. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - IV					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5046	**MATERIALS SYNTHESIS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Develop a solid understanding of the fundamental principles of nanoscience and nanotechnology, including unique properties and behaviours of nanomaterials.	Analyze
CO 2	Acquire knowledge of various synthesis methods for nanomaterials, such as chemical vapor deposition, sol-gel, physical vapor deposition, and wet chemical methods.	Understand
CO 3	Gain proficiency in advanced characterization techniques used for nanomaterials, including electron microscopy, spectroscopy, TEM, etc.,	Understand
CO 4	Learn the principles of designing and engineering nanomaterials with specific properties, such as size, shape, and surface functionalities	Understand
CO 5	Develop skills in the fabrication of nanomaterials, Electrolysers, solar cells, Batteries etc.,	Remember

b. Syllabus

Units	Content	Hrs.
I	Introduction to chemical synthesis of ceramic materials, Basics of nucleation and growth processes in solution-based synthesis. Solution based approaches- co-precipitation, sol-gel, hydrothermal, sonochemical methods.	9
II	Solid State route- solid state reaction basics, combustion synthesis, Basics of sintering process- chemical reaction and phase transformation kinetics in solids.	9
III	Vapour phase synthesis –PVD, CVD, molecular beam epitaxy etc. Solid substrate- vapour interactions in CVD, PVD. Effect of vapour deposition conditions on growth and morphology of ceramic films.	9
IV	Synthetic approaches, properties and applications of 0D, 1D, 2D and 3D (porous) nanostructured materials, Quantum Technology and Carbon Nano Materials	9
V	Nanostructured materials Characterization: SEM-EDAX, TEM, Elemental mapping, X-ray Photoelectron Spectroscopy (XPS), Electrochemical Characterization measurements and its device fabrication technologies, Fuel cell, batteries, solar cells, Hydrogen electrolyser, capacitor.	9

Text Books & References:

1. 1. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005.
2. Chemistry of Nanomaterials: Synthesis, properties and applications by CNR Rao et.al., Royal Society of Chemistry, Cambridge UK 2006.
3. Active Metals: Preparation, characterization, applications – A. Furstner, Ed., VCH, New York 1996.
4. Characterization of Nanophase materials – Z.L Wang (ed), Wiley-VCH, New York 2000.
5. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
6. Nanostructured Silicon – based powders and composites – Andre P Legrand, Christiane Senemaud, Taylor and Francis, London New York 2003.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3

Part – C **(Detailed answer- 5 x 7 = 35 marks)**	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza-tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - IV					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5047	**MATERIALS SYNTHESES AND CHARACTERISATION LAB**	**-**	**-**	**4**	**2**

Total 10 experiments (any 5 from each section)

MATERIALS SYNTHESES LAB	
S. NO	**EXPERIMENTS**
1	Synthesis ZnO nanoparticles
2	Synthesis TiO_2 nanoparticles
3	Synthesis of Co_3O_4 and CoO nanoparticles
4	Synthesis of $NiCoO_2$ and $NiCo_2O_4$ nanoparticles
5	Synthesis Ag nanoparticles
6	Synthesis of Ag@Cu_2O Core-Shell Nanoparticle
7	Synthesis of Fe_3O_4
8	Synthesis of Quantum Dots
9	Synthesis of organic/inorganic polymers
10	Synthesis of graphene and/or 2D materials
MATERIALS CHARACTERIZATIONS LAB	
S. NO	**EXPERIMENTS**
1	UV-Vis spectroscopic characterizations of materials
2	Fluorescence spectroscopic characterizations of materials
3	XRD characterization of materials
4	FTIR analysis of materials
5	XPS characterizations of materials
6	Microscopic characterizations of materials
7	Semiconducting materials' characterization
8	Cyclic voltammetry characterization of materials
9	Thermal characterizations (TG-DTA, DSC) of materials
10	Composition analysis of materials (combustion/EDAX)

SEMESTER - V

SEMESTER - V					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5051	**POLYMER SCIENCE AND TECHNOLOGY**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	On completion of the course, students can explain the concepts of polymers and special emphasis on petrochemical products.	Remember
CO 2	Students may understand the structure property relationship of polymers	Understand
CO 3	Students can apply the design principle to various types of materials.	Apply
CO 4	Students can solve the problems based on polymers	Analyze
CO 5	Students can handle the day-to-day problems associated with polymers and provide solutions.	Skill

b. Syllabus

Units	Content	Hrs.
I	**Polymer synthesis and properties:** Introduction to polymers, types of polymerizations: addition, condensation and stereo-regular polymerization. Initiators used, important steps involved, kinetics and mechanism of addition, condensation and stereo-regular polymerizations. Copolymerization and its kinetics. Important techniques of polymerization such as emulsion, bulk, solution and suspension. Polymer melting point, glass transition temperature, and structure-property relationship.	9
II	**Natural Polymers:** Chemical & Physical structure, properties, source, important chemical modifications. Chemical and Physical structure, properties of Carbohydrates, Protein, Nucleic acids. Applications of polymers such as proteins, cellulose, starch, resin, shellac, latex, vegetable oils.	9
III	**Synthetic polymers:** Manufacturing of various fractions of crude petroleum important for the polymer industry for raw Materials such as ethylene, propylene, butadiene, acrylic monomers, and various solvents. Petroleum-based materials for common usage and polymer production.	9
IV	**Polymer Materials and Processing:** Polymer materials, natural and synthetic materials, polymeric liquid crystals, conducting and photo conducting polymers, biodegradable polymers, polymer blends and composites, Polymer degradation and stabilization. Introduction to plastic and rubber processing, compounding of polymers, polymer recycling, Polymer physics, Polymer solutions and polymer rheology.	9
V	**Polymer Characterization and Testing:** Polymer characterization, molecular	9

	weight determination by GPC, viscosity, light scattering, and osmometry. Physical methods of polymer analysis such as IR, Raman, NMR, Thermal analysis of polymers using DSC, TGA, DTA, DMA, microscopy (optical and electron), Polymer testing: mechanical, electrical, thermal, and optical methods.	

Text Books:

1. Billmeyer F, 'Textbook of Polymer Science', 3 ed. Wiley Interscience, 2007.
2. Fundamentals of Polymer Science: An introductory text, 2nd Ed. P. Painter and M. Colman, Technomic publishing Co Inc,1998.
3. Carraher's Polymer Chemistry, Ninth Edition, 2013 by Charles E. Carraher Jr
4. Hiemenz, Paul C., and Timothy P. Lodge. Polymer chemistry. CRC press, 2007.
5. Flory, Paul J. Principles of polymer chemistry. Cornell University Press, 1953.
6. Rabek, Jan F, Experimental methods in polymer chemistry, Wiley & Sons Ltd. 1980.
7. Mark, H. F. Encyclopedia of Polymer Science and Technology, 15 Volume Set. Wiley, 2014.

References:

1. Principles of Polymer Science, Bahadur and Sastry, Narosa Publishing House 2002.
2. Polymer Science , Gowarikar, New Age International Publisher, 2015.
3. Textbook of Polymer Science and Engg, Anilkumar and R. K. Gupta, CRC Press; 3 edition, 2018.
4. Polymer Chemistry: An Introduction, 3rd Ed. Malcolm P. Stevens, Oxford University Press, Inc, 1998.
5. Principles of Polymer Systems, Rodriguez, CRC Press; 6 edition, 2014.
6. Polymer Science and Technology by J. R. Fried, Pearson Prentice Hall; 3 edition, 2014.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - V					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5052	**MECHANICAL BEHAVIOR OF MATERIALS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Understand the basics of elastic and plastic deformation behaviour of materials	Understand
CO 2	Analyse the plasticity, dislocation and strengthening mechanisms	Analyze
CO 3	Understand and analyse the tensile behaviour of materials and correlating with microstructures	Understand
CO 4	Understand and analyse various other mechanical testing practices	Understand
CO 5	Understand fatigue and creep behaviour and evaluate & design materials for better creep and fatigue resistance	Understand

b. Syllabus

Units	Content	Hrs.
I	Elastic and plastic deformation, stress-strain relationship; plastic deformation of metallic materials, Mohr's circle, yielding criterion- Von Mises, and maximum-shear-stress/Tresca yielding criterion, failure criteria under combined stresses	9
II	Elements of theory of plasticity, dislocation theory, properties of dislocation, stress fields around dislocations, elementary dislocation interactions; application of dislocation theory to work hardening and strengthening mechanisms.	9
III	Engineering stress-strain curve, true stress-strain curve, instability intension, stress distribution at the neck, ductility measurement, effect of strain rate and temperature on flow properties, testing machines, Tensile properties of important materials.	9
IV	Introduction, Brinell, Vickers and Rockwell hardness tests, Meyer hardness, analysis of indentation by an indenter, relationship between hardness and the flow curve, micro-hardness tests, hardness conversion; hardness at elevated temperatures. Introduction to torsion, torsional stresses for large plastic strains, types of torsion failures torsion test vs. tension test, hot torsion testing.	9
V	Introduction to fatigue testing, practice and evaluation; fatigue crack growth; low cycle, high cycle fatigue; Introduction to creep; stress rupture testing; creep data extrapolation; fatigue-creep interactions; super plasticity.	9

Text Books:
1. Dieter G.E., 'Mechanical Metallurgy', 3rd. Edition, McGraw Hill Publications, 2004
2. Dowling NE, Mechanical Behaviour of Materials, 4th Ed, Pearson, 2013
3. Hull, D., Bacon, D.J., Introduction to Dislocations, 5th Ed., Butterworth-Heinemann, 2011 4 Suryanarayana, AVK., 'Testing of Metallic Materials', BS Publications, 2018

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - V					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5053	**PRINCIPLES AND APPLICATIONS OF SPECTROSCOPIC METHODS**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Learn about the nature of light and the origin of spectra	Understand
CO 2	Understand the theoretical basis for molecular spectroscopy	Understand
CO 3	Correlate theoretical aspects and apply knowledge in various spectroscopic data interpretation	Apply
CO 4	Analyze experimental data originating from various spectroscopic characterization techniques	Analyze
CO 5	Design the new materials for target-specific applications upon understanding the structure-property relationships through spectroscopic characterizations	Skill

b. Syllabus

Units	Content	Hrs.
I	Nature of light; wave-particle duality; Einstein's photoelectric effect and the uncertainty principle; stationary states; quantum numbers; origin of spectra; transition probability; transition dipole moments and selection rules; spectral broadening; intensity of spectral lines; Fourier transforms in spectroscopy.	**12**
II	Rotational, vibrational, and electronic energy levels; rotational and vibrational spectroscopy of diatomic and polyatomic molecules; selection rules; FTIR/FTIR-ATR spectroscopy; instrumentation; and applications.	**12**
III	Raman scattering, rotational and vibrational Raman spectra, selection rules, molecular symmetry, mutual exclusion principle, and experimental data analysis.	**12**
IV	Theory of absorption and emission of light, Einstein coefficient, Laser, Born-Oppenheimer approximation, Morse potential, anharmonicity, Franck-Condon principle, UV-Vis spectroscopy, photophysics, instrumentation, and applications.	**12**
V	Term symbols, electron transitions and their resulting wavelengths, principles of UPS and XPS, Auger electron, surface charging, depth profiling, deconvolution, instrumentation, and data analysis.	**12**

Text Books:

1. Fundamentals of molecular spectroscopy, C. N. Banwell and E. M. McCash, 4th edition, Tata McGraw-Hill (1994).
2. Introduction to spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, 5th edition, Cengage Learning India (2015).
3. Physical methods for chemists, R. S. Drago, 2nd edition, Affiliated East West Press (2016).
4. McQuarrie, J. D.; Simon, J. D. Physical Chemistry: A Molecular Approach; VivaBooks: New Delhi, 1997.
5. Fundamentals of photochemistry, K. K. Rohatgi Mukherjee, New Age Publishers (2017).

References:

1. Principles of fluorescence spectroscopy, J. R. Lakowicz, 3rd edition, Springer (2006).
2. Photoelectron spectroscopy: Principles and applications, S. Hüfner, 3rd edition, Springer (2003).
3. Understanding NMR spectroscopy, J. Keeler, 2nd edition, Wiley (2010).
4. Infrared and Raman spectroscopy: Methods and applications, B. Schrader, 1st edition, Wiley-VCH (1995).

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - V					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5054	**HEAT TREATMENT OF MATERIALS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	To learn different types of furnaces used in heat treatments and heating mechanisms.	Analyze
CO 2	To understand the foundation of heat treatment processes affecting microstructure	Understand
CO 3	Concept behind the microstructure under equilibrium and non-equilibrium cooling. To acquaint with TTT and CCT diagrams and associated microstructure under different industrial cooling conditions.	Understand
CO 4	Significant roles of microstructural features on mechanical properties.	Understand
CO 5	Heat transfer mechanism in heat treatment process and associated microstructure	Remember

b. Syllabus

Units	Content	Hrs.
I	Objectives and Principles of heat treatment. Iron-Carbon Phase Equilibrium Diagram; Austenitisation, Transformation of austenite to pearlite, Bainite and Martensite; Characteristics of transformation products, T-T-T-and C-C-T diagrams; Factors affecting T-T-T curves	9
II	Heat treatment processes: Different types of annealing, spheroidizing, normalsing, hardening, tempering, patenting, austempering, martempering, Sub-zero treatment.	9
III	Thermo mechanical treatment of Steels; Ausforming, Isoforming, Cryoforming, Heat removal mechanism, Hardenability of steels– Significance of hardenability, Determination of hardenability, Jominy End quench test, Factors influencing hardenability, Heat Treatment Defects, Residual stresses developed upon heat treatment.	9
IV	Age Hardening: Basic requirements and steps. Heat treatment of non-ferrous metal and alloys -- Aluminium alloys, Magnesium alloys, Copper and its alloys, Titanium alloys, Ni and its alloys.	9
V	Practical considerations in heat treatment: Accessories, Cooling media, Types of furnaces and Furnace atmosphere. Surface heat treatment – Carburizing of steels,	9

	Cyniding and Carbonitriding, Nitriding, Flame hardening, Induction hardening, Laser hardening etc.	

Text Books/References:

1. An Introduction to Physical Metallurgy – S. N. Avner, McGraw-Hill Book Company.
2. ASM Metals Hand Book – Vol. IX, ASM International Materials Society.
3. Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, Charlie R. Brooks, ASM international, 1996.
4. Principles of Heat Treatment – R. C. Sharma, New Age International (P) Ltd.
5. Heat Treatment of Metals – V. Singh (Standard Publication Distributors) New Delhi

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza-tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - V					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5055	**CLEAN ENERGY TECHNOLOGY**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Describe the fundamentals and main characteristics of clean energy sources and their differences compared to fossil fuels.	Remember
CO 2	Explain the technological basis for harnessing clean energy sources	Understand
CO 3	Recognize the effects that current energy systems based on fossil fuels have on the environment and society	Remember
CO 4	Discuss how to utilize local energy resources (renewable and non-renewable) to achieve the sustainable energy system	Analyze
CO 5	Get a road map for design of materials for sustainable energy generation and harvesting methods	Skill

b. Syllabus

Units	Content	Hrs.
I	Global Energy Needs -Current energy status of India - Energy production from different sources - Hydrothermal - Geothermal - Solar - Renewable/Non-Renewable sources - Environmental impact - Necessity of energy materials.	12
II	Materials for Thermal Power Generation - Environmental Impact of thermal power plants. Improving Efficiency of thermal power plants - Materials challenges in high temperature and pressure of steam- Thermal Barrier Coating (TBC) over turbines – Materials Compositions for TBC -Yttria stabilized Zirconia and perovskite-based compositions.	12
III	Batteries - Types of Batteries- battery mechanism - Electrochemical reactions: Corrosion, oxidation, and prevention- Open circuit voltage - theoretical capacity - theoretical specific energy calculations - Irreversible losses in battery -Testing of a Battery - Lithium Primary Battery – Secondary Rechargeable Batteries - Lead Acid Battery - Ni- Cd Battery - Li-ion Battery - Recent developments in Batteries - Industrial Testing and Standard procedures for Battery - Fabrication Techniques.	12
IV	Fuel Cells, Components of Fuel Cells - types of Fuel Cells - the difference between batteries and fuel cells - working of fuel cell - theoretical efficiency - various factors affecting efficiency - calculation of the consumption of gases - high temperature - intermediate and low- temperature fuel cells - Materials for Solid Oxide Fuel cells -materials for Polymer Electrolyte Fuel Cells - Automobile and stationary power applications.	12

V	Ragone Plot - Supercapacitors - Non-Faradaic/Faradaic - Hybrid type - role of carbon materials in Supercapacitors- Photovoltaics -the principle of photovoltaic cell - Material challenges - perovskites as absorbers - Harvesting of waste heat by thermoelectric materials - Properties of materials to be used for thermoelectric applications.	12

Text Books/References:

1. Series of Articles on "Materials Research Bulletin" 37 (2012) - Thermal Barrier coatings for efficient gas turbine engines
2. Linden D and Reddy Thomas B., Handbook of Batteries, Mc- Graw Hill (2001)
3. A.J.Bard and L.R. Faulkner, Electrochemical Methods: Fundaments and Applications, Wiley 2nd Edition (2000)
4. James Larminie and A. Dicks, Fuel Cells Explained, Wiley 2nd edition (2003)
5. Fuel Cell Handbook by EG&G Technical Services (2004) (e- copy available)
6. Sossina M. Haile, Materials for Fuel Cells, Materials Today (March 2003)
7. Allan J. Jacobson, Materials for solid oxide Fuel Cells, Chemistry of Materials 22, 60 (2010)
8. Green, M. A. Solar Cells: Operating Principles, Technology, and System Applications. Prentice Hall (1981)
9. Bell, Lon E. "Cooling, Heating, Generating Power, and Recovering Waste Heat with Thermoelectric Systems." Science 321 (September 12, 2008): 1457-1461

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - VI

SEMESTER - VI					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5061	**SEMICONDUCTOR MATERIALS AND DEVICES**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Ability to apply basic concepts of Inorganic and Organic Semiconductor materials for electronic device application in modern electronic industry.	Understand
CO 2	Detailed knowledge of various classifications and applications to VLSI, LEDs and solar cells.	Analyze
CO 3	Holistic view of the latest progress in two-dimensional (2D)-one-dimensional (1D) and nano materials.	Apply
CO 4	Emphasis on nano-electronic applications such as Schottky barrier transistors, flexible Electronics	Understand
CO 5	Learn on the physical principles and operational characteristics of Semiconductor devices and some of its important applications.	Remember

b. Syllabus

Units	Content	Hrs.
I	Inorganic and Organic Semiconductor: Energy bands, carrier transport, mobility, drift diffusivity, excess carrier, injection and recombination of the excess carriers, carrier statistics; High field effects: velocity saturation, hot carriers and avalanche breakdown.	9
II	Majority carrier Devices: MS contacts rectifier and non-rectifier, MIS structures, MOSFET, hetero-junction, HEMT and band diagrams, I-V and C-V characteristics.	9
III	MOS structures: Semiconductor surfaces; The ideal and non-ideal MOS capacitor band diagrams and CVs; Effects of oxide charges, defects and interface states. MOSFET: Structures and Device Characteristics, Short-Channel effects. Charge coupled Devices (CCDs), application to VLSI.	9
IV	Non-volatile Memory Device. Optoelectronic Devices: solar cell, photo detectors, LEDs, laser diodes. Nano structures and concepts: quantum wells, supper lattice structures, nanorod, quantum dot, CNTs, 2D materials: grapheme, BN, MoS2 etc, matamaterials.	9
V	Multistage Amplifiers: BJT at high frequencies, frequency response of RC coupled amplifiers and transformer coupled amplifier.	9

Text Books/References:

1. Donald A. Neamen, Semiconductor Physics and Devices Basic Principles, 3rdedn.McGraw-Hil (2003)
2. B.G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, 6thEdn., Prentice Hall, 2006.
3. S. M. Sze and Kwok K. Ng, Physics of Semiconductor Devices, Wiley (2013).
4. M. Hussa, A. Dimoulas and A. Molle, 2D Materials for Nano Electronics, CRC press (2016)
5. M.S. Tyagi, Introduction to Semiconductor Materials and Devices, Willey, Student Edition

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza-tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - VI					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5062	**BIO-MATERIALS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	On completion of the course, students can explain the concepts of biomaterials and special emphasis on biocompatible materials.	Remember
CO 2	Students may understand the structure property relationship biomaterials	Understand
CO 3	Students can apply the design principle to various types of Biomaterials.	Apply
CO 4	Students can evaluate the suitability of biomaterials	Analyze
CO 5	Students can handle the day-to-day problems associated with biomaterials and provide solutions.	Skill

b. Syllabus

Units	Content	Hrs.
I	Introduction to biomaterials, brief history of biomaterials, Evolution of Biomaterials, Common Applications for biomaterials. Biodegradable Polymers: Chemistry, Degradation and Applications, Polymer Degradation, Biodegradable Polymers, "short term" medical applications, Synthetic and Natural Biodegradable Polymers, polymer Degradation Mechanisms. Metallic biomaterials: Effect of metal ion oxidation potential, Metal degradation, corrosion of implanted metals on polymers.	9
II	Ceramic biomaterials, biomedical applications of bio ceramics, dentistry, orthopaedic implant, desired properties, type of bio ceramics, relatively inert/non absorbable, non-inert bio ceramics/resorbable, surface reactive /semi-inert bio ceramics. biodegradation of ceramic, factors that influence degradation.	9
III	Drug delivery: General Fabrication Techniques: compression molding, melt molding/casting, Solvent casting techniques. Drug delivery mechanism: bulk, and surface erosion. Smart drug delivery: chemically responsive, pH-responsive, glucose-responsive, light-responsive, heat-responsive, magnetically responsive, ultrasonically responsive, mechanically and electrically triggered systems, physical targeting, chemical targeting, biological targeting. Hydrogels: classification, uses, preparation, interfacial polymerization.	9
IV	Biocompatibility testing: In vitro Assessment, In Vivo Assessment. Biological scaffolds, Scaffold for tissue engineering, classification, processing, thermally induced phase separation, fiber bonding technique, solvent casting and particulate leaching technique, supercritical CO_2 scaffold production, rapid	9

	prototyping/solid freeform fabrication, freeze-drying of porous collagen, scaffolds classification, properties.	
V	Nanotechnology in Biomaterials: Electrospinning, Self-assembly. Nanomaterials: nanotubes, nanowires, nanoparticles. Nanodevices: Electrical Recording, Biosensors. 3D printing. Bioconjugation, fluorescence tagging, common functional group transformation, and biolabeling. Biomaterials for imaging and diagnosis: Immunofluorescent Staining, Fluorescence and Confocal Microscopy, comparison, advantages, and applications.	9

Text Books/References:

1. Buddy D.Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2nd edition, 2004.
2. Damien Alloyeau, Christine Mottet, Christian Ricolleau, Nanoalloys: Synthesis, Structure and Properties, Springer Publisher, 2012.
3. R.P.Lanza, R.Langer, J.Vacanti, Principles of Tissue Engineering, Academic Press, 2nd Edition, 2000.
4. Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, Nanocomposite Science and Technology, WileyVCH Verlag, Weiheim, 2003.
5. Dietmar Hutmacher, Wojciech Chrzanowski, Biointerfaces: Where Material Meets Biology, Royal Society of Chemistry, 2014.

References:

1. Biomaterials : An Introduction, by Park, Joon, Lakes, R. S. Publisher: Springer, 2007.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - VI					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5063	**COMPUTATIONAL METHODS AND AI MATERIALS SCIENCE**	**4**	**-**	**-**	**4**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Deeper understanding of computational techniques needed for Materials science	Remember
CO 2	Train students in theoretical aspects of computational modelling and simulation techniques required to study materials	Understand
CO 3	Applying the correlation between fundamental quantum mechanical calculations and prediction of materials properties	skill
CO 4	Handling of cutting edge Materials modelling software tools and online open resources on materials	Analyze
CO 5	Understanding the basic principles of using AI in Materials Science	Understand

b. Syllabus

Units	Content	Hrs.
I	Unix core shell scripting – Bash scripting, Data handling and processing, gnuplot for making plots – 2D and 3D, Use of Numpy for scientific computing, Thermodynamic concepts , Statistical mechanics – Equilibrium and Non-Equilibrium systems, Concept of Ensembles, Stochastic processes and coarse graining	12
II	Introduction to Multi-scale model, Monte Carlo simulations, sampling, Metropolis algorithm, , Basics of Molecular dynamics, Tutorials on LAMMPS – MD simulation	12
III	Introduction to Density Functional theory, Many-body problem Born-Oppenheimer approximation, Hohenberg Kohn theorem, Kohn Sham equation, Functionals – exchange correlation, basis sets, local density approximation (LDA), Generalized Gradient approximation, Ab-initio method, solving simple structures	12
IV	Artificial Intelligence in Materials Science, importance of building and maintaining material databases, introduction to machine learning models to predict the material properties; Generative AI models to create new material structures with target specific properties	12
V	Materials Performance Optimization tools, Design of experiments (DOE), Analysis of Variance (ANOVA), Artificial intelligence for materials science, Materials Genome initiative	12

Text Books/References:

1. D. Raabe, Computational materials science, Wiley VCH (1998)
2. Z. H. Barber, Introduction to Materials Modeling, Maney publishing (2005)
3. D. Frenkel and B Smith, Understanding Molecular simulations, Academic Press (2002)
4. Douglas Montgomery, Design and Analysis of Experiments, John Wiley and Sons, 5th edition (2001)
5. Rober G Parr and Yang Weitao, Density Functional theory of atoms and molecules, Oxford University Press (1994)

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - VI					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5064	**MAGNETIC AND OPTICAL PROPERTIES OF MATERIALS**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Analyze types of magnetic materials based on their magnetic properties	Analyze
CO 2	Understanding the basic principles governing magnetic interactions at the atomic level	Understand
CO 3	in-depth analysis of temperature dependent magnetic properties	Analyze
CO 4	Understanding of fundamental principles dictating the optical properties of materials	Understand
CO 5	Measurement techniques for magnetic and optical properties	skill

b. Syllabus

Units	Content	Hrs.
I	**Origin of Magnetism**, Magnetic moment, Basic units, Exchange interaction, types of magnetic materials: Diamagnetic, Paramagnetic and Ferromagnetic Materials, Magnetic susceptibility, Temperature dependent Magnetization curves for different materials, Magnetization-Magnetic field behavior, Hysteresis loop of Ferromagnetic materials, Soft and Hard magnetic materials	**12**
II	**Magnetic property measurements**, Producing high magnetic field - Electromagnets, Vibrating Sample Magnetometer, Superconducting Quantum Interference Device (SQUID)	**6**
III	**Magnetic materials for various applications:** Rare earth magnets, Ferrites and hexaferrites, Yittrium Iron Garnet, Magnetostriction, Magnetoresistance, Giant Magnetoresistance, Magnetic memory technology	**9**
IV	Concept of interference, diffraction, polarization, Geometrical optics, Optical materials, electromagnetic radiation, light -matter interactions, optical properties of metals and non-metals, dielectric function, refraction, reflection, absorption, transmission, scattering, color, opacity and applications of optical phenomena.	**9**
V	Luminescence, thermal emission, lasers, photoconductivity, LED, optical fibers, optical property of semiconductors, band gap, anisotropic optical materials & birefringence, application of optical materials.	**9**

Text Books/References:

1. B.D. Cullity and Charles D Graham Jr, Introduction to Magnetic Materials, Wiley publishers (2008).
2. J.M.D. Coey, Magnetism and Magnetic Materials, Cambridge University Press (2010).
3. Colin N. Banwell and Elaine M McCash, Fundamentals of Molecular spectroscopy, Mc Graw Hill education, 4th edition (2017).
4. Anthony Mark Fox, Optical Properties of Solids, Oxford University Press (2001).

References:

1. Nicolas Spaldin, Magnetic Materials: Fundamentals and Applications, Cambridge University Press, 2nd edition (2011).
2. Justin Peatross and Michael Ware, Physics of light and Optics, Brigham Young University (2015) edited 2025 - Licence for free distribution.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - VI					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5065	**PHYSICAL METALLURGY**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	The students will be able to understand the fundamental alloy formations and solid solutions.	Analyze
CO 2	Understand the basic concepts of phase diagrams.	Understand
CO 3	Broad view of Phase transformations.	Understand
CO 4	Knowledge of Bainitic, Austenitic and Pearlitic transformations.	Understand
CO 5	Study the concepts of Heat treatment of Ferrous alloys.	Remember

b. Syllabus

Units	Content	Hrs.
I	**Introduction**-Alloy formation-Solid solutions- Hume Rothery rules, Substitutional and interstitial solid solutions with example-Size effect – Super alloys - Phase equilibria and solubility limit – Components and phases- Effect of temperature and composition- Criteria for solid solubility.	9
II	**Phase Diagrams**– Binary phase diagram- Isomorphous binary phase diagram - Lever rule- Intermetallic compounds - Solidification of different types of solid solutions – Iron Carbon (Fe-C) diagram – Effect of alloying element on Fe-C diagram. Ternary phase diagrams and Fe-Fe_3C phase diagram- Classification of steels and their microstructures -applications.	9
III	**Phase Transformations**: Eutectic-Eutectoid-Peritectic phases in phase diagram- Super cooling- Nucleation of spherical solid particle in a liquid and mechanism- Homogenious and Heterogeneous nucleation and energy aspects – Hall Petch equation – Solid state transformation- Fraction of Transformation at constant rate of nucleation and growth-Possible transformations from Austenite–Time Temperature Transformation (TTT) curves – Effect of carbon, grain size and alloying elements on TTT curves-	9
IV	**Bainitic Transformation**: Mechanism- Diffusive theory- Displacive theory- Upper and lower bainite - **Austenite Transformation** – formation of austenite- Homogenization of austenite and its kinetics- Austenite grain size – Effect of grain size on mechanical properties – **Pearlitic transformation-** Transformation	9

	rate- morphology-mechanism- Hull Mehl Model and its kinetics of transformation- Effects of alloying addition on pearlitic transformation.	
V	**Heat Treatment of Ferrous alloys:** Annealing, Normalising, Hardening – Hardenability measurements: tempering, case hardening, precipitation hardening – Thermo-mechanical treatments -Heat treatment furnaces – atmospheres – quenching media. Martempering – Austempering.- Recovery, recrystallization and grain growth.	9

Text Books/References:

1. S. H. Avner, "Introduction to Physical Metallurgy", 2nd edition, McGraw Hill, 1985.
2. W. D. Callister, Jr. "Materials Science and Engineering" John Wiley & Sons, 2016.
3. V. Raghavan,"Physical Metallurgy", Prentice Hall of India, 1985.
4. Vijendra Singh, "Physical Metallurgy", Standard Publishers, 2005
5. V. Raghavan, "Solid State Phase transformations" Prentice Hall, 1987.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - VI					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5066	**FUNCTIONAL MATERIALS LAB - I**	**-**	**-**	**8**	**2**

Maximum any 10 experiments will be carried out.

MATERIALS SYNTHESES LAB	
S. NO	**EXPERIMENTS**
1	Thermal evaporation for metallic thin film depositions.
2	Reactive sputtering of metals or ceramics by DC/ RF magnetron sputtering.
3	Polymer thin film deposition by spin coating and dip coating.
4	Smart surface preparation by Soft lithographic process
5	Polymer fiber preparation by electro spinning process.
6	Single level photolithographic fabrication of devices
7	Contact angle measurements- surface energy effect on wetting of surface.
8	Optical behavior of Liquid Crystals
9	Tribology of bio-coatings
10	Cytotoxicity Evaluation.
11	Development of implantable biomaterials.
12	Synthesis of biocompatible materials.
13	Agarose Gel Electrophoresis (AGE)
14	Antimicrobial properties of Ag Nanoparticles

References :

1. Cabrini, Stefano, and Satoshi Kawata, eds. Nanofabrication handbook. CRC Press, 2012
2. Sarangan, Andrew. Nanofabrication: Principles to Laboratory Practice. CRC Press, 2016.
3. Mattox, Donald M. Handbook of physical vapor deposition (PVD) processing. William Andrew, 2010.
4. Mack, Chris. Fundamental principles of optical lithography: the science of microfabrication. John Wiley & Sons, 2008.
5. Jones, P., and Stan Wertheimer. "Gel Electrophoresis, Nucleic Acids, Essential Techniques." Analytical Biochemistry 245.2, John Wiley& Sons, 1997.
6.Xian, Wujing. A laboratory course in biomaterials. CRC Press, 2009.

SEMESTER - VII

SEMESTER - VII					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5071	**CORROSION SCIENCE AND TECHNOLOGY**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	Understand theories of ionization and the principle of electrochemistry.	Understand
CO 2	Gain knowledge about various aspects of electrochemical processes, working mechanisms, and analysing electrochemical processes.	Apply
CO 3	Learn and remember various laws relevant to the electrochemical processes.	Remember
CO 4	Understand electrochemical processes and their impact on corrosion.	Analyze
CO 5	Students will understand different types of corrosion, corrosion mechanisms in heterogeneous environments, and address practical problems related to corrosion protection.	Skill

b. Syllabus

Units	Content	Hrs.
I	Conductance and conductivity, Arrhenius theory of electrolytic dissociation, electrolysis, electrochemical cells, classification of electrolytes, origin of electrode potential, standard potential, Nernst equation, electrode potentials, types of reference and working electrodes, EMF series.	**9**
II	Kohlrausch's law of independent migration of ions. Activities in electrolytic solutions, mean activity coefficient, ionic atmosphere, theories of Double-Layer structure, diffuse-double-layer theory of Gouy and Chapman, the Stern Model, Adsorption of ions and neutral compounds. Influence of the double layer on charge transfer processes.	**9**
III	Types of overpotentials - origin and minimization, polarizable and non-polarizable electrodes, hydrogen evolution and oxygen reduction reactions. Transition state theory and Gibbs free energy of activation.	**9**
IV	Definition and importance of corrosion, electrochemical nature and forms of corrosion, and its prevention in various industries- The direct and indirect effects of corrosion.	**9**
V	Types of corrosion, environmental factors, thermodynamics and kinetics of corrosion, corrosion measurement techniques, and various corrosion protection methods.	**9**

Text Books/References:
1. S. Glasstone (2006), Electrochemistry, Affiliated to East-west press, 1st Edition.
2. Crow & Crow (2004), Principles and Applications of Electrochemistry, Chapman Hall, London, 4th Edition.
3. P.T. Kissinger and W. R. Heineman, Laboratory Techniques in Electroanalytical Chemistry, 2nd Edition, Marcel Dekker Inc., 1996.
4. Fontana, M.G., Corrosion Engineering, Tata McGraw-Hill (2008). 3rd Ed. (seventh reprint)
5. Jones, D.A., Principles and Prevention of Corrosion, Prentice-Hall (1996)

References:
1. Electrochemistry. Principles and Applications, Edmund C. Potter and C. V. King 1957 J. Electrochem. Soc. 104 115C, DOI:10.1149/1.2428553.
2. Sastri, V.S., Ghali, E. and Elboujdaini, M., Corrosion prevention and protection: Practical solutions, John Wiley and Sons (2007).
3. E. Gileadi, Physical Electrochemistry, Fundamental, Techniques and Applications, Wiley-VCH, 2011.
4. J. Wang, Analytical Electrochemistry, 3rd Edition, Wiley – VCH, 2006.

c. Mapping of Program Outcomes with Course Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

d. Evaluation Scheme

	CO1	CO2	CO3	CO4	CO5	Total
Internal	8	8	8	8	8	40
External	12	12	12	12	12	60
Total	**20**	**20**	**20**	**20**	**20**	**100**

e. Mapping Course Outcome with Internal Assessment (40 Marks)

	CO1	CO2	CO3	CO4	CO5
Assignments	1	1	1	1	1
Seminar	1	1	1	1	1
Test	5	5	5	5	5
Attendance	1	1	1	1	1
Total	8	8	8	8	8

f. Mapping Course Outcome with External Assessment (60 Marks)

Category	CO1	CO2	CO3	CO4	CO5
Part – A (Objective - 10 x 1 = 10 marks)	2	2	2	2	2
Part – B (Short Answer - 5 x 3 = 15 marks)	3	3	3	3	3
Part – C (Detailed answer- 5 x 7 = 35 marks)	7	7	7	7	7
Total	**12**	**12**	**12**	**12**	**12**

g. Rubric for Assignments

Sl. No	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Content 50%	Ideas are detailed, well developed, supported with specific evidence & facts and examples	Ideas are detailed, Developed and supported with evidence and facts mostly specific.	Ideas are presented but not particularly developed or supported;	Content is not sound	Not attended	CO1, CO2, CO3
2	Organiza -tion 50%	Includes title, introduction, statement of the main idea with illustration and conclusion.	Includes title, introduction, statement of main idea and conclusion.	organizational tools are weak or missing	No organiz ation	Not attended	CO3, CO4, CO5

h. Rubric for Seminar

Sl. No.	Criteria	100%	75%	50%	25%	0%	Relation to COs
1	Knowledge and Understanding 50%	Exceptional knowledge of facts, terms, and concepts	Detailed knowledge of facts, terms, and concepts	Considerable knowledge of facts, terms, and concepts	Minimal knowledge of facts, terms, and concepts	Not Attended	CO1, CO2, CO3
2	Presentation 50%	Well Communicated with logical sequences, examples, and references	Communic ated with sequences	Just Communicate d	No coherent communicatio n	Not Attended	CO3, CO4, CO5

SEMESTER - VII					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5072	**ENERGY MATERIALS AND TECHNOLOGY**	**3**	**-**	**-**	**3**

a. Course Outcome (CO)

On the successful completion of the course, the student will be able to

(Course outcomes are specific for a particular course. CO should be specific, measurable, achievable, realistic, and time-bound)

	COURSE OUTCOME	LEVEL
CO 1	To Understand Energy Conversion Principles	Analyze
CO 2	To help students acquire knowledge in the basics of energy materials	Understand
CO 3	Students will gain knowledge regarding Identify Energy Materials and Evaluate Storage Technologies	Understand
CO 4	To understand the Synthesis and Fabrication of Energy Materials	Understand
CO 5	Student will gain knowledge on Energy materials Design for Sustainability	Remember

b. Syllabus

Units	Content	Hrs.
I	Current energy scenario; Energy and climate, Outline of alternative energy schemes, clean low cost, sustainable energy production based on renewable energy sources, properties of sunlight, Energy and environment correlations, Environmental degradation due to energy production and utilization, global warming; Environmental impact assessment of materials used in energy and applications and their properties, sustainability issues,	**9**
II	Overview of biomass as energy source, Biofuels, types of biofuels and production technologies; Advanced biosystems and biofuel production, Green chemical technologies, Green Chemistry and Green Engineering, alternative solvents, supercritical fluids, Catalysis, Homogenous catalysts, heterogeneous catalyst, Biocatalysts.	**9**
III	Solar thermal conversion, principles of photovoltaic energy conversion, Types of photovoltaic cells, first, second and third generation solar cells, PV system design and economics, Fundamentals of nanostructured solar cells, Hydrogen economy, hydrogen production, solar water splitting (SWS), photocatalysts.	**9**
IV	Electrochemical cell, Faraday's laws, Issues and challenges of functional nanostructured materials for electrochemical energy conversion systems, Fuel cells, Principles and nanomaterials design for; Proton exchange membrane fuel cells; Types of fuel cells. Current status and future trends.	**9**
V	Issues and challenges of functional nanostructured materials for electrochemical	**9**

	energy storage systems, Primary and Secondary batteries, Lithium-ion batteries, Current status and future trends. Capacitor, Electrochemical supercapacitors, Current status and future trends, electro chromic energy storage device, porous materials to store clear energy gases, Metal organic frame works (MOFs), hydrogen storage, Storage of carbon dioxide, CO2 capture and conversion.	

Text Books/References:

1.Jingbio louise Liu, Sajid Bashir, Advanced Nanomaterials and their applications in Renewable energy, Elsevier, 2015

2. Tetsuo Soga, Nanostructured Materials for Solar Energy Conversion, Elsevier , 2006

3. Jenny Nelson, The Physics of Solar Cells, Imperial College Press, 2003.

4. Allen J.Bard and Larry R. Faulkner, Electrochemical methods: Fundamentals and Applications, 2nd Edition, John Wiley & Sons. Inc, 2004.

5. G.A. Nazri and G. Pistoia, Lithium Batteries: Science and Technology, Kluwer Academic Publishers, Dordrecht, Netherlands, 2004.

6. J. Larmine and A. Dicks, Fuel Cell System Explained, John Wiley, New York, 2000.

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SEMESTER - VII					
COURSE CODE	COURSE NAME	L	T	P	CREDITS
MSN5073	**FUNCTIONAL MATERIALS LAB - II**	**-**	**-**	**8**	**2**

Maximum any 10 experiments will be carried out.

MATERIALS SYNTHESES LAB	
S. NO	**EXPERIMENTS**
1	Measurement of dielectric constant of materials.
2	Measurement of capacitance of materials
3	Conductivity measurements of materials
4	Hysteresis loop measurement of ferroelectric materials
5	Piezoelectric coefficient measurements of piezoelectric materials.
6	Frequency response analysis of solid and liquid dielectric materials
7	Measurement of volume and surface resistivity of dielectric materials
8	Measurement of polarisation index of dielectric materials
9	Determination of breakdown strength of dielectric materials
10	Fabrication and capacitance measurement of super capacitor
11	Determination of carrier type, mobility and concentration of semiconductors.
12	Solar cell fabrication and I-V Characterization.
13	Agarose Gel Electrophoresis (AGE)
14	Antimicrobial properties of Ag Nanoparticles

References :

1. Callister, William D., and David G. Rethwisch. Materials science and engineering. Vol. 5. NY: John Wiley & Sons, 2011.
2. EW. Golding Electrical Measurements and Measuring Instruments, 5th ed., Reem publications, 2011
3. R. E. Hummel, “Electronic Properties of Materials” Springer, 2011.