B. Tech.

IN

Materials Science and Engineering

CURRICULUM AND SYLLABI OF COURSES

(I to VIII Semesters)

(Effective from 2019)

School of Materials Science and Engineering

NATIONAL INSTITUTE OF TECHNOLOGY CALICUT

CALICUT 673601

KERALA, INDIA

1. Background to the Programme

a) General description of the benefits that will be acquired by the students who will pursue the proposed programme

The proposed programme is a four year bachelor’s degree in technology, with an emphasis on rapidly developing energy, polymer, bio and nano materials. The course is designed to make the students capable of taking up the challenges in the field of materials science and engineering. A student undergoing the proposed course will learn chemistry and physics of materials along with related biology and mathematics combined with the principles of mechanical, chemical and electrical engineering. After successful completion of this course the student will have the basic understanding of all classes of materials. He/she will be well versed with the conventional as well as modern techniques in materials characterisation. This will make such students highly marketable in current industrial and R&D scenario. Moreover, the programme incorporates nanotechnology courses in the curriculum, which will enable the students to use the principles of nanoscience and technology for developing new materials as well as tailoring the properties of existing materials. In addition to the solid technical foundation, the curriculum also ensures overall development of students, especially in communication, project management, time management, organizational and computing skills.

b) Sector (s)/employment markets to which the graduates could look for gainful employment

Graduates in the materials science and engineering will cater the multidisciplinary needs in the sectors like health care, energy, environment, aerospace, automobile, defence, etc. Industry oriented elective courses are included in the proposed curriculum and syllabus for the programme. The need for design and development of new materials to overcome the current challenges in the various industries itself will drive the recruitment of materials scientists and engineers in the respective fields. The proposed graduates could be potential candidates for taking up challenging R&D and industrial tasks in defence, automobile, oil, health care, energy and environmental sectors.

2. Justification

Novel multifunctional materials having enhanced properties are the need of hour worldwide for sustainable development. The need for technological advancement in the thrust fields of this era such as energy, green technology and health care demands better understanding of materials science and technology. The proposed **Materials Science and Engineering (MSE)** undergraduate course focuses on the fundamentals of all class of materials including nanomaterials. Special emphasis is also made on the structure-property correlation of various materials such as biomaterials, nanomaterials, ceramics, metals, polymers, composites and electronic materials.

3. Objectives

The course structure and the syllabi of B.Tech. MSE is designed to provide an in-depth understanding and hands-on research experience in the advanced materials technology with an emphasis on rapidly growing areas such as health care, energy and environment. In addition to the theory/laboratory courses, the students complete a major theoretical/experimental project in the final year related to materials science and engineering. The course provides a solid platform to develop critical thinking, problem-solving skills, communication skills and project management. Graduates of this programme will be ready to take up jobs in industry (energy, environment, polymer/rubber, healthcare, biomedical, nanotechnology etc.), as well as to develop a research-based career.

The major objectives are summarised below:

- To provide the students strong understanding of the basics of the materials science and characterisation, as well as hands-on experience on the advanced characterisation techniques
- To provide a platform to create highly skilled and competitive man power in the rapidly growing area of materials science and engineering.
- To develop interdisciplinary knowledge as well as technical and personal skills required to take-up the demands and challenges faced by the society.

4. Relevance of B.Tech. MSE in SMSE, NIT Calicut

The School of Materials Science and Engineering has played a pioneer role in nanotechnology and nanomaterials research since its establishment in 2009. The school offers M.Tech. as well as PhD programmes in nanotechnology and related areas. Faculty members of school of Materials Science and Engineering are having adequate teaching and research expertise in the area of materials science and engineering. The school undertake sponsored as well as consultancy project related MSE from various agencies such as DST, DRDO, HPCL,CVRDE, SERB, TATA Steel, CSIR, KSCSTE, NTPC, ARDB, DBT and BRNS total worth about 5 crores. School offers M.Tech and PhD programmes in nanotechnology and related areas. The faculties have published books, book chapters and more than 100 international journals with high impact factor in the area of Materials science, Nano science and technology.

The School of Materials Science and Engineering is equipped with seven laboratories where cutting edge research is carried out in the area of applied nanomaterials, energy, environment, display devices, smart surfaces and biomaterials. Moreover, the school hosts an advanced microscopy centre of the institute, where students get hands-on experience on scanning electron as well as probe microscopy. The students completing this programme will provide highly skilled materials engineers and scientists with adequate knowledge and practical expertise.

The Programme Outcomes (POs) of B. Tech. In Materials Science and Engineering

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able

	to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

The Programme Specific Outcomes (PSOs) of B. Tech. in Materials Science and Engineering

PSO1	Apply the knowledge of materials science and engineering to take up the challenges in the multidisciplinary areas.
PSO2	Attain the competence in the development of high performance materials and their characterisation.
PSO3	Accomplishment of technical and personal skills required to take-up the demands and challenges faced by the society.

CURRICULUM

The total minimum credit for completing the B. Tech. programme in Materials Science and Engineering is 160.

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES

The structure of B.Tech. programme shall have the following Course categories:

Sl. No.	COURSE CATEGORY	Number of Courses	Credits
1.	Mathematics (MA)	4	12
2.	Science (BS)	5	10
3.	Humanities (HL)	3	9
4.	Basic Engineering(BE)	6	15
5.	Professional Core (PC)	28	87
6.	Open Electives (OE)	2	6
7.	Departmental Electives (DE)	5	15
8.	Other Courses (OT)	4	6
	TOTAL	58	160

COURSE REQUIREMENTS

1. MATHEMATICS

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MA1001D	Mathematics I	3	1	0	3
2.	MA1002D	Mathematics II	3	1	0	3
3.	MA2001D	Mathematics III	3	1	0	3
4.	MA2002D	Mathematics IV *	3	1	0	3
		Total	12	4	0	12

* Mathematics IV will be branch specific.

2. SCIENCE

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	PH1001D	Physics	3	0	0	3
2.	PH1091D	Physics Lab	0	0	2	1
3.	CY1001D	Chemistry	3	0	0	3
4.	CY1094D	Chemistry Lab	0	0	2	1
5.	BT1001D	Introduction to Life Science	2	0	0	2
		Total	8	0	4	10

3. HUMANITIES

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	MS1001D	Professional Communication	3	0	0	3
2.	ME3104D	Principles of Management	3	0	0	3
3.	MS4003D	Industrial economics	3	0	0	3
		Total	9	0	0	9

4. BASIC ENGINEERING

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1001D	Engineering Mechanics	3	0	0	3
2.	ZZ1003D	Basic Electrical Sciences	3	0	0	3
3.	ZZ1002D	Engineering Graphics	2	0	2	3
4.	ZZ1004D	Computer Programming	2	0	0	2
5.	ZZ1091D	Workshop I	0	0	3	2
6.	ZZ1092D	Workshop II	0	0	3	2
		Total	10	0	8	15

5. OTHER COURSES (OT)

Sl.No.	Course Code	Course Title	L	T	P	Credits
1.	ZZ1093D	Physical Education	0	0	2	1
2.	ZZ1094D	Value Education	0	0	2	1
3.	ZZ1095D	NSS	0	0	2	1
4.	MT3004D	Environmental engineering	3	0	0	3
		Total	3	0	6	6

6. PROFESSIONAL CORE

Sl.No	Course Code	Course Title	Prerequisites	L	T	P	Credits
1.	MT2001D	Structure of materials	Nil	3	0	0	3
2.	MT2002D	Physics and chemistry of materials	Nil	4	0	0	4
3.	CE2001D	Mechanics of solids	ZZ1001D Engineering Mechanics	3	0	0	3
4.	ME2004D	Fluid mechanics and fluid machinery	Nil	3	0	0	3
5.	ME2013D	Thermodynamics	Nil	3	0	0	3
6.	CE2097D	Materials Testing Lab	Nil	0	0	3	2
7.	CH2006D	Heat Transfer	Nil	3	0	0	3
8.	MT2003D	Ceramics and glasses	Nil	3	0	0	3
9.	MT2004D	Fundamentals of nanomaterials	Nil	3	0	0	3

10.	MT2005D	Polymer Science and Technology	Nil	3	0	0	3
11.	MT2006D	Metallurgical engineering	Nil	3	0	0	3
12.	MT2091D	Materials Processing Lab	Nil	0	0	3	2
13.	MT2092D	Fluid flow and heat transfer Lab	Nil	0	0	3	2
14.	MT3001D	Synthesis and fabrication of nanomaterials	Nil	4	0	0	4
15.	MT3002D	Composite materials	Nil	3	0	0	3
16.	MT3003D	Materials characterization	Nil	4	0	0	4
17.	MT3091D	Materials synthesis and characterization lab	Nil	0	0	3	2
18.	EE3021D	Electrical engineering materials	Nil	3	0	0	3
19.	MT3005D	Biomaterials	Nil	3	0	0	3
20.	MT3006D	Computational methods in materials science	Nil	2	0	3	4
21.	MT3007D	Magnetic and optical Properties of Materials	Nil	3	0	0	3
22.	MT3092D	Functional materials Laboratory I	Nil	0	0	3	2
23.	MT3093D	Mini project and Seminar	Nil	-	-	-	3
24.	MT4001D	Energy materials and technology	Nil	3	0	0	3
25.	MT4002D	Corrosion science and engineering	Nil	3	0	0	3
26.	MT4091D	Functional materials Laboratory II	Nil	0	0	3	2
27.	MT4092D	Project :Part 1	Nil	0	0	6	3
28.	MT4093D	Project: Part 2	Nil	0	0	16	8
Total				59	0	43	87

7. DEPARTMENT ELECTIVES

Considering the multidisciplinary background of the programme it is proposed to offer electives from different specialized industrial tracks. Students can opt for these electives based on their interest and career prospective.

INDUSTRIAL TRACK ELECTIVES							
Sl.No	**Course Code**	**Course Title**	**Prerequisites**	**L**	**T**	**P**	**Credits**
TRACK 1 – ENERGY							
1	MT3021D	Thermal engineering	Nil	3	0	0	3
2	MT4021D	Hydrogen and Fuel cell	Nil	3	0	0	3
3	MT4022D	Batteries and Super capacitors	Nil	3	0	0	3
4	MT4023D	Photovoltaic systems	Nil	3	0	0	3
TRACK 2 – HEALTH CARE							
5	MT3022D	Bio imaging	Nil	3	0	0	3
6	MT3023D	Toxicology	Nil	3	0	0	3
7	MT3024D	Nanotechnology of Bioactives	Nil	3	0	0	3
8	BT3001D	Genetic Engineering	Nil	3	0	0	3
9	BT3002D	Bioinformatics	Nil	3	0	0	3
10	MT4024D	Material fundamentals for biomedical applications	Nil	3	0	0	3
11	MT4025D	Bio Sensors and Devices	Nil	3	0	0	3

TRACK 3 – POLYMER TECHNOLOGY							
12	MT3025D	Polymer Materials	Nil	3	0	0	3
13	MT3026D	Rubber Technology	Nil	3	0	0	3
14	MT4026D	Tyre Technology	Nil	3	0	0	3
15	MT4027D	Plastic Processing	Nil	3	0	0	3
TRACK 4 – METALLURGY							
16	MT3027D	Physical and Mechanical metallurgy	Nil	3	0	0	3
17	ME3121D	Powder Metallurgy	Nil	3	0	0	3
18	MT4028D	Steel and Non-Ferrous Metallurgy	Nil	3	0	0	3
GENERAL ELECTIVES							
19	MT3028D	Application of Nanofluids	Nil	3	0	0	3
20	MT3029D	Micro and nano fluidics	Nil	3	0	0	3
21	MT3030D	Micro Electro Mechanical Systems	Nil	3	0	0	3
22	MT3031D	Carbon nanostructures	Nil	3	0	0	3
23	MT3032D	Semiconductor nanostructures	Nil	3	0	0	3
24	MT3033D	Interface and colloid science	Nil	3	0	0	3
25	MT4029D	Introduction to Textile engineering	Nil	3	0	0	3
26	MT4030D	High performance materials	Nil	3	0	0	3

OPEN ELECTIVES

Two elective courses to be credited from other departments

Course Structure

Semester I

Sl. No	Course Code	Course Title	L	T	P	Credits
1.	MA1001D	Mathematics I	3	1	0	3
2.	PH1001D/CY1001D	Physics/Chemistry	3	0	0	3
3.	MS1001D/ ZZ1003D	Professional Communication/ Basic Electrical Sciences	3	0	0	3
4.	ZZ1001D/ ZZ1002D	Engineering Mechanics/ Engineering Graphics	3/2	0	0/2	3
5.	ZZ1004D/BT1001D	Computer Programming / Introduction to Life Science	2	0	0	2
6.	PH1091D/CY1094D	Physics Lab/ Chemistry Lab	0	0	2	1
7.	ZZ1091D/ ZZ1092D	Workshop I/Workshop II	0	0	3	2
8.	ZZ1093D/ZZ1094D/ZZ 1095D	Physical Education /Value Education/ NSS	-	-	-	3*
	Total Credits		14/ 12	1	5/8	17+3*

*Note: Three courses of 1 credit each has to be credited within the first four semesters.

Semester II

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MA1002D	Mathematics II	3	1	0	3
2.	CY1001D/PH1001D	Chemistry/ Physics	3	0	0	3
3.	ZZ1003D/MS1001D	Basic Electrical Sciences/ Professional Communication	3	0	0	3
4.	ZZ1002D/ ZZ1001D	Engineering Graphics/ Engineering Mechanics	2/3	0	2/0	3
5.	BT1001D/ ZZ1004D	Introduction to Life Science./ Computer Programming	2	0	0	2
6.	CY1094D/PH1091D	Chemistry Lab / Physics Lab	0	0	2	1
7.	ZZ1092D/ ZZ1091D	Workshop II/ Workshop I	0	0	3	2
	Total Credits		12/ 14	1	8/5	17

Semester III

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MA2001D	Mathematics III	3	1	0	3
2.	MT2001D	Structure of materials	3	0	0	3
3.	MT2002D	Physics and chemistry of materials	4	0	0	4
4.	CE2001D	Mechanics of solids	3	0	0	3
5.	ME2004D	Fluid mechanics and fluid machinery	3	0	0	3
6.	ME2013D	Thermodynamics	3	0	0	3
7.	CE2097D	Materials Testing Lab	0	0	3	2
	Total Credits					21

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MA2002D	Mathematics IV	3	1	0	3
2.	CH2006D	Heat Transfer	3	0	0	3
3.	MT2003D	Ceramics and glasses	3	0	0	3
4.	MT2004D	Fundamentals of nanomaterials	3	0	0	3
5.	MT2005D	Polymer Science and Technology	3	0	0	3
6.	MT2006D	Metallurgical engineering	3	0	0	3
7.	MT2091D	Materials Processing Lab	0	0	3	2
8.	MT2092D	Fluid flow and heat transfer Lab	0	0	3	2
	Total Credits					22

Semester V

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MT3001D	Synthesis and fabrication of nanomaterials	4	0	0	4
2.	MT3002D	Composite materials	3	0	0	3
3.	MT3003D	Materials characterization	4	0	0	4
4.	MT3004D	Environmental engineering	3	0	0	3
5.	ME3104D	Principles of Management	3	0	0	3
6.		Elective I	3	0	0	3
7.	MT3091D	Materials synthesis and characterization lab	0	0	3	2
	Total Credits					22

Semester VI

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	EE3021D	Electrical engineering materials	3	0	0	3
2.	MT3005D	Biomaterials	3	0	0	3
3.	MT3006D	Computational methods in materials science	2	0	3	4
4.	MT3007D	Magnetic and optical properties of materials	3	0	0	3
5.		Elective II	3	0	0	3
6.	MT3092D	Functional materials Laboratory I	0	0	3	2
7.	MT3093D	Mini project and Seminar	-	-	-	3
	Total Credits					21

Semester VII

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MT4001D	Energy materials and technology	3	0	0	3
2.	MT4002D	Corrosion science and engineering	3	0	0	3
3.		Elective III	3	0	0	3
4.		Elective IV	3	0	0	3
5.	MS4003D	Industrial economics	3	0	0	3
6.	MT4091D	Functional materials Laboratory II	0	0	3	2
7.	MT4092D	Project :Part 1	-	-	6	3
	Total Credits					20

Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.		Elective V	3	0	0	3
2.		Elective VI	3	0	0	3
3.		Elective VII	3	0	0	3
4.	MT4093D	Project: Part 2	-	-	16	8
	Total Credits					17

Notes:

1. For the successful completion of B.Tech. programme, a student must complete the minimum number of courses of each category specified in the curriculum of the specific programme. In addition to the above, the student must have acquired a total of 160 credits.
2. A student who completes all the course requirements (except the project) before the final semester may be permitted to undertake project at an institute/industry outside with the consent of the department

MA1001D MATHEMATICS I

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Real valued function of real variable: Limit, Continuity, Differentiability, Local maxima and local minima, Curve sketching, Mean value theorems, higher order derivatives, Taylor's theorem, Integration, Area under the curve, Improper integrals. Function of several variables: Limit, Continuity, Partial derivatives, Partial differentiation of composite functions, Differentiation under the integral sign, Local maxima and local minima, Saddle point, Taylor's theorem, Hessian, Method of Lagrange multipliers.

Module 2: (13 Lecture hours)
Numerical sequences, Cauchy sequence, Convergence, Numerical series, Convergence, Tests for convergence, Absolute convergence, Sequence and series of functions, point-wise and uniform convergence, Power series, Radius of convergence, Taylor series.
Double integral, Triple integral, Change of variables, Jacobian, Polar coordinates, Applications of multipleintegrals.

Module 3: (13 Lecture hours)
Parameterised curves in space, Arc length, Tangent and normal vectors, Curvature and torsion, Line integral, Gradient, Directional derivatives, Tangent plane and normal vector, Vector field, Divergence, Curl, Related identities, Scalar potential, Parameterised surface, Surface integral, Applications of surface integral, Integral theorems: Green's Theorem, Stokes' theorem, Gauss' divergence theorem, Applications of vector integrals.

References:

1. H. Anton, I. Bivensand S. Davis, Calculus, 10th edition, New York: John Wiley & Sons, 2015.
2. G. B. Thomas, M.D. Weirand J. Hass, Thomas' Calculus, 12th edition, New Delhi, India: Pearson Education, 2015.
3. E. Kreyszig, Advanced Engineering Mathematics, 10th edition, New York: John Wiley & Sons, 2015.
4. Apostol, Calculus Vol 1, 1st ed. New Delhi: Wiley, 2014.

MA1002D MATHEMATICS II

Pre-requisites: Nil

Total hours: 39

L	T	P	C
3	0	0	3

Module 1: (16 Lecture hours)

System of Linear equations, Gauss elimination, Solution by LU decomposition, Determinant, Rank of a matrix, Linear independence, Consistency of linear system, General form of solution.

Vector spaces, Subspaces, Basis and dimension, Linear transformation, Rank-nullity theorem, Inner-product, Orthogonal set, Gram-Schmidt orthogonalisation, Matrix representation of linear transformation, Basis changing rule.

Types of matrices and their properties, Eigenvalue, Eigenvector, Eigenvalue problems, Cayley-Hamiltonian theorem and its applications, Similarity of matrices, Diagonalisation, Quadratic form, Reduction to canonical form.

Module 2: (13 Lecture hours)

Ordinary Differential Equations (ODE): Formation of ODE, Existence and uniqueness solution of first order ODE using examples, Methods of solutions of first order ODE, Applications of first order ODE.

Linear ODE: Homogenous equations, Fundamental system of solutions, Wronskian, Solution of second order non-homogeneous ODE with constant coefficients: Method of variation of parameters, Method of undetermined coefficients, Euler-Cauchy equations, Applications to engineering problems, System of linear ODEs with constant coefficients.

Module 3: (10 Lecture hours)

Gamma function, Beta function: Properties and evaluation of integrals.

Laplace transform, Necessary condition for existence, General properties, Inverse Laplace transform, Transforms of derivatives and integrals, Differentiation and Integration of transform, Unit-step function, Shifting theorems, Transforms of periodic functions, Convolution, Solution of differential equations and integral equations using Laplace transform.

References:

1. E. Kreyszig, Advanced Engineering Mathematics, 10^{th} edition, New Delhi, India: Wiley, 2015.
2. G. Strang, Introduction to Linear Algebra, Wellesley MA: Cambridge Press, 2016.
3. R. P. Agarwal and D. O ’Regan, An Introduction to Ordinary Differential Equations, New York: Springer, 2008.
4. V. I. Arnold, Ordinary Differential Equations, New York: Springer, 2006.
5. P. Dyke, An Introduction to Laplace Transforms and Fourier Series, New York: Springer, 2014.

PH1001D PHYSICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 Lecture hours):
Particle nature of radiation – Photoelectric effect, Compton effect, Wave nature of matter – matter waves, wave packets description, phase and group velocity, uncertainty principle. Formulation of Schrödinger equation, physical meaning of wave function, expectation values, time-independent Schrödinger equation, quantization of energy for bound particles. Application of time-independent Schrödinger equation to free particle, infinite well, finite well, barrier potential, tunneling.

Module 2: (14 Lecture hours):
Simple Harmonic Oscillator, two-dimensional square box, the scanning tunneling microscope. Wave function for two or more particles, indistinguishable particles, symmetry and anti-symmetry under exchange of particles, Pauli's exclusion principle, electronic configurations of atoms. Quantum model of a solid – periodicity of potential and bands, E – k diagram, effective mass, band gap.

Module 3: (13 Lecture hours):
Microstates and macrostates of a system, equal probability hypothesis, Boltzman factor and distribution, ideal gas, equipartition of energy, Maxwell speed distribution, average speed, RMS speed, Quantum distributions - Bosons and Fermions, Bose-Einstein and Fermi-Dirac distribution, applications.

References:

1. Kenneth Krane, Modern Physics, 2nd Ed., Wiley (2009)
2. Arthur Beiser, Concepts of Modern Physics, 6th Ed., Tata Mc Graw –Hill Publication (2009)
3. Robert Eisberg and Robert Resnick, Quantum Physics of atoms, Molecules, Solids, Nuclei and Particle, 2nd Ed., John Wiley(2006)
4. David Halliday, Robert Resnick and Jearl Walker, Fundamentals of Physics, 6th Ed., Wiley (2004)

CY1001D CHEMISTRY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (14 Lecture hours)

Spectroscopy – General Principles, Infrared, group frequencies, Electronic spectroscopy of conjugated molecules, Woodward-Fieser Rule.

Chromatography – Retention and Separation factors, Theoretical plates, Instrumentation and uses of Gas Chromatography and High Performance Liquid Chromatography

Thermal analysis – Thermogravimetry, Differential Scanning Calorimetry and Differential Thermal Analysis

Module 2: (12 Lecture hours)

Electrochemical corrosion – Mechanisms, control and prevention.

Cyclic voltammetry, Switching potentials, Cathodic and anodic peak currents Potentiometry, Fuel cells – Types and applications

Liquid crystals – Phase types, uses in displays and thermography.

Module 3: (13 Lecture hours)

Catalysis – Homogeneous and heterogeneous catalysis, Organometallic compounds, 18-electron rule, Oxidative addition, Reductive elimination, insertion and Elimination reactions, Wilkinson's catalyst in alkene hydrogenation, Zeigler-Natta catalysis in polymerization of olefins.

Enzyme catalysis – Mechanisms, significance of Michaelis – Menten constant, Turnover number, Co-enzymes and cofactors

References:

1. C. N. Banwell and E. M. McCash, *Fundamentals of Molecular Spectroscopy*, 4th edition, Tata McGraw Hill, New Delhi, 2010.
2. D. A. Skoog and D. M. West, F. J. Holler and S. R. Crouch, *Fundamentals of Analytical Chemistry*, Brooks Cole, Florence, 2004.
3. H. H. Williard, L. L. Merrit, J. A. Dean and F. A. Settle, *Instrumental Methods of Analysis*, Wadsworth Publishing Company, Belmont, California, 1986.
4. B. R. Puri, L. R. Sharma, M. S. Pathania, *Principles of Physical Chemistry,* Vishal Publishing, New Delhi, 2000.
5. J. E. Huheey, E.A. Keiter and R.L. Keiter, *Inorganic Chemistry, Principles of Structure and Reactivity*, 4th Ed, Harper Collins College Publishers, New York, 1993.
6. C. Elschenbroich, *Organometallics*, 3rd edition, Wiley-VCH Verlag GmbH, Weinheim, 2006.

MS1001D PROFESSIONAL COMMUNICATION

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 Lecture hours)

Role and importance of verbal communication, Everyday active vocabulary, Common words used in transitions, enhancing vocabulary, affixes and changes in pronunciation and grammatical functions, words often confused in pronunciation and usage. Passage comprehension- skimming, scanning techniques, note making, note taking and summarizing. Deciphering meaning from contexts. Two types of meaning- literal and contextual. Constructive criticism of speeches and explanations.

Module 2: (15 Lecture hours)

Fundamental grammar, Simple structures, passivizing the active sentences, reported speech, the judicious use of tenses and moods of verbs, forming questions and conversion from questions to statements and vice versa, forming open –ended and close- ended questions. Words and style used for formal and informal communication. Practice converting informal language to formal, the diction and the style of writing. Dealing with the nuances of ambiguous constructions in language. Learning authoritative writing skills, polite writing and good netiquette. Writing for internships and scholarships.

Module 3: (12 Lecture hours)

Kinesics, Proxemics, Haptics, and other areas of non-verbal communication, fighting communication barriers, positive grooming and activities on the same. Different types of interviews, and presentation- oral, poster, ppt. Organizing ideas for group discussions, the difference between GD and debates.

References:

1. Duck, Steve and David T. Macmahan. *Communication in Everyday Life*. 3rd Ed. Sage, 2017.
2. Quintanilla, Kelly M. and Shawn T. Wahl. *Business and Professional Communication*. Sage, 2016.
3. Gamble, Kawl Teri and Michael W. Gamble. *The Public Speaking Playbook*. Sage, 2015.
4. Tebeaux, Elizabeth and Sam Dragga. *The Essentials of Technical Communication*, 3rd Ed. OUP, 2015
5. Raman, Meenakshi and Sangeetha Sharma. *Technical Communication: Principles and Practice*, OUP, 2015
6. MacLennan, Jennifer. *Readings for Technical Communication*. OUP, 2007.

ZZ1001D ENGINEERING MECHANICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: Basic Concepts (13 Lecture hours)

Introduction: 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.

Module 2: Statics (13 Lecture hours)

Equations of 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.

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.

Module 3: Dynamics (13 Lecture hours)

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.

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.

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

ZZ1002D ENGINEERING GRAPHICS

Pre-requisites: Nil

L	T	P	C
2	0	2	3

Total hours: 52

Module 1: (15 Lecture hours)
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; orthographic projection of points on principal, profile, and auxiliary planes.

Module 2: (17 Lecture hours)
Orthographic projection of straight line in simple and oblique positions; application of orthographic projection of line; orthographic projection of planes in simple and oblique position on principal and profile planes; orthographic projection of lines and planes on auxiliary planes.

Module 3: (20 Lecture hours)
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; orthographic projection of solids in section; development of surfaces of solids; method of isometric projection.

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.

ZZ1003D BASIC ELECTRICAL SCIENCES

Pre-requisites: None

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (11 Lecture hours)

Analysis of Resistive Circuits: v-i relationship for Independent Voltage and Current Sources Solution of resistive circuits with independent sources- Node Voltage and Mesh Current Analysis, Nodal Conductance Matrix and Mesh Resistance Matrix and symmetry properties of these matrices Source Transformation and Star-Delta / Delta-Star Conversions to reduce resistive networks Circuit Theorems - SuperpositionTheorem, Thevenin's Theorem, Norton's Theorem and Maximum Power Transfer Theorem. Magnetic Circuits: MMF, Magnetic Flux, Reluctance, Energy stored in a Magnetic Field, Solution of Magnetic Circuits. Two Terminal Element Relationships: Inductance - Faraday's Law of Electromagnetic Induction, Lenz's Law, Self and Mutual Inductance, Inductances in Series and Parallel, Mutual Flux and Leakage Flux, Coefficient of Coupling, Dot Convention, Cumulative and Differential Connection of Coupled Coils.Capacitance – Electrostatics, Capacitance, Parallel Plate Capacitor, Capacitors in series and parallel, Energy stored in Electrostatic Field, v-i relationship for Inductance and Capacitance

Module 2: (9 Lecture hours)

Single Phase AC Circuits: Alternating Quantities - Average Value, Effective Value, Form and Peak factors for square, triangle, trapezoidal and sinusoidal waveforms. Phasor representation of sinusoidal quantities - phase difference, Addition and subtraction of sinusoids, Symbolic Representation: Cartesian, Polar and Exponential forms. Analysis of a.c circuits - R, RL, RC, RLC circuits using phasor concept, Concept of impedance, admittance, conductance and susceptance. Power in single phase circuits - instantaneous power, average power, active power, reactive power, apparent power, power factor, complex power, solution of series, parallel and series parallel a.c circuits.

Module 3: (11 Lecture hours)

Sensors and Transducers: principles of piezoelectric, photoelectric, thermoelectric transducers, thermistors, strain gauge, LVDT, etc, Measurement of temperature, pressure, velocity, flow, pH, liquid level, etc. Basics of Signal Amplification: (Explanation based on two port models is only envisaged) – voltage gain, current gain and power gain, amplifier saturation, types of amplifiers (voltage, current, transconductance and transresistance amplifiers) and relationship between these amplifier models, frequency response of amplifiers, single time constant networks. Operational amplifier basics: Ideal op-amp, inverting, noninverting, summing and difference amplifiers, integrator, differentiator

Module 4: (8 Lecture hours)

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) - MUX-based implementation of combinatorial circuits , Sequential circuits: SR,JK, T and D filpflops, counters and registers using D flip flops, Basics of data converters (at least one ADC and DAC).

References:

1. J.W. Nilsson and S.A. Riedel, *Electric Circuits*, 8th ed., Pearson, 2002
2. K.S. Suresh Kumar, *Electric Circuits & Networks*, Pearson Education, 2009
3. C. A. Desoer and E. S. Kuh, *Basic Circuit Theory*, McGraw Hill, 2009
4. J. A. Edminister, *Electric Circuit Theory*, Schaum's Outline series: 6th ed., McGraw Hill, 2014
5. A. D. Helfrick and W. D. Cooper, *Modern Electronic Instrumentation and Measurement Techniques*, Prentice Hall of India, 2003
6. A. S. Sedra and K. C. Smith, *Microelectronics*, 6thed.,Oxford University Press, 2013

C. H. Roth and L. L. Kinney, *Fundamentals of Logic Design*,7thed., Cengage Learning,2014

ZZ1004D COMPUTER PROGRAMMING

Pre-requisites: Nil.

L	T	P	C
2	0	0	2

Total hours: 26

Module 1: (Lecture 10 hours)
Data Types, Operators and Expressions: Variables and constants - declarations - arithmetic and logical operators – Assignment operator – Input/Output.
Control Flow: Statements and blocks – if-else, switch, while, for and do-while statements – break and continue – goto and labels.

Module 2: (Lecture 08 hours)
Functions and Program structure: Basics of functions, Parameter passing – scope rules – recursion.

Module 3: (Lecture 08 hours)
Aggregate data types: Single and multidimensional arrays, structures and unions – Pointers to arrays and structures – passing arrays and pointers as arguments to functions.

References:

1. B.S. Gottfried, *Programming with C (Schaum's Outline Series)*, 2nd ed. McGraw-Hill, 1996.
2. B. W. Kernighan and D. M. Ritchie, *The C Programming Language*, 2nd ed. Prentice Hall, 1988.
3. W. Kernighan, *The Practice of Programming*, Addison-Wesley, 1999.

BT1001D INTRODUCTION TO LIFE SCIENCE

Pre-requisites: None

L	T	P	C
2	0	0	2

Total hours: 26

Module 1: (09 Lecture hours)
Origin and evolution of life, Biogenesis and Louis Pasteur, Oparin-Haldane hypothesis, Darwin's view on natural selection. unity and diversity of life, Chemistry of life, introduction to structure and function of the biological macromolecules like carbohydrates, proteins, lipids, DNA and RNA

Module 2: (09 Lecture hours)
Prokaryotic and eukaryotic cells, structure and organization of cells, intracellular compartmentalization, functions of various organelles. Extracellular components and cell-cell communication, overview of Mitosis and Meiosis, basic concepts in energy transformation and photosynthesis.

Module 3: (08 Lecture hours)
Principles of Mendelian inheritance and chromosomal basis of heredity, linked genes, genetic disorder. Ecosystems and restoration ecology, energy flow, chemical and nutrient cycling, primary production in ecosystems, conservation of biodiversity.

References:

1. L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, and J. B. Reece, *Campbell Biology*, 11th ed. Pearson, 2017.
2. D. L. Nelson and M. M. Cox, *Lehninger Principles of Biochemistry*, 4th ed. W H Freeman and Company, 2005.
3. C. Starr, C. Evers, L. Starr, *Biochemistry, Biology: Concepts and Applications*, 10th ed. 2017.
4. J. M. Berg, J. L. Tymoczko, and L. Stryer, *Biochemistry*, 6th ed. W H Freeman and Company, 2007.
5. H. Lodish, A. Berk, C. A. Kaiser, and M. Krieger, *Molecular Cell Biology*, 6th ed. W. H. Freeman, 2007.

PH1091D PHYSICS LAB

Pre-requisites: Nil

L	T	P	C
0	0	2	1

Total hours: 26

LIST OF EXPERIMENTS

1. Magnetic Hysteresis loss - Using CRO
2. Band gap using four probe method
3. Hall effect- determination of carrier density, Hall coefficient and mobility
4. Solar cell characteristics
5. Double refraction – measurement of principle refractive indices.
6. Measurement of N.A & Attenuation
7. Measurement of e/m of electron – Thomson's experiment
8. Determination of Planck's constant
9. Measurement of electron charge – Millikan oil drop experiment
10. Determination of magnetic field along the axis of the coil
11. Newton's rings
12. Laurent's Half shade polarimeter –determination of specific rotatory power
13. Study of P-N junction
14. Study of voltage-current characteristics of a Zener diode.
15. Laser – measurement of angle of divergence & determination of λ using grating
16. Measurement of magnetic susceptibility- Quincke's Method / Gouy's balance.
17. Mapping of magnetic field
18. Temperature measurement by using thermocouple

NOTE: Any 8 experiments have to be done.

References:

1. A.C. Melissinos, J. Napolitano, Experiments in Modern Physics, Academic Press (2003)
2. Avadhanulu, Dani and Pokley, Experiments in Engineering physics, S. Chand & Company ltd (2002).
3. S.L. Gupta and V. Kumar, Practical physics, Pragathi Prakash (2005)

CY1094D CHEMISTRY LAB

Pre-requisites: Nil

L	T	P	C
0	0	2	1

Total hours: 26

LIST OF EXPERIMENTS

1. Determination of specific rotation by polarimetry
2. Potentiometric titrations
3. Estimation of ions using complexometry
4. Determination of strength of an acid using pH meter
5. Analysis of organic and inorganic compounds
6. Conductometric titrations using acid or mixture of acids
7. Separation of compounds using chromatography
8. Colorimetric estimations
9. Determine the eutectic temperature and composition of a solid two component system
10. Synthesis of organic/inorganic compounds and their characterizations
11. Determination of molecular weight of polymers

NOTE: Selected experiments from the above list will be conducted

References:

1. G. H. Jeffery, J. Bassett, J. Mendham and R.C. Denny, *Vogel's Text Book of Quantitative Chemical Analysis*, Longmann Scientific and Technical, John Wiley, New York,1989.
2. A. I. Vogel, *Elementary Practical Organic Chemistry – Small Scale Preparations*, Pearson India, New Delhi, 2011.
3. A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hannaford and P. W. G. Smith, *Vogel's Text Book of Practical Organic Chemistr*y, Longman and Scientific Technical, New York, 1989.

ZZ1091D WORKSHOP I

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Civil Engineering Workshop: (24 Lecture hours)

1. Introduction to Surveying – Linear measurements – Hands on session on Setting out of a small residential building.
2. Introduction to Levelling – Hands on sessions using Dumpy level – Levelling exercise.
3. Introduction to Total Station – Hands on sessions - small exercises.
4. Tests on cement and aggregates: Demonstration of standard consistency, initial and final setting time of cement - Hands on sessions - Compressive strength test on cement mortar cubes and sieve analysis for coarse and fine aggregates.
5. Tests on hardened concrete, brick, timber and steel: Demonstrations on hardness tests (Rockwell hardness), impact tests (Charpy and Izod) on steel specimens-demonstration on properties of timber – Hands on sessions - Compression test on concrete cubes, bricks and tension test on mild steel specimen.
6. Masonry: Hands on sessions - English bond, Flemish bond – wall junction – one brick – one and a half brick - Arch construction.
7. Water supply and sanitation: Study of water supply pipe fittings – tap connections – sanitary fittings
8. Various tests on Driver characteristics – Visual acuity and colour blindness, peripheral vision, depth perception, driver reaction time.

Electrical Engineering Workshop: (15 Lecture hours)

1. (a) Familiarization of wiring tools, lighting and wiring accessories, various types of wiring systems.
   (b) Wiring of one lamp controlled by one switch.
2. (a) Study of Electric shock phenomenon, precautions, preventions, Earthing.
   (b) Wiring of one lamp controlled by two SPDT Switches and one 3 pin plug socket independently.
3. (a) Familiarization of various types of Fuses, MCBs, ELCBs, etc.
   (b) Wiring of fluorescent lamp controlled by one switch with ELCB & MCB.
4. (a) Study of estimation and costing of wiring.
   (b) Wiring, control and maintenance of domestic appliances like Mixer machine, Electric Iron, fan, motor, etc.

References:

1. T.P. Kanetkar, S.V. Kulkarni, *Surveying and Levelling - Part1*, Pune Vidyarthi Griha Prakashan, Pune, 1994.
2. B.C. Punmia, *Building Construction*, Laxmi Publications, New Delhi1999.
3. Satheesh Gopi, R. Sathikumar, N. Madh, *Advnaced Surveying*, Pearson Education, 2007.
4. M.S. Shetty, *Concrete Technology*, S. Chand & Company, New Delhi, 2005.
5. K. B. Raina & S. K. Bhattacharya, *Electrical Design Estimating and costing*, New Age International Publishers, New Delhi, 2005.
6. Khanna, S. K., and Justo, C. E. G., *Highway Engineering*, Nemchand and Bros, Roorkee, 2001.
7. Uppal S. L., *Electrical Wiring & Estimating*, Khanna Publishers---5th edition, 2003.
   John H. Watt, *Terrell Croft American Electricians' Handbook: A Reference Book for the Practical Electrical Man*, 9th ed. McGraw-Hill, 2002.

ZZ1092D WORKSHOP II

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Mechanical Engineering Workshop (24 Lecture hours)

The course is intended to expose the student to various manufacturing processes through hands on training in different sections of Central Workshop. During the course, the student learns the properties and selection of different materials and acquires the skill in using various tools and measuring devices.

1. Carpentry: Study of tools and joints – plaining, chiseling, marking and sawing practice, one typical joint- Tee halving/Mortise and Tenon/ Dovetail
2. Fitting: Study of tools- chipping, filing, cutting, drilling, tapping, about male and female joints, stepped joints. Edge preparation for single V joint.
3. Welding: Study of arc and gas welding, accessories, joint preparation. Welding of a single V joint
4. Smithy: Study of tools. Forging of square or hexagonal prism/chisel/bolt
5. Foundry: Study of tools, sand preparation. Moulding practice using the given pattern.
6. Sheet Metal: Study of tools, selection of different gauge sheets, types of joints. Fabrication of a tray or a funnel
7. Machine Shop: Study of the basic lathe operations. Simple step turning exercise.

Electronics Engineering Workshop (15 Lecture hours)

1. (a) Familiarization of electronic components, colour code, multimeters.
   (b) Bread board assembling-Common emitter amplifier.
2. (a) Study of soldering components, solders, tools, heat sink.
   (b) Bread board assembling-phase shift oscillator.
3. (a) Soldering practice-Common emitter amplifier.
   (b) Soldering practice-Inverting amplifier circuit.
4. (a) Study of estimation and costing of soldering PCB, 3 phase connections.
   (b) PCB wiring and fault Identification of appliances like Electronic Ballast, fan regulator, inverter, UPS, etc.

References:

1. W. A. J. Chapman, Workshop Technology - Parts 1 & 2, 4th ed. New Delhi, India, CBS Publishers & Distributors Pvt. Ltd., 2007.
2. Welding Handbook. 9th ed. Miami, American Welding Society, 2001.
3. J. Anderson, Shop Theory, New Delhi, India, Tata McGraw Hill, 2002.
4. J. H. Douglass, Wood Working with Machines, Illinois, McKnight & McKnight Pub. Co., 1995.
5. W.A. Tuplin, Modern Engineering Workshop Practice, Odhams Press, 1996.
6. P. L. Jain, Principles of Foundry Technology, 5th ed. New Delhi, India, Tata McGraw Hill, 2009.
7. John H. Watt, Terrell Croft, American Electricians' Handbook: A Reference Book for the Practical Electrical Man, 9th ed. McGraw-Hill, 2002.
8. G. Randy Slone, Tab Electronics Guide to Understanding Electricity and Electronics, 2nd ed. McGraw-Hill, 2000.
9. Jerry C Whitaker, The Resource Handbook of Electronics, CRC Press-2001.

ZZ1093D PHYSICAL EDUCATION

Pre-requisites: Nil

L	T	P	C
1	0	1	1

UNIT – I: Introduction, definition, aims & objectives of Physical Education. Health, Physical fitness and wellness. Importance, scope and relevance of Physical Education in NITC curriculum.
UNIT – II: Physical fitness and components. Health related Physical fitness and components. Benefits of exercise – physical and physiological.
UNIT – III: Physical exercise and its principles. Activities for developing physical fitness – walking, jogging, running, weight training, stretching, yogasanas. Athletic injuries and their management. Nutritional balance.
UNIT – IV: Motivation and its importance in sports. Stress, anxiety, tension, aggression in sports. Personality, self-confidence and performance. Team cohesion and leadership in sports.
UNIT – V: Lifestyle diseases and its management, Diabetes and Obesity, Hypertension, Osteoporosis, Coronary heart diseases and cholesterol. Back pain, Postural deformities and their remedies.
UNIT – VI: Olympic Values Education. Event & Crisis management.

References:

1. A. M. Najeeb, M. Atul, D. Sumesh, and E. Akhilesh, *Fitness Capsule for university curriculum*. 2015.

ZZ1094D VALUE EDUCATION

Pre-requisites: Nil

L	T	P	C
1	0	1	1

Unit I: (3 Lecture hours): Social Justice Definition –need-parameters of social justice –factors responsible for social injustice –caste and gender –contributions of social reformers.

Unit II: (5 hours): Human Rights and Marginalized People Concept of Human Rights-Principles of human rights-human rights and Indian Constitution-Rights of Women and children-violence against women –Rights of marginalized People-like women, children, dalits, minorities, physically challenged etc.

Unit III: (5 Lecture hours): Social Issues and Communal Harmony Social issues–causes and magnitudealcoholism, drug addiction, poverty, unemployment etc.-communal harmony-concept-religion and its place in public in public domain-separation of religion from politics-secularism role of civil society.

Unit IV: (5 Lecture hours): Media Education and Globalized World Scenario Mass media-functions characteristics- need and purpose of media literacy-effects and influence –youth and children-media power-socio cultural and political consequences mass mediated culture-consumerist culture-Globalization-new media –prospects and challenges-Environmental ethics

Unit V: (2 Lecture hours): Values and Ethics Personal values –family values-social values-cultural values professional values-and overall ethics-duties and responsibilities

Project: 10 hours

References:

1. Sharma, B. K. (2010), 'Human Rights Covenants and Indian Law', PHI Learning Pvt. Ltd.
2. Law Commission of India, (1971), 'Indian Penal code', (http://lawcommissionofindia.nic.in/1-50/report42.pdf), accessed on February 14, 2018.
3. Srivastava, S. S. (2017), 'Central Law Agency's Indian Penal Code along with General Principles (IPC)', Central Law Agency.
4. 'Gandhiji on Communal Harmony', (2003), Mani Bhavan Gandhi Sangrahalaya', Mumbai.
5. 'Social Impact of Drug Abuse', UNDCP, ((https://www.unodc.org/pdf/technical_series_1995-03-01_1.pdf, accessed on February 14, 2018).
6. Bryfonski, D. (2012), 'The Global Impact of Social Media', Green Heaven Publications.
7. Schmidtz, D. & Willott, E. (2012), 'Environmental Ethics: What Really Matters, What Really Works', Oxford University Press.
8. Ranganathanda, S. (1987), 'Eternal Values for a Changing Society: Education for human excellence', BharatiyaVidyaBhavan.
9. Rokeach, M. (1979), 'Understanding human values: Individual and Societal', The New Free Press

ZZ1095D NSS

L	T	P	C
0	0	3	1

NSS activities have been divided in two major groups. These are Regular NSS Activities and Special Camping programme.

(a) Regular NSS Activity: NSS volunteers undertake various activities in adopted villages and slums for community service. The NSS units organise the regular activities as detailed below:

i) Orientation of NSS volunteers: To get the NSS volunteers acquainted with the basics of NSS programmes, for their orientation through lectures, discussions, field visits, audio-visuals etc.

ii) Campus Work: The NSS volunteers may be involved in the projects undertaken for the benefit of the institution and students concerned. Such projects cover maintenance of public properties, tree plantation, waste management and Swach Bharat activities, conservation of water and energy sources, social audits, awareness programmes on drug-abuse, AIDS, population education, and other projects

iii) Community service will be in adopted villages/urban slums independently or in collaboration with others in this field.

iv) Institutional work: The students may be placed with selected voluntary organisations working for the welfare of women, children, aged and disabled outside the campus.

v) Rural Project: The rural projects generally include the working of NSS volunteers in adopted villages for e-governance and digital literacy, watershed management and wasteland development, rainwater harvesting, agricultural operations, health, nutrition, hygiene, sanitation, mother and child care, gender equality sensitization programmes, family life education, gender justice, development of rural cooperatives, savings drives, construction of rural roads, campaign against social evils etc.

vi) Urban Projects: In addition to rural projects other include adult education, welfare of slum dwellers, work in hospitals, orphanages, destitute home, environment enrichment, population education, drug, AIDS awareness, and income generation,

vii) National Days and Celebrations: The National Service Scheme programmes also include the celebration of National days. The purpose of such a provision is to celebrate such occasions in a befitting manner,

viii) Blood Donation Activities,

ix) Campus farming activities,

x) Activities for social inclusion such as organizing programmes for differently – abled children.

Students shall volunteer and contribute to the activities of the National Service Scheme for a minimum duration of 45 hours for the award of credit.

b) Special Camping Programme: Under this, camps of 7 days’ duration are organised during vacations with some specific projects by involving local communities. 50% NSS volunteers are expected to participate in these camps.

SEMESTER III

MA2001D MATHEMATICS III

Pre-requisites: MA 1001

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L	T	P	C
3	1	0	3

Total Hours: 39

Module 1: (15 Lecture hours)
Probability distributions, Random variables, Expectation of a function of a random variable, Mean, Variance and Moment generating function of a probability distribution, Chebyshev's theorem, Binomial distribution, Poisson distribution, Geometric distribution, Hyper- geometric distribution, Normal Distribution, Uniform distribution, Gamma distribution, Beta distribution and Weibull distribution. Transformation of a random variable, Probability distribution of a function of a random variable, Jointly distributed random variables, Marginal and conditional distributions, Bi-variate Normal distribution, Joint probability distribution of functions of random variables**.**

Module 2: (14 Lecture hours)
Population and samples, The sampling distribution of the mean (σ known and σ unknown), Sampling distribution of the variance, Point estimation, Maximum likelihood estimation, Method of moments, Interval estimation, Point estimation and interval estimation of mean and variance. Tests of hypothesis, Hypothesis tests concerning one mean and two means. Hypothesis tests concerning one variance and two variances, Estimation of proportions, Hypothesis tests concerning one proportion and several proportions, Analysis of contingency tables, Chi – square test for goodness of fit.

Module 3: (10 Lecture hours)
Analysis of variance, General principles, Completely randomized designs, Randomized block design. Curve fitting, Method of least squares, Estimation of simple regression models and hypotheses concerning regression coefficients, Correlation coefficient- Estimation of correlation coefficient, Hypothesis concerning correlation coefficient. Estimation of curvilinear regression models.

References:

1. R. A. Johnson, *Miller and Freund's Probability and Statistics for Engineers*, 8th ed. PHI, 2011.
2. W. W. Hines, D. C. Montgomery, D. M. Goldsman, and C. M. Borror, *Probability and Statistics in Engineering*, 4th ed. John Wiley & Sons, 2003
3. S. M. Ross, *Introduction to Probability and statistics for Engineers and Scientists*, 5th ed.Academic Press (Elsevier), 2014.

MT2001D STRUCTURE OF MATERIALS

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)

Introduction to materials- Classification- Crystallography– Solid Solutions-Hume Rothery Rules-Crystal Imperfections, Point Defects- Line Defects-Surface Defects-Bulk Defects-Critical nucleus size and Critical Free energy- Mechanism of Crystallisation- Nucleation-Homogeneous and Heterogenous Nucleation- Growth - Single crystal -Polycrystalline Materials - Basic principles of solidification of metals and alloys. Growth of crystals- Planar growth – dendritic growth – Solidification time - Cooling curves - Non-crystalline solids- Glass Transition Temperature.

Module 2: (13 Lecture hours)

Phase Diagrams: Phase Rule –Unary System- Binary Phase diagrams- Isomorphous systems-Congruent phase diagrams - Free energy Composition curves- Construction -Microstructural changes during cooling- Tie Line- Lever Rule- Eutectic , Peritectic, Eutectoid and Peritectoid reactions-Typical Phase diagrams –Fe-Fe_3C system- Cu-Zn System – Pb-Sn system- Ag-Pt system-Iron-Iron carbide Equilibrium Diagram-perform phase equilibrium calculation and construct phase diagram.

Module 3: (13 Lecture hours)

Introduction to Nanomaterials: Classification of nanostructures, nanoscale architecture, fundamental structure, chemistry, property relationships in nanomaterials and nanomaterial systems, giant molecular solids. Nano clusters, Bulk Nanomaterials, Nanocrystalline materials, nanocomposities. Nanoscale x-ray - electron and neutron diffraction techniques, microscopic techniques.

References:

1. William D. Callister, Jr., "*Materials Science and Engineering an Introduction*", 2/e Edition, John Wiley & Sons, Inc., 2007.
2. V. Raghavan, *"Materials Science and Engineering*", Prentice –Hall of India Pvt. Ltd., 2007.
3. Callister, William D. Jr., *Fundamentals of Materials Science and Engineering: An Integrated Approach* 2nd Ed., John Wiley and Sons, 2003.
4. Robert K, Ian H, Mark G, *Nanoscale Science and Technology,* John Wiley & sons Ltd.,2005.

MT2002D PHYSICS AND CHEMISTRY OF MATERIALS

L	T	P	C
4	0	0	4

Pre-requisites: Nil

Total hours: 52

Module 1: (10 Lecture hours)
Schrödinger equation and the Statistical interpretation, Uncertainty principle, Time dependent Schrodinger equation, Stationary state, Infinite and Finite Square Well, Harmonic Oscillator, Applications to a free particle, Particle in a box, Potential barriers, Double well and multiple well problem, Exciton, Quantum wells and quantum wires, Quantum-size-effect

Module 2: (17 Lecture hours)
Physical, Mechanical, Chemical, Electrical, Thermal, Optical, Magnetic properties of materials, Charge Carriers, DC and AC current conductivity measurement, Size-induced metal-insulator-transition, Chemical physics of atomic and molecular clusters, Phonons, Coulomb Blockade, Single electron tunnelling, Tunnelling transport, Surface waves, Plasmons, Surface phonon-Polariton, Nano-scale magnets, Transparent magnetic materials and Ultrahigh-density magnetic recording materials, magneto resistance, transistors, quantum wells and superlattices, superconductivity, BCS theory, Josephson junctions and tunnelling, SQUID, High temperature superconductors, applications, Fermi energy, Fermi surface, Fermi temperature.

Module 3: (13 Lecture hours)
Solids, close packing in solids, Hexagonal and cubic close packing, Crystal structures, ionic and covalent solids, structure types, spinel structure, perovskite, quasi crystals, amorphous materials, Order and disorder in solids, Defects and impurities, Deep level defects in nanostructures, Surface defects: Dangling bonds, Surface energy, electrostatic stabilization, zeta potential, Surface charge density, van der Waals attraction potential, Steric stabilization.

Module 4 (12 Lecture hours)
Classes of materials- inorganic and organic materials, surfaces, interfaces, Nanomaterials, thin films, and multilayers, porous materials, Covalent organic frameworks, porous organic polymers and related organic porous materials, soft materials- effects of synthesis on the structure and properties of various materials. Chemical and catalytic aspects of materials, catalytic action, kinetic expression, surface science approach to Catalytic Chemistry, fine tuning of catalysts, electrocatalysts, and photocatalytic materials.

References:

1. David J. Griffiths, Introduction to Quantum Mechanics, Pearson, 2016
2. Charles Kittel, Introduction to Solid State Physics, Wiley , 2012
3. Prathap Haridoss, Physics of Materials: Essential Concepts of Solid-State Physics, Wiley, 2015.
4. Robert J. Naumann, Introduction to the Physics and Chemistry of Materials, CRC Press, 2008.
5. K.W. Kolasinski, “Surface Science: Foundations of Catalysis and Nanoscience”, Wiley, 2002.
6. Joel I. Gersten, “The Physics and Chemistry of Materials”, Wiley, 2001.
7. S. Yang and P. Shen: “Physics and Chemistry of Nanostructured Materials”, Taylor & Francis, 2000.
8. Gabor A. Somorjai, Yimin Li, Introduction to Surface Chemistry and Catalysis, 2nd Edition, Wiley, 2010

CE2001D MECHANICS OF SOLIDS

Pre-requisites: ZZ1001D Engineering Mechanics

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1 (13 hours)

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. 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

Module 2 (14 hours)

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. Concept of shear flow and shear center. Analysis of stress and strain : Stress on inclined planes for axial and biaxial stress fields - principal stresses - Mohr’s circle of stress - principal stress problem as an eigenvalue problem - principal strains - strain rosette -thin cylinders (as an example to biaxial stresses)

Module 3 (12 hours)

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.

References:

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

ME2004D FLUID MECHANICS AND FLUID MACHINERY

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (9 hours)
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.

Module 2: (10 hours)
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; Bernoulli's equation; application to flow through pipes; head loss in pipes, Darcy-Weisbach equation; pipes in series and parallel.

Module 3: (20 hours)
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.
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.

References:

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

ME2013D THERMODYNAMICS

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (17 hours)

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; 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; pure substance: phases, phase change processes of pure substances, property diagrams for phase change processes, property tables; ideal-gas: internal energy, enthalpy, specific heats of ideal gases, thermodynamic processes executed by ideal gases, compressibility factor, different equations of state.

Module 2: (12 hours)

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, 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.

Module 3: (10 hours)

Exergy: reversible work and irreversibility, exergy of fixed mass and flow stream, exergy 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.

References:

1. Y. A. Cengel and M. A. Boles, *Thermodynamics: An Engineering Approach*, 8th ed. Mc Graw- Hill, 2015.
2. R. E. Sonntag and C. Borgnakke, *Fundamentals of Thermodynamics*, 9th ed., John Wiley & Sons, 2016.
3. M. J. Moran and H. N. Shapiro, *Fundamentals of Engineering Thermodynamics*, 8th ed. John Wiley & Sons, 2017.
4. P. K. Nag, *Engineering Thermodynamics*, 5th ed. Tata Mc Graw Hill, 2013.

CE2097D MATERIALS TESTING LAB

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

LIST OF EXPERIMENTS

1. Tension test on different types of materials
2. Compression test on different types of materials
3. Shear Test on MS rod
4. Torsion test on MS Specimen
5. Hardness tests on different types of materials
6. Impact tests on different types of materials
7. Bending test on steel beams
8. Tear strength measurement of different types of material
9. Fatigue testing
10. Study of extensometers and strain gauges

References:

1. Timoshenko, S. P., Strength of Materials, CBS publishers, 1988.
2. Gere, J. M., Mechanics of Materials, Cengage Learning , 2019.
3. Brown, R.P., Hand Book of Polymer Testing, Smithers Rapra Press,1997
4. Relevant BIS, ASTM Standards.

SEMESTER IV

MA2002D MATHEMATICS IV

Pre-requisites: 1. MA1001D Mathematics I
2. MA1002D Mathematics II

L	T	P	C
3	1	0	3

Total hours: 39

Module 1: Series Solutions and Special Functions (11 Lecture hours)
Power series solutions of differential equations, Theory of power series method, Legendre Equation, Legendre Polynomials, Frobenius Method, Bessel's Equation, Bessel functions, Bessel functions of the second kind, Sturm-Liouville's Problems, Orthogonal eigen function expansions.

Module 2: Partial differential Equations (10 Lecture hours)
Basic Concepts, Cauchy's problem for first order equations, Linear Equations of the first order, Nonlinear Partial Differential Equations of the first order, Charpit's Method, Special Types of first order equations, Classification of second order partial differential equations, Modelling: Vibrating String, Wave equation, Separation of variables, Use of Fourier Series, D'Alembert's Solution of the wave equation, Heat equation: Solution by Fourier series, Heat equation: solution by Fourier Integrals and transforms, Laplace equation, Solution of a Partial Differential Equations by Laplace transforms.

Module 3: Complex Numbers and Functions (9 Lecture hours)
Complex functions, Derivative , Analytic function, Cauchy- Reimann equations, Laplace's equation, Geometry of Analytic functions: Conformal mapping, Linear fractional Transformations, Schwarz- Christoffel transformation, Transformation by other functions.

Module 4: Complex Integration (9 Lecture hours)
Line integral in the Complex plane, Cauchy's Integral Theorem, Cauchy's Integral formula, Derivatives of analytic functions. Power series, Functions given by power series, Taylor series and Maclaurin's series. Laurent's series, Singularities and Zeros, Residue integration method, Evaluation of real Integrals.

References:

1. E. Kreyszig, *Advanced Engineering Mathematics*, 8th ed. John Wiley & Sons, 1999.
2. I. N. Sneddon, *Elements of Partial Differential Equations*. Dover Publications, 2006.
3. C. R. Wylie and L. C. Barret, *Advanced Engineering Mathematics*, 6th ed. McGraw Hill, 1995.
4. D. W. Trim, *Applied Partial Differential Equations*. PWS – KENT publishing company, 1994.

CH2006D HEAT TRANSFER

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1 (13 Lecture hours)

Importance of heat transfer in chemical engineering operations, modes of heat transfer, Fourier's law of heat conduction, steady-state conduction through walls (single and multi-layers), heat flow through a cylinder and sphere, heat transfer in extended surfaces, unsteady state heat conduction.

Module 2 (14 Lecture hours)

Concepts of heat transfer by convection, individual heat transfer coefficient, calculation of overall heat transfer coefficients from individual coefficients, fouling factors, analogies between transfer of momentum and heat – Reynolds analogy, Prandtl and Colburn analogy, dimensional analysis in heat transfer, heat transfer coefficient for flow through pipe, non-circular conduit, flow past flat plate, flow through packed beds, heat transfer by natural convection, Heat transfer to fluids with phase change, heat transfer from condensing vapours, drop-wise and film type condensation, Nusselt equations for film type condensation, condensation for superheated vapours, heat transfer to boiling liquids, boiling of a saturated liquid, maximum flux and critical temperature drop, minimum flux and film boiling, sub-cooled boiling.

Module 3 (12 Lecture hours)

Evaporation: theory of evaporation, single effect and multiple effect evaporation, design calculation for single and multiple effect evaporators. Heat exchangers- counter-current and parallel flows, energy balances, overall heat transfer coefficient, log-mean temperature difference, heat transfer equipment, single pass and multi-pass heat exchangers, plate heat exchangers, design of heat exchangers. Radiation heat transfer-emissive power, blackbody radiation, emissivity, laws of radiation, radiation between surfaces.

Reference

1. McCabe, W.L. and Smith, J.C., Unit Operation of Chemical Engineering, 7thEdn., McGraw Hill, New York, 2014.
2. Holman, J.P., Heat Transfer, 10thEdn. McGraw Hill, 2017.
3. Kern, D.Q., Process Heat Transfer, McGraw Hill Co. Inc., 2001.
4. Coulson, J.M. and Richardson, J.F., Chemical Engineering, Vol 1, 6thEdn., Butterworth-Heinemann, 1999.
5. Cengel, Y. A, Ghajar, A. J, and Kanoglu, M., Heat and Mass Transfer Fundamentals and Applications, 5th Edn, McGraw Hill Education, 2017

MT2003D CERAMICS AND GLASSES

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)

Definition & scope of ceramics and ceramic materials, Classification of ceramic materials – conventional and advanced, Areas of applications, Ceramic crystal structures - Corrundum, Wurtzite, Zinc blende, Rocksalt Perovskite and Spinel structure etc., Raw material for ceramics: The range and scope of various natural minerals and inorganic nonmetallic materials to be used as raw materials for ceramic products, General ideas about the characterization of natural and synthetic materials. Ceramic Phase Equilibrium Diagrams: Techniques of determining phase diagrams, One-two and three components phase diagrams, Examples, Phase composition versus temperature, Non-equilibrium phases. Typical ceramic systems like zirconia - calcium oxide / magnesium oxide / ceria , calcia - silica , magnesia - silica , soda - lime - silica , lime - alumina - silica etc.

Module 2: (13 Lecture hours)

Cement & Concrete : Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC, Compound formation, setting and hardening, Tests of cement and concrete, Ceramic Coatings : Types of glazes and enamels, Elementary ideas on compositions, Process of enamelling & glazing and their properties, Classification of Refractories: Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application. Whitewares : Classification and type of Whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas.

Module 3: (13 Lecture hours)

Glass: Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses. Application of glasses, Structure of Glass, XRD, SAXS & SANS and other methods of determining glass structure. Structural models of glass, Reaction mechanisms, Ion exchange & network breakdown processes. Glass durability controlling factors, Improvement of durability. Optical properties of glasses- Refractive index, Molar volume & Ionic refractivity, Birefringence. Ligand field theory and ultraviolet – visible absorption, Colloidal colours, Solarisation, Infra-red absorption. Photosensitive/Photo chromic glasses, Optical applications.

References:

1. Norton, Frederick Harwood. *Elements of ceramics*. Vol. 2. Addison-Wesley Press, 1952.
2. Barsoum, Michel, and M. W. Barsoum. *Fundamentals of ceramics*. CRC press, 2002.
3. Kingery, W. David, Harvey Kent Bowen, and Donald Robert Uhlmann. *Introduction to ceramics*. Vol. 183. New York: Wiley, 1976.
4. Worrall, William E. *Ceramic Raw Materials: Institute of Ceramics Textbook Series*. Elsevier, 2013.
5. Ryan, William. *Properties of ceramic raw materials*. Elsevier, 2013.
6. Kreidl, N. J. *Glasses and the Vitreous State*, J. Zarzycki.1992.
7. Paul, Amal. *Chemistry of glasses*. Springer Science & Business Media, 1989.
8. Bansal, Narottam P., and Robert H. Doremus. *Handbook of glass properties*. Elsevier, 2013.
9. Van Vlack, Lawrence H. *Physical ceramics for engineers*. Addison Wesley Publishing Company, 1964.

MT2004D FUNDAMENTALS OF NANOMATERIALS

Pre-requisites: Nil
.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (16 Lecture hours)
Quantum Structures, Quantum Confinement, Density of states. Electronic and Geometric Structure of materials, Bulk to Nano transition, Energy bands, FCC based structures, Magic numbers, Surface effects of Nano materials. Size dependence of properties - Mechanical Properties, Optical Properties, Electrical Properties, Dielectric Properties, Magnetic Properties, Classification of nanostructures, Nanostructured multilayers, Metal Nanoparticles, semiconductor and oxide nanoparticles, Metals Nano clusters, Carbon Nanostructures, Fullerenes, nanotubes, Graphene, carbon dots.

Module 2: (10 Lecture hours)
Methods of synthesis of Nanomaterials, Top down and bottom up approaches, Physical Approaches, Aerosol Synthesis, Chemical Vapour Deposition, Plasma Synthesis, Electro deposition, etc. Chemical approaches, Solvothermal synthesis, Hydrothermal Synthesis, Reverse Micellar Method, Micro Emulsion Method, Sol Gel Synthesis, Microwave method, Sonochemical Process, Co- Precipitation, VLS growth of 1D nanomaterials, porous materials, template assisted synthesis.

Module 3: (13 Lecture hours)
Nanomaterial characterizations, electron microscopy, scanning probe microscopy, Raman and IR spectroscopy, UV-Visible absorption spectroscopy, X-ray photoelectron spectroscopy.
Applications- Nanomaterials in Medicine- Diagnosis and drug delivery, Nanomaterials for Energy-hydrogen fuel generation, solar cells, fuel cells, supercapacitors, electrochromic energy materials, Nanomaterials for Catalysis, Nanomaterials in Fabrics, Nanomaterials for Environment, nanotoxicology.

References:
1. William D. Callister Jr*, "Materials Science and Engineering – An Introduction",* John Wiley and Sons Inc. 6th Edition, 2006.
2. Charles P. Poole Jr, Frank J Owens*, "Introduction to Nanotechnology"*, John Wiley and Sons Inc, 2009.
3. Pradeep T. *"Nano: The Essentials"* McGraw Hill Education India (2007)
4. Gunter Schimd *"Nanoparticles –From theory to application*", Wiley-VCH, 2004.
5. C.N.R. Rao, A. Muller, A.K. Cheetham*, "The Chemistry of Nanomaterials",* Wiley-VCH, 2003.
6. M A Shah, Tokeer Ahmad, *Principles of Nanoscience and Nanotechnology*, Narosa Publishing House, 2010.

MT2005D POLYMER SCIENCE AND TECHNOLOGY

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)

Different types of polymerizations like addition, condensation and stereoregular polymerization. Initiators used, important steps involved, kinetics and mechanism of addition, condensation and stereoregular polymerizations. Copolymerization and its kinetics. Important techniques of polymerization such as emulsion, bulk, solution and suspension. Polymer melting point, glass transition temperature, structure-property relationship.

Module 2: (13 Lecture hours)

Polymer characterization, molecular weight determination by GPC, viscosity, light scattering and osmometry. Physical methods of polymer analysis such as IR, NMR, X-ray etc. Thermal analysis of polymers using DSC, TGA, DTA, DMA etc. Polymer degradation and stabilization: Thermal, oxidative, photochemical and ozone degradation, degradation under special environments. Mechanism of different types of degradation. Commonly used anti- degradants and the mechanism of their stabilization.

Module 3: (13 Lecture hours)

Polymer physics, solution properties of polymers, Polymer synthesis: Synthesis of speciality polymers such as aromatic polyether, polyacetals, polyamides, polymers with metal in their back bone, phosphorus and sulphur-containing polymers, polymeric liquid crystals, conducting and photo conducting polymers. Polymer supported solid phase reactions, Merrifield method.

References:

1. Hiemenz, Paul C., and Timothy P. Lodge. *Polymer chemistry*. CRC press, 2007.
2. Flory, Paul J. *Principles of polymer chemistry*. Cornell University Press, 1953.
3. Rabek, Jan F, *Experimental methods in polymer chemistry*, Wiley & Sons Ltd. 1980
4. Mark, H. F. *Encyclopedia of Polymer Science and Technology, 15 Volume Set*. Wiley, 2014.
5. Kricheldorf, Hans R. *Handbook of polymer synthesis*. Vol. 24. CRC Press, 1991.
6. Billmeyer, Fred W. *Textbook of polymer science*, John Wiley & Sons Ltd, 1971.

MT2006D METALLURGICAL ENGINEERING

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Ferrous Metals: Pig iron, Blast furnace, Cast iron, Sponge iron, Corex & Mandrex process, Effect of chemical elements on iron & steel, Steel making process, Classification of steels, Application of carbon steel, Influence of the constituents on steel, Alloy steel, Effect of alloying elements on steel, Principles of heat treatment of steels and cast iron, Surface treatments, Recrystallization, recovery, and grain growth.

Module 2: (13 Lecture hours)
Powder Metallurgy: Process description, Maintenance of metal powders, Blending of powders, Compaction, Pre-sintering, Sintering, Secondary operation, Products of powder metallurgy, Advantage of the process, Disadvantages & limitation, Design consideration, Forming Process: Casting, Mechanical working process, Welding, Brazing, Soldering, Machining of metals, Mechanical Tests: Tensile test, Compression test, Hardness test, Impact test, Fatigue test, Creep & stress-rupture test.

Module 3: (13 Lecture hours)
Non-Ferrous Metals & alloys: Metallurgical processing of Non ferrous metals, Aluminium, Its extraction, alloys & applications, Copper, Its extraction , alloys & applications, Zinc, Its extraction , alloys & applications , Lead, Its extraction , alloys & applications . Alloys for high temperature service conditions.

References:

1. Swarup, D., and D. Swarup. *Elements of Metallurgy*. BH University Press, 1969.
2. Avner, Sidney H. *Introduction to physical metallurgy*. Vol. 2. New York: McGraw-Hill, 1974.
3. Lakhtin, IUrii Mikhailovich, and Nicholas Wienstein. *Engineering physical metallurgy*. Foreign Languages Publishing House, 1962.
4. Reed-Hill, Robert E., Reza Abbaschian, and Reza Abbaschian. *Physical metallurgy principles,* Affiliated East-West Press, 1973.

MT2091D MATERIALS PROCESSING LAB

Pre-requisites: Nil

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L	T	P	C
0	0	3	2

Total hours: 39

Selected experiments in the field of processing of metals and alloys, polymers, ceramics and composites. Experiments include thermo mechanical processing of metals and alloys, mixing and compounding of polymers, fabrication of composites, powder processing and sintering techniques etc.

LIST OF EXPERIMENTS

1. Heat treatment studies of metals and alloys.
2. Processing of ceramic materials like zirconium, clay, Hydroxyapatite etc.
3. Processing of polymer materials like polyaniline, Melamine –formaldehyde etc.
4. Casting of thermosetting resins.
5. Rubber compounding.
6. Polymer Nano composite preparation.
7. Production of plastic products using injection moulding, extrusion, blow moulding etc.
8. Preparation of ceramic reinforcement by Ball milling.
9. Powder processing of metals and ceramics.
10. Polishing Etching and microstructure analysis of metals.

References:

1. Laird, C., J. K. Tien, and J. F. Elliott. "Metallurgical Treatises." *Metallurgical Society of AIME* 1981.
2. Tadmor, Zehev, and Costas G. Gogos. *Principles of polymer processing*. John Wiley & Sons, 2013.
3. Xanthos, Marino, ed. *Functional fillers for plastics*. John Wiley & Sons, 2010.
4. Morton, Maurice, ed. *Rubber technology*. Springer Science & Business Media, 2013.
5. Dieter, George Ellwood, and David J. Bacon. *Mechanical metallurgy*. Vol. 3. New York: McGraw-hill, 1986.

MT2092D FLUID FLOW AND HEAT TRANSFER LAB

Pre-requisites: Nil

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L	T	P	C
0	0	3	2

Total hours: 39

Selected experiments relevant in the field of fluid flow and heat transfer- Calibration of flow measuring devices. demonstration of laminar and turbulent flow in pipes; characteristics of pumps; measurement of thermophysical properties; study of forced and natural convection heat transfer; performance study of heat exchangers and refrigeration system.

LIST OF EXPERIMENTS

1. Calibration of orifice meter
2. Calibration of notches/weirs
3. Performance and operating characteristics of centrifugal pumps
4. Determination of losses in piping system
5. Determination of viscosity and surface tension of liquids
6. Demonstration of laminar and turbulent flow in pipes
7. Determination of thermal conductivity of solids and liquids
8. Determination of heat transfer coefficient in forced convection heat transfer
9. Determination of heat transfer coefficient in natural convection heat transfer
10. Determination of Effectiveness of Plate Type Heat Exchanger
11. Determination of COP of a vapour compression refrigeration system
12. Determination of critical heat flux in boiling heat transfer

References:

1. F. M. White*, Fluid Mechanics*, 7th ed. McGraw Hill, 2011.
2. Y. A. Cengel and J. M. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, 3rd ed. McGraw Hill, 2014.
3. J. P. Holman and S. Bhattacharya, *Heat Transfer*, 10th ed. McGraw Hill Education, 2002.
4. Y. A. Cengel and A. J. Ghajar, *Heat and Mass Transfer,* 5th ed. McGraw Hill Education, 2015.
5. W. S. Janna, *Engineering Heat Transfer*, 3rd ed. CRC Press, 2009

SEMESTER V

MT3001D SYNTHESIS AND FABRICATION OF NANOMATERIALS

Pre-requisites: Nil
Total hours: 52

L	T	P	C
4	0	0	4

Module 1: (13 Lecture hours)
Vacuum Technology, General principles, An overview of molecular materials, Functional materials, Nanomaterials, Classification of nanomaterials, 0D, 1D and 2D nanomaterials, Unique bonding in nanoparticles and powders, Chemical synthesis of monodisperse spherical nanocrystals, Gas phase chemistry, Metal nanoparticles, Semiconductor nanocrystals, Quantum dots, Aerogels: porous nanostructures, Mesoporous solids, Synthesis of 1D nanomaterials, Electro deposition.

Module 2: (13 Lecture hours)
Fullerenes, Discovery and electronic structure, Carbon nanotubes and onions, Graphene, graphene nano ribbons, Metal-carbon clusters, Metallocarbohedrenes, carbon quantum dots. Organic monolayers, LB films, Self assembled monolayers-silanes, thiols, carboxylic acids, Chemistry with LB and SAM films, superlattices.

Module 3: (13 Lecture hours)
Fabrication of thin films by Physical Methods: Molecular beam epitaxy, Chemical vapour and Physical vapour deposition method, Nanofabrication by photons and charged beams, Optical lithography, Deep UV, extreme UV and X ray lithography, Optical and E-beam lithography mask making, Mask less optical lithography, Nanofabrication by scanning probes, Nanoscraching and oxidation, Soft lithography, Nanoimprint lithography, Immersion lithography, Dip pen lithography, Nanofabrication by replication, Nanofabrication by self-assembly and scanning tunnelling techniques, Nanopatterning, Nanomanipulation, MEMS fabrication, Lab on chip.

Module 4: (13 Lecture hours)
Design and fabrication of devices. Common nanofabrication strategies, Basic metal-oxide –semiconductor (MOS) device fabrication and design aspects. Field- effect Transistor layout and fabrication. CMOS technology, State-of- the art and advanced CMOS technologies, Silicon - on –Insulator devices, Pressure sensor and energy harvesting device fabrications.

References:

1. Pradeep T. *“Nano: The Essentials*” by McGraw Hill Education India, 2007.
2. Gunter Schimd *“Nanoparticles –From theory to application*”, Wiley-VCH, 2004.
3. C.N.R. Rao, A. Muller, A.K. Cheetham, *“The Chemistry of Nanomaterials*”, Wiley-VCH, 2003.
4. Janos H. Fendler*, “Nanoparticles and Nanostructured Films-Preparation*, Characterisation and Applications”, Wiley-VCH, 1998.
5. Kenneth J. Klabunde, Ryan M Richards, *“Nanoscale materials in chemistry*”, Second edition, John Wiley & Sons, 2009.
6. Kazuaki Suzuki, Bruce W Smith*, “Microlithography: science and technology*”, CRC press 2007
7. Mark J. Jackson, *“Microfabrication and Nanomanufacturing”,* CRC Press Taylor & Francis Group, Published in 2006

MT3002D COMPOSITE MATERIALS

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Lecture hours)

Introduction to composite materials along with its basic requirements and classification; Various models analyzing the design and performance of composite materials; Understanding the composite modulus, strength and fracture behaviour for structural applications; Composites including nano-composites for electrical, superconducting and device applications; Fabrication and processing of metal matrix (MM), polymer Matrix (PM) and ceramic matrix (CM) composites and their characterization; Fabrication of nano-composites; Secondary processing and joining of various composite materials for structural applications and their fracture behaviour and safety.

Module 2: (14 Lecture hours)

Fabrication Composites : Fabrication of Metal Matrix Composites: Commonly used Matrices, Basic Requirements in Selection of constituents, solidification processing of composites - XD process, Spray processes - Osprey Process, Rapid solidification processing, Dispersion Processes - Stir-casting & Compocasting,Screw extrusion, Liquidmetal impregnation technique - Squeeze casting, Pressure infiltration, Lanxide process),Pinciple of molten alloy infiltration, rheological behaviour of meltparticle slurry, Synthesis of In situ Composites; Fabrication of Polymer Matrix Composites - Commonly used Matrices Basic Requirements in selection of Constituents, Moulding method, Low pressure closed moulding, pultrusion, Filament winding, Fabrication of ceramic matrix composites - Various techniques of vapour deposition, Liquid phase method and Hot pressing etc., Fabrication of nano-composites

Module 3: (15 Lecture hours)

Composites for satellites and launch vehicles: Composites- type of composites- fibre composites,particulate composites, and foam composites. Desired properties of a matrix. Polymer matrix: Thermosets and thermoplastics. Fiber reinforced polymer (FRP) Types of fibers, mechanical properties of fibers, glass fibers, carbon fibers, aramid fibers, metal fibers, alumina fibers, boron fibers, silicon carbide fibers, silica fibers, etc. Theory of reinforcement, laminated composites. Strength of laminates, special classification of laminates, Testing of Composites: Mechanical testing of composites, tensile testing, compressive testing, intra laminar shear testing, inter laminar shear testing, fracture testing etc. Joining of composites: Adhesively bonded joints & mechanically fastened joints, environmental effects on composites. Composite characterization by mechanical, thermal and DMTA techniques. Failure mechanics of composites. Dental filling composites, fibrous and particulate composites in orthopedic implants. Biomimetic materials, nanoscale materials/engineering; bioactive/ bioresponsive materials, polymer scaffolds, principles of tissue engineering. Industrial Application of Composite Materials : Civil constructions of structures/panels, Aerospace industries, Automobile and other surface transport industries, Packaging industries, House hold and sports components etc, Fracture & Safety of Composite.

References:

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons, *Biomaterials Science, An introduction to Materials Science,* 2nd Edn, Elsevier Academic Press, London, 2004.
2. J. Park and R.S.Lakes, *Biomaterials An Introduction, 3rd Edn.* Springer Science, New York, 2007.
3. F.Silver and C. Doillon, *Biocompatibility, Interactions of biologicals and Implantable Materials* Volume 1. Polymers, VCH Publishers, New York, 1989.

MT3003D MATERIALS CHARACTERIZATION

Pre-requisites: Nil

.

L	T	P	C
4	0	0	4

Total hours: 52

Module 1: (19 Lecture hours)
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).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.

Module 2: (15 Lecture hours)
Surface profilometry measurements - BET surface area analysis - 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,

Module 3: (18 Lecture hours)
Temperature measurement techniques, Infrared thermography, Thermo reflectance thermography, Liquid crystal thermography. Interferometry- Electronic speckle pattern interferometry- Measurement of properties of Nanofluids -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

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.

MT3004D ENVIRONMENTAL ENGINEERING

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 Lecture hours)

Scope and importance of environmental studies; environmental acts and regulations; environmental pollution, Causes, effects and control measures of Air pollution , Water pollution , Soil pollution , Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards , Solid waste Management : Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution. Pollution case studies. climate change; global warming; acid rain; ozone layer depletion, Environment Protection Act, Various pollution regulations, Introduction to ISO and ISO 14000, Natural Hazards and Disasters, Concept of environmental hazards, Environmental stress & environmental disasters, Types of environmental hazards and disasters, Natural disaster reduction and management, Provision of Immediate relief measures to disaster affected people, Prediction of hazards & disasters, Measures of adjustment to natural hazards, Mitigation.

Module 2: (13 Lecture hours)

Study and significance of natural resources, Renewable biological resources, Wildlife conservation/ management, Fisheries, Forestry, Energy resources, Energy consumption, Scarcity and conservation**,** Ecosystems, concept of an ecosystem, structure and function of an ecosystem, biodiversity and its conservation – introduction, definition, genetic, species and ecosystem diversity, bio geographical classification of India, value of biodiversity;

Module 3: (14 Lecture hours)

From unsustainable to sustainable development: sustainable energy technologies; renewable and non-renewable resources: use of alternate energy resources; energy audit; BEE rating; carbon capture and storage: analysis using carbon foot print and water foot print; sustainable manufacturing technologies: sustainable production and consumption; life cycle analysis; green manufacturing standards; green logistics, Bioremediation, Types of bioremediations, Bio augmentation for bioremediation,

Project work:

A project work based on a field trip / visit to an industry to study the environmental impact.

References:

1. H. Jadhav and V. M. Bhosale, *Environmental Protection and Law*. Himalaya Publication House, 1995.
2. M. L. Mckinney and R. M. Schocr, *Environmental Science Systems and Solutions*, Web enhanced edition, Jones and Bartlett Publishers, 1998.
3. D. S. Sengar, *Environmental law.* Prentice hall of India, 2007.
4. K. D. Wagner, *Environmental Management*. W.B. Saunders Co., 1998.
5. United Nations Industrial Development Organization, *Industrial Development Report 2016*.
6. G. Seliger, *Sustainable Manufacturing - Shaping Global Value Creation*. Springer, 2012.
7. D. A. Dornfeld, *Green Manufacturing: Fundamentals and Applications*. Springer, 2012.
8. N. K. Jha, *Green Design and Manufacturing for Sustainability*. CRC Press, 2015.

ME3104D PRINCIPLES OF MANAGEMENT

Pre-requisites: Nil
Total hours: 39

L	T	P	C
3	0	0	3

Module 1 (15 hours)
Introduction to management, classical, neo-classical and modern management theories, Levels of managers and skill required. Management process – planning – mission – objectives – goals – strategy – policies – programmes – procedures. Organizing, principles of organizing, organization structures, Directing, leadership, motivation, Controlling.
Module 2 (11 hours)
Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making.
Module 3 (13 hours)
Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, entrepreneurship, business plans, corporate social responsibility, patents and Intellectual property rights.

References

1. H. Koontz, and H. Weihrich, *Essentials of Management: An International Perspective.* 8th ed. McGraw-Hill, 2009.
2. R. W. Griffin, *Management: Principles and Applications,* Cengage Learning, 2008.
3. P. Kotler, K. L. Keller, A. Koshy, and M. Jha, *Marketing Management: A South Asian Perspective.* 14th ed. Pearson, 2012.
4. M. Y. Khan, and P. K. Jain, *Financial Management*, Tata-McGraw Hill, 2008.
5. R. D. Hisrich, and M. P. Peters, *Entrepreneurship: Strategy, Developing, and Managing a New Enterprise*, 4th ed. McGraw-Hill Education, 1997.
6. E. B. Roberts, *Entrepreneurs in High Tech-Lessons from MIT and beyond,* Oxford University Press, 1991
7. D. J. Sumanth, *Productivity Engineering and Management*, McGraw-Hill Education, 1985.

MT3091D MATERIALS SYNTHESIS AND CHARACTERIZATION LAB

Pre-requisites: Nil

L	T	P	C
0	0	3	2

Total hours: 39

Selected experiments from a list of experiments relevant to understand and acquire practical knowledge on synthesis and characterization of different materials. The material science lab will be particularly focusing on the different nanomaterial as well as nanocomposite synthesis in various methods and its characterization using advanced instruments. Experiments may include synthesis of ceramic materials, polymer materials and nanomaterials.

LIST OF EXPERIMENTS

1. Synthesis of aluminosilicate by sol-gel route
2. Characterization of aluminosilicate by XRD
3. Hydrothermal synthesis of ceramic powders
4. Precipitation reaction of mixed metal oxides
5. Particle size distribution and zeta potential analysis of mixed metal oxides
6. Bottom up synthesis of CdS/CdSe nanoparticles; Optical absorption spectra; Band gap estimation from the band edge
7. Characterization of semiconductor nanomaterial by FESEM and DLS
8. Chemical synthesis of Ag nanoparticles-Turkevich method; UV-Visible absorption of the colloidal sol; Mie formalism; Estimation of size by curve fitting
9. Synthesis of TiO_2 by sol gel method and study its photocatalytic activity in the degradation of organic contaminants
10. Preparation of polymer nanocomposite and study of its mechanical properties.
11. Thermal analysis of polymer materials using TGA/DSC
12. Synthesis of polysilanes and characterization by IR spectroscopy

References:

1. Rabek, Jan F, Experimental methods in polymer chemistry -, John Wilely & sons, New York, 1980.
2. D. Braun, H. Cherdron, M. Rehahn, H. Ritter, B. Voit, *Polymer Synthesis: Theory and Practice Fundamentals, Methods, Experiments,* Fourth Edition, Springer, 2004.
3. Barsoum, Michel, and M. W. Barsoum. *Fundamentals of ceramics*. CRC press, 2002.
4. Segal, David. *Chemical synthesis of advanced ceramic materials*. Vol. 1. Cambridge University Press, 1991.
5. Pradeep, T. A textbook of nanoscience and nanotechnology. Tata McGraw-Hill Education, 2003.
6. C. N. R. Rao, h.c. mult. Achim Müller, A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, 2004.

SEMESTER VI

EE3021D ELECTRICAL ENGINEERING MATERIALS

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (11 hours)

Conducting materials: Review of metallic conduction on the basis of free electron theory-electrical and thermal conductivity-Wiedemann-Franz law-drawback of classical theory-quantum free electron theory- Fermi-Dirac distribution - variation of conductivity with temperature and composition, Materials for electric resistances general electric properties: brushes of electrical machines, lamp filaments, fuses and solder. Semiconductors: Mechanism of conduction in semiconductors. Density of carriers in intrinsic semiconductors the energy gap - types of semiconductors. Hall Effect - compound semiconductors - basic ideas of amorphous and organic semiconductors

Magnetic materials: Classification of magnetic materials - origin of permanent magnetic dipoles ferromagnetism - hysterisis curve-magnetostriction - hard and soft magnetic materials- magnetic materials used in electrical machines instruments and relays.

Module 2: (11 hours)

Dielectrics: Dielectric polarization under static fields - electronic, ionic and dipolar polarizations - behaviour of dielectrics in alternating fields - mechanism of breakdown in gases, liquids and solids- factors influencing dielectric strength- capacitor materials-Ferro and piezo electricity

Insulating materials-complex dielectric constant - dipolar relaxation .dielectric loss insulator materials used inorganic materials (mica, glass, porcelain, asbestos) - organic materials (paper, rubber, cotton silk fiber, wood, plastics, bakelite) - resins and varnishes - liquid insulators(transformer oil) - gaseous insulators (air, SF6, and hydrogen) – ageing of insulators.

Module 3: (9 hours)

Special purpose materials and processes: Thermo couple materials-soldering materials- fuse materials- contact materials-structural materials-fluorescent and phosphorescent materials- galvanizing and impregnation process -

Super conductors – effect of magnetic field- Meissner effect-type I and type II superconductors –London equations –Josephson effect –applications of superconductors.

Module 4: (8 hours)

Materials for electronic components – resistors –insulated moulded resistors-Cracked carbon resistors-alloy resistors-metallic oxide thin film resistors-High value resistors-wire wound resistors-non linear resistors –varistors –capacitors-mica- dielectric capacitors-glass-dielectric capacitors-plastic-dielectric capacitors etc – inductors –air cored coils –cored coils-ferrite core-relays- Applications of nano materials.

References:

1. Indulkar C.S. and Thiruvengadam S, *An Introduction to Electrical Engineering Materials*, 6th ed., S. Chand & Co Pvt Ltd, 2011.
2. P.K. Palanisamy, *Solid State Physics*, Scitech Publications, Hyderabad, 2011.
3. A.J. Dekker, *Electrical Engineering Materials,* 1st ed., Prentice Hall of India, 1963.
4. Yu Koritsky, *Electrical Engineering Materials*., Moscow MIR, 1970.
5. Arumugam M., Materials Science., Anuradha Publishers, 1990.
6. Kapoor P.L., *Electrical Engineering Materials*, Khanna Publications, 2014.
7. Hutchison T.S. and Baird D.C, *The Physics of Engineering Solids*, 2nd ed., John Wiley Publications, 1968.
8. S.O.Kasap, *Principles of Electrical engineering Materials and Devices*, Tata McGraw Hill. 2000
9. R.K. Rajput, *Electrical Engg. Materials*, 2nd ed., Laxmi Publications, 2015.
10. T. K. Basak, *Electrical Engineering Materials*, New age International, 2008.
11. Solymar, *Electrical Properties of Materials*, 9th ed., Oxford University Press, 2014.
12. I. P. Jones, *Material Science for Electrical and Electronic Engineering*, Oxford University Press, 2000.
13. TTTI Madras, *Electrical Engineering materials*, Tata McGraw Hill, 2004.

MT3005D BIOMATERIALS

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Biomaterials – Ceramics- Bioinert, Bioactive and bioresorbable ceramics, FRPs, fabrics glasses, Bioglasses – Natural materials – Composites – Thin films, Grafts, coatings – Fabrics – Biologically functional materials. Classes of Materials Used in medicine: Metals – Polymers – Hydrogels – Bioresorbable and Bioerodible-pyrolytic carbon important biometallic alloys: Ti-based, stainless steels, Co-Cr-Mo alloys Natural Nanobiocomposites, Biomimetic Nanocomposites and Biologically Inspired Nanocomposites.

Module 2: (13 Lecture hours)
Applications of biomaterials in Medicine and dentistry: Cardio vascular – Nonthrombogenic treatment and strategies – Dental implants – Adhesives and sealants – Ophthalmologic applications – Orthopedic applications – Drug delivery systems – Sutures – Burn dressings – Bioelectrodes – Biomedical sensors and Biosensors. In-vivo cell & tissue engineering case studies: Artificial organs, Artificial skin, Artificial blood vessel, Artificial pancreas, Artificial liver, regeneration of bone, muscle and nerve. Practical aspects of biomaterials – Implants and devices – New products and standards.

Module 3: (13 Lecture hours)
Biomaterial surface contact elements: blood composition, plasma proteins, cells, tissues. Biointerface phenomena: Molecular and cellular processes with living environment, blood-materials interaction, short and long term reactions to the body. Biomaterials processing technologies implants and medical devices; Improvement of materials biocompatibility by different methods

References:

1. Buddy D.Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, *Biomaterials Science: An Introduction to Materials in Medicine,* Academic Press, 1st edition, 1997.
2. Damien Alloyeau, Christine Mottet, Christian Ricolleau, *Nanoalloys: Synthesis, Structure and Properties,* Springer 20012
3. R.P.Lanza, R.Langer, J.Vacanti, *Principles of Tissue Engineering,* Academic Press, 2nd Edition, 1997.
4. Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, *Nanocomposite Science and Technology*, Wiley-VCH Verlag, Weiheim, 2003.
5. Dietmar Hutmacher, Wojciech Chrzanowski, *Biointerfaces: Where Material Meets Biology*, Royal Society of Chemistry 2014

MT3006D COMPUTATIONAL METHODS IN MATERIALS SCIENCE

Pre-requisites: Nil

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L	T	P	C
2	0	3	4

Total hours: 26 Lecture +39 Lab

Module 1: (8 Lecture +12 Lab hours)
Computer simulation as a tool for material science: Need and Prospects .Introduction to Ab initio methods: Electronic states of many particle systems. Introduction to first principles energy methods: The Hartree-Fock approximation, Density functional theory, periodic systems, group theory, pseudo potential approach. Perturbation and linear response.

Module 2 (8 Lecture +12 Lab hours)
Introduction to Ab-initio Molecular Dyanmics, Applications: Fullerene, point defect in crystals. Introduction to Tight binding methods: Formalism, parametrization, calculation of matrix elements. Methods to solve Schrodinger equation for large systems, self-consistent tight binding formalism. Applications: Fullerene, Silicon and transition metal clusters

Module 3 (10 Lecture +15 Lab hours)
Empirical methods and coarse graining; Reduction to classical potentials: Polar, Van der Waals, embedded atom potential, potential for covalent bonds. The Connolly Williams approximations: Lattice Gas Model. Potential renormalization. Monte Carlo methods: stochastic process, Markov chain, ergodicity. Algorithms for Monte Carlo methods. Random Number generators. Applications: systems of classical particles, nucleation, crystal growth. Introduction to Quantum Monte Carlo methods

References:

1. Ohno K. K. Esfarjani and Y. Kawazoe, *“Computational Material Science”,* Springer Verlag, 1996.
2. W. D. Callister, Jr*., “Materials Science and Engineering: An Introduction”,* New York: John Wiley and Sons, 2003.
3. M. H. Kalos and P.A. Whitlock, *Monte Carlo Methods Volume I: Basics*, New York: John Wiley and Sons, 1986.
4. J. E. Freund and R. E. Walpole, *“Mathematical Statistics”,* Englewood Cliffs, NJ: Prentice-Hall, 1980.
5. Kurt Binder, “*Monte Carlo Methods in Statistical Physics”,* Springer, 5th Edition, 2005.

MT3007D MAGNETIC AND OPTICAL PROPERTIES OF MATERIALS

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Magnetic Properties, Basic Concepts, Oribital and spin-permanent magnetic moment of atoms, Diamagnetism and Paramagnetism, Ferromagnetism, Antiferromagnetism and Ferrimagnetism, The Influence of Temperature on Magnetic Behaviour, Domains and Hysteresis, exchange of energy, magnietocrystalline energy, magnetostriction, Magnetic Anisotropy, Soft Magnetic Materials, Hard Magnetic Materials, Magnetic Storage, Superconductivity, spintronics, memory devices, multiferroic materials

Module 2: (13 Lecture hours)
Optical Properties, Introduction, Electromagnetic Radiation, Light Interactions with Solids, Atomic and Electronic Interactions, Optical properties f metals and non-metals, Refraction, Reflection , Absorption, Transmission, Color, Opacity and Translucency in Insulators, Applications of optical phenomena, Luminescence, Photoconductivity, Lasers, Laser generation and optics, Laser Applications in Materials Processing, Fundamentals of laser materials interactions and laser ablation, Laser materials, Optical Fibers in Communications, optical materials, liquid crystals and LCD,LED devices.

Module 3: (13 Lecture hours)
Thermal properties of materials: introduction, heat capacity, thermal expansion of materials, thermal conductivity, thermal diffusivity, Emissivity, thermal stability, thermal insulation materials, Phase change materials: Types of PCMs, encapsulation of PCM, applications.

References:

1. R. E. Hummel, *“Electronic Properties of Materials”* Springer, 2011
2. Charles Kittel, *Introduction to Solid State Physics*, John Wiley & Sons 1991
3. Neil W. Ashcroft and N. David Mermin, *Solid State Physics*, , Sauders College, Philadelphia, USA, 1976
4. Rawlings, R. D., et al. *Materials Science*. Springer, 2013.
5. Callister, William D., and David G. Rethwisch. *Materials science and engineering*. Vol. 5. NY: John Wiley & Sons, 2011.
6. Shackelford, James F., et al. *CRC materials science and engineering handbook*. CRC press, 2016.

MT3092D FUNCTIONAL MATERIALS LABORATORY I

Pre-requisites: Nil

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L	T	P	C
0	0	3	2

Total hours: 39

Selected experiments from a list relevant in the field of functional materials fabrication and property analysis. The experiments includes device fabrication experiments, smart material property analysis and biomaterial properties.

LIST OF 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.

MT3093D MINI PROJECT AND SEMINAR

Pre-requisites: Nil

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L	T	P	C
0	0	0	3

Total hours: 39

Students may undertake short research projects under the direction of members of the faculty, normally 3 hrs/week. A written, detailed report describing the project and results is required.

For seminar, each student shall prepare a paper on any topic of interest in the field of specialization – material science and Engineering. He/she shall get the paper approved by the Programme Coordinator/ Faculty in-charge and present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar. Appropriate weights will be given for communications skills as well as for capacity to impress the audience and ability to handle question and answer session.

SEMESTER VII

MT4001D ENERGY MATERIALS AND TECHNOLOGY

Pre-requisites: Nil
.

L	T	P	C
3	0	0	3

Total hours: 39

Module1: (10 Lecture hours)
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, 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.

Module2: (16 Lecture hours)
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, 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.

Module3: (13 Lecture hours)
Issues and challenges of functional nanostructured materials for electrochemical 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, CO_2 capture and conversion.

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.

MT4002D CORROSION SCIENCE AND ENGINEERING

Pre-requisites: Nil
.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 Lecture hours)
Corrosion, Basic concepts, types of corrosion, atmospheric, galvanic, pitting, crevice corrosion, intergranular corrosion. Stress corrosion cracking, Season cracking. Basics of Thermodynamics and Kinetics of oxidation and corrosion. Basic electrochemistry - Electrochemical cells-definitions and principles, galvanic and electrolytic cells, Potential measurements, EMF and Galvanic series, Galvanic corrosion and bimetallic contacts. Eh – pH diagrams, fundamental aspects, Construction of Eh – pH diagrams. Copper, Aluminium and general corrosion diagrams

Module 2: (17 Lecture hours)
Electrode kinetics and polarization phenomena: Electrode – solution interface- types of polarization, Exchange current density - polarization relationships Corrosion rate measurement; Polarization technique, basic concepts, Mixed potential theory– bimetallic couples, Activation and diffusion controlled mixed electrodes - Methods of corrosion prevention and control, Prevention strategies – coatings, inhibitors and surface engineering, Cathodic protection- principles and classification, factors and monitoring, design aspects- Stray current corrosion, Passivity phenomena, application of mixed potential theory, Corrosion resistant alloys, Anodic protection

Module 3: (10 Lecture hours)
Biological aspects of corrosion, Microbial induced corrosion (MIC), Biofilms, Electrochemical aspects and general mechanisms. Corrosion by aerobic and anaerobic bacteria, Depolarization theory, Biofouling of titanium, prevention of MIC, MIC – Failure analysis, Corrosion of medical implants, Implant materials and corrosivity of human body, Bio corrosion of concrete, Metallurgical factors influencing corrosion. Metallurgy and testing procedures

References:

1. Denny A Jones, *Principles and Prevention of Corrosion* (second edition), PrenticeHall, N. J. (1996).
2. M. G. Fontana, *Corrosion Engineering* (Third Edition) McGraw-Hill Book Company(NY) (1987).
3. H. H. Uhlig and R. W. Revie, *Corrosion and Corrosion Control*, Wiley (NY) (1985).
4. L. L. Shreir, *Corrosion.* Vol I and II, Butterworths, Kent (1976).
5. M.Pourbaix, *Atlas of Electrochemical Equilibria in aqueous solutions*, NACE, Houston (1974).
6. J. D. A Miller, *Microbial Aspects of Metallurgy,* Medical and Tech. Pub. Co. Lancaster (1971).
7. C. A. C. Sequeira, *Microbial Corrosion*, European Federation of Corrosion, Maney Pub. (2000).
8. B. J. Little, *Microbiologically Influenced corrosion*, Wiley-Intersciene (2007)
9. H. Videla, J. F . Wilkes, R. A. Silva, *Manual of Biocorrosion*, CRC Press (1996).
10. S.W. Borenstein, *Microbiologically influenced corrosion* handbook, Woodhead Pub. Ltd, Cambridge (1994).

MS4003D INDUSTRIAL ECONOMICS

Pre-requisites: Nil
.

Total hours: 39

L	T	P	C
3	0	0	3

Module 1: (**9 Lecture hours**)
General foundations of economics: forms of organizations, objectives of firms, opportunity principle, discounting, marginalism versus instrumentalism, production possibility frontier, central problems of an economy- Two sector, Three sector and Four sector circular flow of income. Demand analysis-Individual, Market and Firm demand, Determinants of demand and supply, Shifts and changes in demand and supply, Market equilibrium, Shortages versus surpluses, Price ceiling, Price floor- Elasticity of demand and business decision making.

Module 2: (15 Lecture hours)
Production functions in the short and long run-cost concepts- Short run and long run costs economies and diseconomies of scale-economies and diseconomies of scope-Break even analysis- Vertical & horizontal integration-Product markets-Market structure-Competitive market-Imperfect competition (Monopoly, Monopolistic competition and Oligopoly) and barriers to entry-Pricing in different markets- Price discrimination-Dead weight loss-consumer's surplus – Pricing strategies- Game Theory-Prisoner's Dilemma-Maximin, Minimax, Saddle point, Nash Equilibrium.

Module 3: (15 Lecture hours)
Macro-Economic Aggregates-Gross Domestic Product; Gross national product, net domestic product, Transfer payments, Depreciation, Economic Indicators; Models of measuring national income; Fiscal deficit, primary deficit, Inflation and deflation; Fiscal and Monetary Policies; Monetary system; Indian stock market; Development Banks; NBFIs, role of Reserve Bank of India, Money Market, Capital market; NIFTY, SENSEX, Break even analysis, Margin of safety, Leverage, Depreciation, scrap value, salvage value, straight line method, declining balance method. double declining method, Taxes, Externalities, Financial ratios-Current ratio, Debt ratio, ROE, Quick ratio, net profit margin, debt to equity ratio.

References:

1. R. S. Pindyck, D. L. Rubinfield, and P. L. Mehta, *Microeconomics*, 9th ed. Pearson Education, 2018.
2. P. A. Samuelson and W. D. Nordhaus, *Economics*, 19 ed. Tata McGraw Hill, 2015.
3. G. N. Mankiw, *Principles of Micro Economics*, 7th ed. Cengage Publications, 2014.
4. S. B. Gupta, *Monetary Economics: Institutions, Theory & Policy*. S. Chand & Co., 2013.
5. K. E. Case, R. C. Fair, and S. Oster, *Principles of Economics*, 10th ed. Prentice Hall, 2011.
6. P.N.: Supplementary materials would be suggested / supplied for selected topics on financial markets Indian economy.

MT4091D FUNCTIONAL MATERIALS LABORATORY II

Pre-requisites: Nil

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L	T	P	C
0	0	3	2

Total hours: 39

Selected experiments relevant in the field of electrical properties of functional materials. Experiments include study on dielectric, ferroelectric, semiconducting and piezoelectric properties of materials, experiments on simple prototype devices are also included.

LIST OF 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.

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.

MT4092D PROJECT – PART 1

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L	T	P	C
0	0	6	3

Students are required to take up a project (generally in groups) in any topic related to Materials science and engineering under the guidance of a faculty member. The project work commenced in VII Semester shall be continued in VIII Semester too. At the end of the VII semester, an interim report describing the details of the project work has to be submitted to the Department, usually in a prescribed format. Presentation of this part of the work is to be done before an evaluation committee.

SEMESTER VIII

MT4093D PROJECT - PART 2

L	T	P	C
0	0	16	8

The project work commenced in VII Semester shall be continued in VIII Semester. At the end of the VIII semester, the final report/thesis describing the details of the entire project work has to be submitted to the Department, usually in a prescribed format. Presentation of the entire work is to be done before an evaluation committee and a successful oral defence of the thesis before the committee.

<u>ELECTIVES</u>
INDUSTRIAL TRACK ELECTIVES

<u>TRACK 1 – ENERGY</u>

MT3021D THERMAL ENGINEERING

Pre-requisites: Nil
.
Total hours: 39

L	T	P	C
3	0	0	3

Module 1: (10 Lecture hours)
Analysis of gas power cycles: carnot cycle, otto cycle, diesel cycle, four-stroke SI and CI engines; two-stroke SI and CI Engines; valve and port-timing diagrams, super charging & turbo charging, engine systems: cooling system; lubrication system; ignition system, transmission system. Fuel systems; electronic fuel injection systems; multi point fuel injection systems; gasoline direct injection system; common rail direct injection system;

Module 2: (10 Lecture hours)
Fuels, Thermochemistry, combustion in SI engines: stages of combustion; ignition lag; flame propagation; knocking in SI engines; pre ignition, factors affecting knocking, octane number; combustion in CI engines: stages of combustion; ignition delay; knocking in CI engines, factors affecting knocking; comparison of knocking in SI and CI engines; cetane number; IC engine performance: determination of friction power emission norms; exhaust treatment technologies

Module 3: (19 Lecture hours)
Properties of steam: Steam tables and Mollier chart; ideal and actual Rankine cycle; reheat and regenerative cycles; co-generation; Analysis and application of gas turbine cycles: open and closed cycles; Brayton cycle; Properties of atmospheric air; psychometric chart; vapour compression refrigeration cycle: ideal and actual; components and systems. Steam generators: fire tube, Lancashire, locomotive boilers; water-tube; Babcock and Wilcox and bent-tube boilers; mountings and accessories; schematic diagram of a modern steam generator; overfeed and underfeed stokers; Steam turbines: classification, impulse and reaction turbines; efficiencies, compounding; condensers: surface and mixing condensers; cooling towers; Compressors, Environmental aspects of thermal power systems; dust collectors; waste heat recovery techniques

References:

1. Y. A. Cengel and M. A. Boles, *Thermodynamics - An engineering approach,* 4th ed., Tata McGraw Hill, 2005.
2. J. B. Heywood, *Internal Combustion Engines Fundamentals*, McGraw Hill, 2017.
3. V. L. Maleev, *Internal Combustion Engines: Theory and Design*. McGraw Hill, 1983.
4. V. Sajith and S. Thomas, *Internal Combustion Engines,* 1st ed. Oxford University Press, 2017.
5. H. Cohen, *Gas Turbines Theory,* 4th ed. Longman, 1996.
6. M. M. El-Wakil, *Power Plant Engineering*, 1st ed. McGraw Hill, 1985.
7. P. K. Nag, *Power Plant Engineering*, 4th ed. McGraw Hill, 2017.
8. W. F. Stoecker and J.W. Jones, *Refrigeration & Air Conditioning*, 2nd ed. McGraw Hill, 1983.
9. C. P. Arora, *Refrigeration & Air Conditioning*, 3rd ed. McGraw Hill, 2008.

MT4021D HYDROGEN AND FUEL CELL

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (16 Lecture hours)

Forms of energy sources and environmental impact, Renewable Energy, Properties of hydrogen as fuel, General introduction to infrastructure requirement for hydrogen production, Dispensing and utilization of hydrogen fuel. Hydrogen production: conventional methods, Water splitting- Electrolysis, photochemical water splitting using solar radiation, Visible light photocatalysts, catalysts supports, nanomaterial photocatalysts. Hydrogen storage: Issues, Nanomaterials in generation and Storage of hydrogen, Physical storage, Physical-chemical storage.

Module 2: (13 Lecture hours)

Introduction to Fuel Cells-History-principle-working. Unit cells, Fuel cell stacking, Types of fuel cells- Polymer Electrolyte Fuel Cell (PEFC), Alkaline Fuel Cell (AFC), Direct Methanol Fuel Cell (DMFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC), Microbial Fuel Cell, Relative merits and demerits. Fuel Cell Characterization: In-situ and Ex-situ characterization techniques.

Module 3: (10 Lecture hours)

Thermodynamics of Fuel Cells: Significance of Gibbs free energy, Concept of chemical potential and emf, Nernst equation, Fuel Cell Efficiency, Cell Energy Balance, Ideal Performance, Actual Performance. Electrode Kinetics: Overvoltages, Tafel Equation, Charge Transfer Reaction, Intrinsic (standard) rate constant and the transfer coefficient, Butler – Volmer theory for electrode kinetics, Exchange Currents, Mass Transport Effects. Electrolytes and Electrocatalysis: Nano materials used in Fuel Cell, Ionomeric Membranes, Mechanism of proton transport, Membrane Electrode Assembly (MEA), In-situ and Ex-situ characterization techniques.

References:

1. Bard,A. J. , L. R., Faulkner, *Electrochemical Methods*, Wiley, New York, 2004.
2. Basu, S. (Ed) *Fuel Cell Science and Technology*, Springer, New York, 2007.
3. Sorenson B, *Hydrogen and Fuel Cells: Emerging Technologies and Applications*, Bent Sorenson, Academic Press, 2005
4. Srinivasan, Supramaniam. *Fuel cells: from fundamentals to applications*. Springer Science & Business media, 2006.
5. Zini, Gabriele, and Paolo Tartarini. *Solar hydrogen energy systems: science and technology for the hydrogen economy*, Springer Science & Business Media, 2012.

MT4022D BATTERIES AND SUPER CAPACITORS

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (14 Lecture hours)

Equilibrium Electrochemistry, Spontaneous Chemical Reactions, The Nernst Equation , Cells at Equilibrium, Standard Potentials, Dilute Solutions of Nonelectrolytes, Dynamic Electrochemistry, Double Layer, Helmholtz Model, Gouy–Chapman or Diffuse Model, Charge Transfer at the Interface, Redox Charge- Transfer Reactions, The Butler–Volmer Equation, Charge-Transfer Resistance (Rct), Whole Cell Voltages, Mass Transport Control, Diffusion and Migration, The Limiting Current Density, Rotating Disk Electrode Fundamental concepts about energy storage, chemical energy storage and electrochemical energy storage. Techniques for using chemically stored energy. Techniques for conversion between electrical and chemical energy. Materials used in electrochemical energy conversion systems.

Module 2: (13 Lecture hours)

Batteries With Aqueous Electrolytes, General Aspects, Current-Producing Chemical Reaction, Classification, Thermodynamic Aspects, Types of Batteries, Performance, Electrical Characteristics, Operational Characteristics, Batteries with Nonaqueous Electrolytes, Electrolytes Based on Aprotic Nonaqueous Solutions, Ionically Conducting Molten Salts, Ionically Conducting Solid Electrolytes, Primary Lithium Batteries, Lithium ion Batteries, Design and Technology of Lithium ion Batteries, Electric Characteristics, Lithium–Air Batteries, Lithium–Sulfur Batteries, Sodium Ion Batteries.

Module 3: (12 Lecture hours)

Similarities and difference between supercapacitors and batteries for storing electrical energy, Faradaic and non-Faradaic processes, Types of capacitors, Charge and Discharge behaviour of electrochemical capacitors, energetics and elements of the kinetics of electrode processes, The double layer and surface functionalities at carbon, Pseudocapacitance, The electrolyte in supercapacitor design and performance, Electrochemical behaviour at Porous electrodes, Energy density and power density, .practical aspects of preparation and evaluation of Electrochemical capacitors, Technology development.

References:

1. François Béguin and Elżbieta Frąckowiak (Eds), *Supercapacitors Materials, Systems, and Applications,* Wiley-VCH Verlag GmbH & Co, 2013.
2. Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich, *Electrochemical power sources batteries, fuel cells, and supercapacitors,* John Wiley & Son, 2015
3. B.E. Conway, *Electrochemical Supercapacitors Scientific fundamentals and Technological Applications,* Kluwer Academic, New York 1999.
4. Claus Daniel and J¨urgen O. Besenhard, (Ed) *Handbook of Battery Materials*, Wiley-VCH Verlag & Co. 2011 Wiley-VCH Verlag & Co. KGaA, 2011
5. Jean-Marie Tarascon, Patrice Simon, *Electrochemical Energy Storage, Vol 1*, John Wiley & Sons, Inc., 2015.

MT4023D PHOTOVOLTAIC SYSTEMS

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)

Review of Semiconductor Physics, Electrons and holes in semiconductors, Photo carrier generation and recombination, Junctions**;** p-n, p-i-n and metal-semiconductor contacts, band bending, homo and hetero-junctions, Analysis of p-n and p-in junction, Depletion region, Carrier and current densities, Current voltage characteristics in dark and light, Photovoltaic System Engineering.

Module 2: (13 Lecture hours)

Sustainable energy production based on renewable energy sources, Solar energy potential for PV, irradiance, solar radiation and spectrum of sun, Photovoltaic effect, conversion of solar energy into electrical energy, behaviour of solar cells, Device Physics of Solar Cells, Principle of cell design: Cell type, Optical design, surface and bulk recombination losses, design and fabrication of metal contacts, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current, Solar PV modules: Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output. Photovoltaic cell interconnection and module manufacturing, photovoltaic system component, stand-alone and grid-connected photovoltaic system, photovoltaic applications.

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Module 3: (13 Lecture hours)

Crystalline Silicon and III-V Solar cells, Single, tandem and multi-junction solar cells, Thin Film Solar cells: Amorphous silicon, cadmium telluride and copper indium gallium diselenide based solar cells, dye sensitized solar cells, nanoparticles and quantum dots solar cells, Organic photovoltaic Devices, perovskite solar cells, hybrid solar cells

References:

1. K.N. Tu, J.W. Mayer and L.C. Feldman*, Electronic Thin Film Science for Electrical Engineers and Materials Scientists,* MacMillan Publishing Co, New York, 1992.
2. A.L. Fahrenbruch and R.H. Bube, *Fundamentals of Solar Cells,* Academic Press, 1983.
3. Jenny Nelson, *The Physics of Solar cells*, Imperial College, UK, 2003.
4. Wang**,** Xiaodong, Wang**,** Zhiming M. (Ed.), *High-Efficiency Solar Cells: Physics, Materials, and Devices,* Springer, 2014.
5. Green, Martin, *Third Generation Photovoltaics Advanced Solar Energy Conversion*, Springer, 2003.
6. Park, Nam-Gyu, Grätzel, Michael, Miyasaka, Tsutomu (Ed.), *Organic-Inorganic Halide Perovskite Photovoltaics*, Springer, 2016.

TRACK 2 – HEALTH CARE

MT3022D BIO IMAGING

Pre-requisites: Nil
.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (16 Lecture hours)
Basic optics-Light waves and physical optics, physics of waves, interaction of light waves-Hyugen's wavelets, interference, diffraction and types, polarization, Spectroscopy, spectral imaging and mechanism, spatially dispersive spectroscopy, coded aperture spectroscopy, interferometric spectroscopy, resonant spectroscopy, Raman imaging, Fluorescent microscopy basics, Fluorescent probes, Wide field Epifluorescence Microscopy Single-Photon Excitation (SPE) Confocal Microscopy, Two-Photon Excitation (TPE) Microscopy, FRET Microscopy and other advanced techniques. Multiphoton imaging, modes in multiphoton imaging, two photon excited fluorescence, second harmonic generation, Third harmonic generation, lasers and system design, Molecular imaging: Fluorescence after photo bleaching, fluctuation spectroscopy, fluorescent labeling and techniques.

Module 2: (13 Lecture hours)
Introduction to advanced methods for manipulation of single cells and single molecules, single-molecule imaging techniques, label-free optical imaging methods including Raman and infrared microscopy. Surface plasmon resonance, Correlative light and transmission/scanning electron microscopy basics- fluorescence and electron microscopy, Integrated CLEM device setup, sample preparation techniques. Optical tweezers – requirement and calibration, applications and limitations. Magnetic tweezers: configuration (Permanent and electromagnetic) applications

Module 3: (10 Lecture hours)
Medical imaging analysis methods such as whole body analysis and Positron emission tomography (PET), magnetic resonance imaging (MRI), MRI contrast agents, Spions, positron emission tomography (PET), computed tomography (CT) and ultrasound (US), sound propagation in biological tissue, Doppler ultrasound.

References:

1. David J Brady, *Optical Imaging and Spectroscopy*, Wiley, 2009.
2. Rongguang Liang, *Biological and medical physics, biomedical engineering*, Springer, 2013
3. Thomas Muller-Reichert, *Methods in Cell Biology Correlative Light and Electron Microscopy III,* Elsevier, 2017.
4. Mark A Haidekker, *Medical Imaging Technology*, Springer, 2013.
5. Kier C Neuman et al, *Single-molecule force spectroscopy: optical tweezers, magnetic tweezers and atomic force microscopy,* Nature Methods, June 2008, 5(6): 491–505
6. Liao, Hong-Gang; Zheng, Haimei, *Liquid Cell Transmission Electron Microscopy*, Annual Review of Physical Chemistry, 2016.

MT3023D TOXICOLOGY

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (14 Lecture hours)

Introduction to toxicology, Growth phase of cells, various kinds of cell death, types of toxicology- Analytical Toxicology, Applied toxicology, Clinical toxicology, Veterinary toxicology, Forensic toxicology, Environment toxicology, Nanotoxicology, Xenobiotic, Toxicity, types of toxicity and studies, Signalling molecules & their receptors- Functions of cell surface receptors- Pathways of intracellular signal transduction- Signal transduction and cytoskeleton -Development & differentiation of cells – Cell death and types.

Module 2: (13 Lecture hours)

Endocytosis and pinocytosis, Pathways of uptake of small materials and nanoparticles- Phagocytosis, clatherine dependent endocytosis, caveolin mediated endocytosis, macropinecytosis, receptor mediated endocytosis. Translocation and their outcomes - Hematological toxicity, pulmonary toxicity, hepatotoxicity, nephrotoxicity, splenic toxicity, Types of nanoparticles and their effects on different types of toxicity- 1D ,2D and 3D nanomaterials.

Module 3: (12 Lecture hours)

Human exposure to nanomaterials and types – inhalation, dermal and ingestion, Assays for toxicity - Acute toxicity testing –LD_{50}- The fixed dose procedure (FDP)- The acute toxic category (ATC) method- MTT Assay, SRB assay - Acute toxicity testing for inhalation, Mutagenicity testing, Carcinogenicity testing, Toxicokinetics-neuro and embryotoxicity. Experimental Assays to test for presence, Machines to visualize in vivo nanoparticles, sensors for in vivo nanoparticles and embryonic cell based testing, Nanoparticle Classification Systems (NCS) and ISO based classification and guidelines.

References:

1. Vineet Kumar Nandita Dasgupta Shivendu Ranjan, *Nanotoxicology: Toxicity Evaluation, Risk Assessment and Management,* Taylor and Francis, 2018.
2. Nelson Durán, Silvia S. Guterres Oswaldo L. Alves, *Nanotoxicology: Materials, Methodologies, and Assessments,* Springer, 2014.
3. Yuliang Zhao, Zhiyong Zhang, and Weiyue Feng, *Toxicology of Nanomaterials*, Wiley VCH, 2016.
4. Antonietta M. Gatti, Stefano Montanari*, Case Studies in Nanotoxicology and Particle Toxicology*, Elseiver, 2015.
5. Harvey Lodish, *Molecular Cell Biology*, Macmillan Learning, 2007.

MT3024D NANOTECHNOLOGY OF BIOACTIVES

L	T	P	C
3	0	0	3

Pre-requisites: Ni
.
Total hours: 39

Module 1: (14 Lecture hours)
Introduction to bio pigments-pigments, A World of Colorless Compounds, Molecular Affinities of Pigments, Pigments in Biology, Reasons to Use Color Additives, Importance of Natural Colorants, Basic Toxicology of Colorant Additives, Natural Pigments- Distribution, function, introduction of natural pigments from microorganisms, microbial pigments from eukaryotic sources, natural pigments from prokaryotes, introduction to food colour- Classification of Food Colors. Other Natural Pigments Analytical Techniques and the Evaluation of Color Purity, Methodological Aspects- Extraction, Saponification, Separation, Characterization. Chemicals and Colorants as Nutraceuticals-Fundamentals, Food Items as Nutraceuticals, Phytochemicals as Nutraceuticals, Natural Colorants as Nutraceuticals, Natural colors and preservatives- introduction.

Module 2: (13 Lecture hours)
Nano technology in nutraceuticals- Nutraceuticals to treat cancer, Nutraceuticals with anti-inflammatory potential, Nutraceuticals with potential antimicrobial activity, Application of nanoparticles in nutraceutical delivery, Biopolymers- application in Nutraceuticals, Nanoparticles as nutraceutical carriers, Factors affecting the nutraceutical delivery, Targeting nanocarriers. Application of nanotechnology in Natural colors and preservatives, Application of Nano technology in bio pigments, Nano encapsulation- principles, methods, techniques and application, application in Nano encapsulation.

Module 3: (12 Lecture hours)
Nano technology in Food industry, nanofoods, characteristics, Materials in nanofoods and implementing Nanotechnology into food products, Application in functional foods, Applications and benefits, Implications and risks, Future trends of nanofoods, Nanopackaging for enhanced shelf life, Food processing and food safety and bio-security, Effects of nanomaterials on organ systems.

References:

1. Padua, Graciela W., and Qin Wang, eds. *Nanotechnology research methods for food and bioproducts* John Wiley & Sons, 2012.
2. Bagchi, Manashi, Hiroyoshi Moriyama, and Fereidoon Shahidi. *Bio-nanotechnology: a revolution in food, biomedical and health science,* John Wiley & Sons, 2012.
3. Singh, Om V., ed. *Bio-pigmentation and Biotechnological Implementation.,* John Wiley & Sons, 2017. Sabliov, Cristina, Hongda Chen, and Rickey Yada, eds. *Nanotechnology and functional foods: effective delivery of bioactive ingredients,* John Wiley & Sons, 2015.
4. Carle, Reinhold, and Ralf Schweiggert, eds. *Handbook on Natural Pigments in Food and Beverages: Industrial Applications for Improving Food Color*, Woodhead Publishing, 2016.
5. Delgado-Vargas, Francisco, and Octavio Paredes-López. *Natural colorants for food and nutraceutical uses,* CRC press, 2002.

BT3001D GENETIC ENGINEERING

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Basic concepts of recombinant DNA technology, Isolation, identification and characterization of DNA fragments; Plasmids, Phagemids, Cosmids, Restriction Enzymes, Type I, II and III, Nomenclature and sequence recognition, Restriction mapping, Construction of *E. coli* vectors, Ligation of DNA fragments, Blunt end and cohesive end ligation, T4 DNA ligase, Use of Klenow fragment, T4 DNA polymerase, Alkaline phosphatase, Polynucleotide kinase, Screening of recombinant DNA fragments.
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Module 2: (13 Lecture hours)
Cloning in M13 vectors, Yeast vectors, Mammalian vector, Expression vectors. Hybridization techniques- Southern hybridization, northern hybridization; Labeling of probes, Nick translation, Construction of genomic DNA and cDNA libraries, Linkers, Adapters, DNA sequencing methods, Sanger Dideoxy sequencing method, Maxam-Gilbert sequencing method.

Module 3: (13 Lecture hours)
Polymerase chain reaction, Primer design, Variants of polymerase chain reaction, DNA fingerprinting, DNA footprinting, Site-directed mutagenesis, Restriction fragment length polymorphism, Application of genetic engineering in agriculture, medicine, Cloning of Dolly the sheep, Creation of synthetic bacteria.

References:

1. S. B. Primrose and R. Twyman, Principles of Gene Manipulation and Genomics, 7thEdn. Wiley-Blackwell, 2006.
2. D. S. T. Nicholl, An Introduction to Genetic Engineering, 3rdEdn. Cambridge University Press, 2008.
3. J. D.Watson, T. A. Baker, S. P. Bell, and A. Gann, Molecular Biology of the Gene, 6thEdn. Benjamin Cummings, 2007.
4. J. Dale and M. von Schantz, From Genes to Genomes: Concepts and Applications of DNA Technology, 2ndEdn. Wiley-Interscience, 2007.

BT3002D BIOINFORMATICS

Prerequisite: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Introduction to Bioinformatics, Nucleotide and Protein sequence databases, Genbank, NCBI, DDBJ, Pubmed, UniProt, PROSITE, SCOP; Protein structural data bases – RCSB-PDB, EMBL-EBI,Nucleotide and Protein Sequence analysis,Substitution matrices, PAM, BLOSUM, Gap penalties, Sequence homology searching using FASTA and BLAST, Dynamic programming algorithms for sequence alignment.

Module 2: (13 Lecture hours)
Multiple alignments, Common multiple alignment methods, Practical aspects of multiple alignments for identification of motifs and patterns, CLUSTALW, PROSITE, Hidden Markov model, Phylogenetic analysis, Elements of phylogenetic models, Determining the substitution model tree, Evaluating phylogenetic trees.

Module 3: (13 Lecture hours)
Predictive methods, Codon bias detection, Detection of functional sites in the DNA sequences, Plasmid construction, Restriction mapping of DNA, Primer design, Modular nature of proteins - Protein identity based on primary, secondary and tertiary structure of proteins, Sequencing of DNA-Human Genome Project, Detection of SNPs and their relevance, Gene predictions, protein homology modeling, Bioinformatics approaches for Molecular modeling in drug discovery.

References:

1. Arthur K. Lesk, Introduction to Bioinformatics, 3rdEdn. Oxford University Press, 2008.
2. J. Pevsner, Bioinformatics and Functional Genomics, 2ndEdn. Wiley-Blackwell, 2009.
3. R. Drubin, S.R. Eddy, A. Krogh, and G. Mitchison, Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, 1stEdn, Cambridge University Press, 1999.
4. W.H. Majoros, Methods for Computational Gene Prediction, 1st Edn. Cambridge University Press, 2007.

.MT4024D MATERIAL FUNDAMENTALS FOR BIOMEDICAL APPLICATIONS

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)

Biomaterials: Definition, Introduction – Bulk properties – Surface properties. Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, physical (electrical, optical, magnetic, thermical), chemical and biological properties.

Module 2: (13 Lecture hours)

Biology, Biochemistry and medicine: Proteins – Cells – Tissues. Host reactions to biomaterials: Inflammation, Wound Healing, and the Foreign Body Response – Immunology and the Complement System - Systemic Toxicity and Hypersensitivity – Blood Coagulation and Blood-Materials Interactions – Tumorigenesis and Biomaterials – Implant-associated Infection – Testing of Biomaterials. Biocompatibility, implant associated infection; Testing of biomaterials: *in vitro* assessment, *in vivo* assessment, blood materials interactions; Desinfection and sterilization of biomaterials.

Module 3: (13 Lecture hours)

Design of materials for biomedical application: Cardiovascular, dental implants, orthopedic application, skin, ophthalmologic applications, wound healing, sutures, biomedical and biosensors; Implantation techniques for soft tissue and hard tissue replacements; Problems and possible solutions in implant fixation; Failure analysis of medical devices and implants.

Degradation of biomaterials in the biological environment: Chemical and biochemical degradation – Degradative effects – Mechanical breakdown – Pathologic calcification of biomaterials.

References:

1. Amit Bandyopadhyay, Susmita Bose, *Characterization of Biomaterials,* Elsevier, 1st edition 2013.
2. Chandra P. Sharma, *Biointegration of Medical Implant Materials: Science and Design,* Elsevier, 1st edition 2010.
3. Eliaz, *Degradation of Implant Materials,* Noam (Ed.), Springer 2012.
4. Buddy D. Ratner, Allan S. Hoffman*, Biomaterials Science: An Introduction to Materials in Medicine* Academic Press, 3rd edition 2012.

MT4025D BIOSENSORS AND DEVICES

Pre-requisites: Nil

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L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Lecture hours)
Defining the basic concept of a biosensor, Difference from any other chemical sensor, Overview of biosensor applications, medicine, agriculture, bioproduction, and environment, Desired characteristics of biosensors: reliability, simplicity, cost, and related parameters, operating conditions, calibration, positive and negative controls, safety, Calibration curves, the method of standard addition, and sensitivity , signal-to-background ratio, and detection limits, Generations of biosensors – first, second and third, Design of biosensors- Samples, transducers and electronics, CMOS-Based Biosensors.

Module 2: (13 Lecture hours)
Biochemical recognition, Enzymes: biological catalysts, specificity, activity, Enzyme kinetics in solution and on a surface. Chemical equillibria- forcing an unfavourable reaction, Cells: Signal transduction through chemoreception, membrane potential, cell metabolism, cytotoxicity, and transformed 'bioreporter' organisms , Antibodies: Immunochemistry, binding affinity and kinetics; Nucleic Acids (RNA and DNA): Basic biochemistry, hybridization; Amplification/self replication; Secondary Structure and folding, Aptamer (oligonucleotide) based recognition and molecularly imprinted polymers, Nanomaterial based sensors- role of 1D ,2D and 3D nanomaterials and case study, Biochips-fundamentals and applications, DNA arrays, Protein Chips, Electronic and Electrochemical microarray chips, Lab-on-Chips.

Module 3: (16 Lecture hours)
Fundamentals of SERS, SERS based sensors, SERS based single molecular detection, Surface Plasmon based sensors, Fluorescence based sensors, FRET, Fiber optics sensors, Piezoelectric biosensors, colorimetric sensors, Electrochemical biosensors – Amperometric, potentiometric, conductometric, field effect transistors, Surface Acoustic Wave Sensors (SAW), Applications, Lab-on-a-chip bio chemical sensors. Enzyme-based biosensors, e.g., the blood glucose sensor, Array-based DNA "biochip" sensors with fluorescence detection, Recent developments in diagnostic tools including "zero-cost" paper microfluidics, DNA sequencing, genetic analysis and single cell analytics

References:

1. L. Gorton, *Biosensors and Modern Biospecific Analytical Techniques*, Elsevier, 2005.
2. Gennady Evtugyn ,*Biosensors-Essentials*, Springer-Verlag, Berlin, 2014.
3. Xueji Zhang, Huangxian Ju, Joseph Wang, *Electrochemical Sensors, Biosensors, Biosensors and their Biomedical Applications*, Academic Press, 2007.
4. Robert S. Marks, Christopher R. Lowe, David C. Cullen, Howard H. Weetall, Isao Karube- *Handbook of Biosensors and Biochips*, John Wiley & Sons,2007.
5. Jon Cooper, Tony Cass, *Biosensors- a practical approach*, Oxford University Press, USA 2004.
6. Ashutosh Tiwari, Anthony P. F. Turner, *Biosensors Nanotechnology*, Wiley, 2014.

TRACK 3– POLYMER TECHNOLOGY

MT3025D POLYMER MATERIALS

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (11 Lecture hours)
General Introduction to individual polymers: Manufacture, structure, properties and applications of styrene butadiene rubber, poly isoprene rubber, comparative evaluation of these different unsaturated rubbers, comparison of polyisoprene rubber with natural rubber with respect to structure, properties and applications. Acrylonitrile- butadiene rubber and polychloroprene rubber.

Module 2: (12 Lecture hours)
Manufacture, general properties and applications of butyl rubber, EPDM and EPM. Comparison of these rubbers with unsaturated elastomers with respect to chemical properties, vulcanization and end uses. Study of other speciality elastomers like hypalon, silicones, polyurethanes, fluorocarbons, ethylene vinyl acetate copolymers etc. Manufacture, properties and applications of different thermoplastic elastomers.

Module 3: (16 Lecture hours)
Preparation, general properties and end use of polyolefins viz. polyethylenes, PVC, polyvinylidene chloride, PTFE, PP, polystyrene, olefin copolymers viz. copolymers of acrylonitrile, styrene, butadiene and vinyl chloride and their terpolymers. Polyacrylics, polyvinyl acetate and polyvinyl alcohol. Preparation, properties and uses of polyamides like Nylon 6 and Nylon66, aromatic polyamides like Kevlar. Polyimides-their structure, preparation and uses. Silicone resins and fluids. Important polyesters in commercial applications. Detailed study on PET and unsaturated polyesters. Cellulose esters used in plastic application, polyurethane foam and coatings. Difference between thermoplastics and thermosets. Manufacture of different PF, UF and MF resins, epoxy, their structure, properties and applications.

References:

1. Morton, Maurice, ed. *Rubber technology*. Springer Science & Business Media, 2013.
2. Blow, Claude M. *Rubber technology and manufacture*, ButterworthHeinmann Ltd, 1971.
3. Brydson, John Andrew. *Plastics materials*. Elsevier, 1999.
4. Whitby, George Stafford, ed. *Synthetic rubber*. J. Wiley, 1954.
5. Ulrich, Henri. *Introduction to Industrial Polymers*, Hanser Publishers, 1993.
6. Moncrieff, Robert Wighton, *Man-made fibres,* Butterworth-Heinemann Ltd, 1975.

MT3026D RUBBER TECHNOLOGY

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Lecture hours)
Processing of field latex into various forms like (a) preserved field latex (b) latex concentrate process like centrifuging and creaming (c) ribbed smoked sheets (d) crepe rubber (e) technically specified solid block forms (crumb rubber) (f) superior processing rubber etc.

Module 2: (13 Lecture hours)
Additives used in rubber compounding: Curing systems, antidegradants, plasticisers, fillers, colourants, blowing agents etc. General compound design. Machinery used for mixing, two roll mill, internal mixers and continuous mixers, extrusion technology, calendering and different types of calenders.

Module 3: (16 Lecture hours)
Moulding: Compression, transfer and injection moulding, different methods of vulcanization such as rotocure, autoclave open steam, high energy radiation etc. Manufacturing methods for the products like (a) rubber foot wear (b) beltings (c) hoses and tubings (d) wire and cables (e) rubber to metal bonded articles (f) mechanical seals, cellular products, manufacture of latex products like foam, dipped goods, latex thread etc.

References:

1. Blow, Claude M. *Rubber technology and manufacture*, ButterworthHeinmann Ltd, 1971.
2. Blackley, David Charles. *Polymer Latices: Science and Technology Volume 3: Applications of Latices*. Springer Science & Business Media, 2012.
3. Birley, A. W. *Polymer processing.* DH Morton-Jones, Chapman and Hall, London, British Polymer Journal 22.4, 1990.
4. Hofmann, Werner. *Rubber technology handbook*. Hanser Publishers, 1989.
5. Naunton, William Johnson Smith, *Applied science of rubber,* Edward Arnold. 1961.

MT4026D TYRE TECHNOLOGY

Pre-requisites: Nil
.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Lecture hours)
A historical introduction to the design and development of tyres of various kinds and types. The current status of tyre industry in India and its future prospects, tyre sizing and marking on the tyres. Different types of tyres: bias, radial, bias-belted tyre and tubeless tyre - their basic functions and performance comparisons. Different components of a tyre, its geometry, basic functions. Functions of a pneumatic tyre: load carrying capacity, vibration and noise reduction, tyre function as a spring, varcontribution to driving control and road adhesion, the tyre friction contribution to driving control, steering control and self-aligning torque.

Module 2: (10 Lecture hours)
Cord-rubber composites and its properties, failure mechanism of cord reinforced rubber. Mechanics of tyre pavement interaction. Tyre forces on dry and wet road surfaces. Tractive forces on dry, wet, ice snow and irregular pavements, breaking and traction of tyres. Tyre wear, rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc. on noise.

Module 3: (19 Lecture hours)
Manufacturing techniques of various tyres, Principles of designing formulations for various rubber components. Tyre reinforcement materials (Textile, steel, glass etc.). Criteria of selection, different styles and construction, textile treatment. Tyre mould design, green tyre design principles, methods of building green tyres for bias, bias-belted, radial and tube-less tyres, green tyre treatments. Tyre curing methods, Tyre related products, their design and manufacturing techniques, tubes, valves, flaps, bladders. Different types, features and operation of tyre building machines, bead winding machine, wire/glass processing machines. Measurement of tyre properties. Tyre construction analysis, endurance test, wheel and plunger tests, traction, noise measurements. Force and moment characteristics, Rolling resistance, non-uniformity, dimensional variations, force variations, radial force variation, lateral force variation. Type, balance, and mileage evaluations. Tyre flaws and separations. X- ray, holography etc. Foot print pressure distribution. BIS standards for tyres, tubes and flaps.

References:
1. Moore, D. F., and D. I. Livingston. "Book Review: A Review of “The Friction of Pneumatic Tyres”." *Tire Science and Technology* 3.4 (1975)
2. French, Tom. *Tyre technology*, Taylor & Francis, 1989.
3. Clark, Samuel K., ed. *Mechanics of pneumatic tires*. US Government Printing Office, 1981.
4. Kovac, Frederick J. "*Tire technology*." 1973.

MT4027D PLASTIC PROCESSING

Pre-requisites: Nil
.

L	T	P	C
3	0	0	3

Total hours: 39

Module: 1 (9 Lecture hours)
Introduction to plastics processing, additives for plastics, mixing and compounding of plastics, mixing and compounding equipment's.

Module 2: (13 Lecture hours)
Injection Moulding: Types of machines, constructional features, details of moulding process, injection moulding of thermosets. Extrusion: Constructional details of extruders, twin screw extruders, dies and take - off equipment, post extrusion processing, calendering, laminating, Rotational moulding: Process and equipment.

Module 3: (17 Lecture hours)
Compression moulding: Hydraulic presses, press capacity and pressure calculations, moulding process. Transfer moulding: Moulding process, advantages. Blow moulding: Extrusion and injection blow moulding. Reaction injection moulding: Introduction, process, advantages. Reinforced plastics: Materials, processing techniques viz - hand lay up, spray lay up, filament winding, autoclave and bag moulding; RRIM.

References:

1. Crawford, Roy J. *Plastics engineering*. Elsevier, 1998.
2. Frados, Joel. *Plastics engineering handbook of the Society of the Plastics Industry, inc*. Van Nostrand Reinhold Company, 1976.
3. Birley, A. W. *Polymer processing*. DH Morton-Jones, Chapman and Hall, London, British Polymer Journal 22.4, 1990.
4. Matthews, George, *Polymer mixing technology*, Elsevier Science Ltd, 1982.

TRACK 4 – METALLURGY

MT3027D PHYSICAL AND MECHANICAL METALLURGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Introduction to atomic bonding. Crystallography: types of crystal structures, unit cell, co-ordination number, atomic packing factor, miller indices, linear and planar density, inter-planar spacing. Types of crystal imperfections: point defects, dislocations, stacking fault, plastic deformation by slip twinning, critical resolved shear stress, dislocation lock, dislocation pile-up, grains and grain boundaries, concept of texture. Strengthening mechanisms: Hall-petch equation, thermo mechanical processing. Metallography: Optical microscopy & specimen preparation, SEM, TEM, X-Ray diffraction. Diffusion: diffusion mechanisms, laws of diffusion, inter-diffusion and Kirkendall effect, types of diffusion, problems based on diffusion.

Module 2: (16 Lecture hours)
Solidification of metals and alloys: cooling curves, nucleation and growth, homogeneous and heterogeneous nucleation, directional solidification. Solid solution, types of solid solutions, Hume-Rothery's rule. Limits of solubility, isomorphous system, lever rule, constitutional super cooling, effect of non-equilibrium cooling, eutectic, peritectic, eutectoid & peritectoid system, complex phase diagram, ternary diagram, composition triangle, ternary eutectic, vertical and horizontal sections, structure of cast metal, coring, segregation & porosity. Binary phase diagrams of common commercial alloys (like; Fe-C, Cu-Sn, Al-Si, Al-Cu, Al-Li, Cu-Ni, Au-Cu, Ni-Cr, Pb-Sn, Cu-Zn, Cu-Sn, Cu-Al, Ti-Al, Ti-V, etc.) and their equilibrium diagrams, discussion on structures, properties and uses. Heat treatment of steel: Annealing, normalizing, hardening & tempering, hardenability T-T-T diagram, Pearlitic, Martensitic & Bainitic transformation, effect of alloy elements on phase diagram & TTT diagram, CCT diagram.
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Module 3: (10 Lecture hours)
Mechanical behaviour of materials: elastic and plastic deformation, stress-strain relationship, plastic deformation of metallic materials, engineering stress-strain & true stress-strain curve.
Fracture: elementary theories of fracture, fracture types, Griffith’s theory of brittle fracture. Hardness Test: different methods, microhardness test, relationship between hardness and other mechanical properties. Impact Test: Charpy and Izod Tests, DBTT curve and its importance, factors affecting the transition temperature, temper embrittlement, Fracture toughness. Fatigue Test: Introduction, stress cycles, S-N Curve, mechanism of fatigue failure, factors affecting fatigue, fatigue life improvement. Creep: Introduction, creep curve, structural changes during creep, mechanism of creep deformation, theories of creep, stress relaxation.

References:

1. Physical Metallurgy - Principles and Practice, Raghavan V., Prentice - Hall of India, 1993
2. Elements of Physical Metallurgy, Guy A.G., 3rd Edition, Addison Wesly, 1974.
3. Reed-Hill, Robert E., Reza Abbaschian, and Reza Abbaschian, *Physical metallurgy principles,* Cengage Learning, 1973.
4. Porter, David A., Kenneth E. Easterling, and Mohamed Sherif. *Phase Transformations in Metals and Alloys,* CRC press, 2009.
5. Verhoeven, John D. *Fundamentals of physical metallurgy*. New York: Wiley, 1975.
6. Cahn, Robert W., and Peter Haasen, eds. *Physical metallurgy*. North-Holland Physics Pub., 1983.

ME3121D POWDER METALLURGY

Pre-requisites: Nil
.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 Lecture hours)
Versatility and benefits of powder metallurgy; PM process; powder production techniques: mechanical, atomization, chemical reduction, carbonyl and electro-chemical processes; ceramic powder production; powder properties and their characteristics; sieve analysis, microscopy, sedimentation analysis; specific surface and other technological properties; powder conditioning.

Module 2: (15 Lecture hours)
Compaction and shaping; cold and iso-static compaction, die compaction, pressing equipments and tooling; powder injection moulding; extrusion and rolling; hot compaction techniques: hot iso-static pressing (hip), equipments, tooling and applications; explosive compaction; slip casting. Sintering stages, single component, material transport mechanisms; model studies: powder shrinkage experiments; sintering diagrams and sintering anomalies; multi-component sintering: solid phase and liquid phase, infiltration and reaction sintering; sintering atmospheres and equipments

Module 3: (12 Lecture hours)
Powder metallurgy products: HSS and carbide tools, porous parts, sintered carbides, cermets, electric and magnetic parts; ceramic components, sintered friction materials; P/M parts of the year; research trends in powder metallurgy.

References:

1. F. Thummler and R. Oberacker, *An introduction to Powder Metallurgy.* The Institute of Materials, The University Press, 1993.
2. ASM Handbook (Vol 7), *Powder Metal Technologies and Application*, 1984.
3. F. Leander and W. G. West, *Fundamentals of Powder Metallurgy.* Metal Powder IndustriesFederation, 2002.
4. G. S. Upadhyaya, *Powder Metallurgy Technology,* 1 1st ed. Cambridge International Science Publishing Co, 2002.
5. A. K. Sinha, Powder *Metallurgy.* Dhanpat Rai Publications, 2003.
6. P. C. Angelo and R. Subramanian, *Powder Metallurgy,* 1st ed. Prentice Hall of India, 2008.

MT4028D STEEL AND NON-FERROUS METALLURGY

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (16 Lecture hours)
Introduction to discovery of metals, importance of metals in modern world, classification of metals and alloys, applications. General principles for extraction of metals, energy and environmental issues in extraction. Introduction to solidification and casting Processes: Process of nucleation and growth, thermodynamical theory and nucleation, homogeneous and heterogeneous nucleation in solids, growth of new phase in solution, dendritic and cellular growth, freezing of ingots. Final finishing operations: surface treatment, heat treatment, shaping and secondary product manufacturing (including deformation processing).

Module 2: (13 Lecture hours)
History of modern steelmaking and Indian scenario. Steelmaking reactions such as oxidation of carbon, silicon, manganese, iron, phosphorous and chromium. Role of refractory and their physicochemical properties in steelmaking. Steelmaking practice; basic oxygen steelmaking; electric steelmaking; recent developments in steelmaking. Types of steel;: Composition, structure, Fe-FeC diagram, solidification process, effect of structure on properties, heat treatments of castings, liquid quench and temper, alloy steels, measurements of hardenability and its significance, production, heat treatment, solidification of steels.

Module 3: (10 Lecture hours)
General methods of extraction in Pyrometallurgy: Drying, calcination, roasting and smelting. Hydrometallurgy: leaching, solvent extraction, ion exchange, precipitation, Electrometallurgy: electrolysis and electro-refining General methods of refining: basic approaches, preparation of pure compounds, purification of crude metal produced in bulk. Production of Cu, Ni, Pb, Zn, Al, Au, Ag, Mg, W, Mo and Ti.

References:

1. Habashi, Fathi. *Handbook of extractive metallurgy*. Wiley-Vch, 1997.
2. American Society for Metals. *Metals handbook. 2. Properties and selection: nonferrous alloys and special-purpose materials*. American Society for Metals, 1990.
3. Ray H.S., Sridhar R., Abraham K.P.;.Extraction of Non-ferrous Metals; West Publin., 1990.
4. Rosenquist T; Principles of Extractive Metallurgy; McGraw Hill Koga Kusha, 1985.
5. Ghosh, A. and Chatterjee, A., Principles and Practices in Iron and Steelmaking, Prentice Hall of India, New Delhi, 2008.
6. Ghosh, A., Secondary Steelmaking, CRC Press, Boca Raton, 2000.

GENERAL ELECTIVES

MT3028D APPLICATION OF NANOFLUIDS

L	T	P	C
3	0	0	3

Pre-requisites: Nil

Total hours: 39

Module 1: (10 Lecture hours)
Nanomaterial – Methods of synthesis – Synthesis of Nanofluids- two step methods- single step method- stability – Sonication- Colloidal stability - Electrical double layer- stabilization methods – steric stabilization - electrostatic stabilization – Surfactants- Types of surfactants – DLVO Theory- Methods of stability measurement - Dynamic light scattering system – Zeta potential – Acoustic Attenuation spectroscopy- Properties of nano fluids- thermal conductivity –viscosity – specific heat – Maxwell’s relations- thermal conductivity models- wetting characteristics. Microscale Fluidic Applications.

Module 2: (10 Lecture hours)
Application of nanofluids in refrigeration and air conditioning - Magnetic nano particles - Rheological fluids - Ferro fluids. Application of nanofluids in Lubricants – Types of lubricants – properties- Nano lubricant additives –solid lubricant additives – lamellar structure – synthesis and characterization - MoS_2/WS_2/graphene nanoparticles- Synthesis methods - Hydraulic assisted exfoliation – Friction and wear measurements – pin on disc –four ball tester. CO_2 sequestration – absorption media – absorption mechanisms.

Module 3: (8 Lecture hours)
Fuels – properties - Nano fuel additives – catalytic nano particles – synthesis and characterization - cerium – defects - cerium based mixed oxide nanoparticles – oxygen storage capacity –diesel engine exhaust emissions HC, CO, NOx, CO_2, smoke - Diesel particulate filter -DPF regeneration, – Alumina in combustion process- Nanoparticle counters. Heterogeneous catalyst for trans esterification of biodiesel- Copper-oxide and Aluminum-oxide brake nanofluid- Electronics applications- Bio medical applications.

Module 4: (11 Lecture hours)
Active and passive methods of enhancing heat transfer – Nanofluid – Heat exchangers – Nanofluid Coolant- Modified surfaces – Surface wetting - Flow stability in thermosyphon loops –Non-intrusive measurements– electric and magnetic field - acoustic waves; Nano encapsulated phase change material- boiling and condensation; Solar-Thermal Energy Collectors - Optical properties of nanofluids - Calorimetry.

References:

1. Nanofluids: Science and Technology, Sarit K. Das, Stephen U. Choi, Wenhua Yu, T. Pradeep, Wiley, 2007.
2. Heat Transfer Enhancement with Nanofluids, Vincenzo Bianco, OronzioManca, Sergio Nardini, KambizVafai, CRC Press, 2017.
3. Thermal Energy Storage Using Phase Change Materials: Fundamentals and Applications, Amy S. Fleischer, Springer, 2015.
4. Applications of Nanofluid for Heat Transfer Enhancement, Mohsen Sheikholeslami and Davood Domairry Ganji, Elsevier, 2017.
5. Nanofluids: Synthesis, Properties and Applications, S M SohelMurshed, Carlos Nieto de Castro, Nova Science Publishers, 2014.

MT3029D MICRO AND NANO FLUIDICS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Introduction to microfluidics, continuum fluid mechanics at small scale, gas and liquid flows, Transport phenomena and related non-dimensional numbers, low Reynolds number flows, surface tension effects, electrokinetics, open surface microfluidics, fundamentals of nanofluidics, fluid flow through nanoporous medium, multiphase flow.

Module 2: (13 Lecture hours)
Fabrication techniques for microfluidics, photolithography, silicon based micromachining, polymer based micromachining, bonding techniques, wafer level assembly and packaging, flow characterization techniques, PIV technique, laser induced fluorescence and confocal microscopy, lab-on-a-Chip devices.

Module 3: (13 Lecture hours)
Biomimetic micro and nanofluidics, surface wettability, smart materials, optofluidics, magnetofluidics, acoustic fluidics, microfluidic optical systems, capillary force actuators, microfluidic sensors, microfluidic valves, particle separation techniques at fluid-fluid interface, microneedles and micromixers, immobilization and detection of biomolecules, clinical diagnostics.

References:

1. Tabeling, P. Introduction to Microfluidics, Oxford, 2005.
2. Nguyen, Nam-Trung, Steven T. Wereley, and Steven T. Wereley. *Fundamentals and applications of microfluidics*. Artech house, 2002.

MT3030D MICRO ELECTRO MECHANICAL SYSTEMS

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (12 Lecture hours)

Outline of micro electro mechanical devices and technologies, materials for micro electro mechanical systems, mechanical properties of MEMS materials, Electromehacnics, Structural Mechanics, material models, thermal considerations, fluid dynamics, Scaling of micro mechanical devices, Electrical principles.

Module 2: (13 Lecture hours)

MEMS Device technology – Sensors, actuators, Different sensing aspects - capacitive-piezo-resistive, inductive and optical. Electrostatic-Parallel plate-interdgitated-Thermal-lorentz force-Sensing-Capacitive-Piezo-resistive-Elctron tunnelling-MEMS Switch-Micro motors-Micro pumps-Micro mixers-Sensor noise.

Module 3: (14 Lecture hours)

MEMS fabrication, Materials for fabrication, Silicon-properties, synthesis, SOI, Physical and Chemical thin films, Wet and Dry Etching, Factors affecting etching, Isotropic and Anisotropic Etching, Etching models, Etch Stops, Plasma etching, Surface micromachining, Wafer Bonding, LIGA, MEMS Packaging

References:

1. Mohamed Gad – el – Hak (ed.), *The MEMS Handbook*, Second Edition, CRC Press, 2005.
2. James J. Allen, *Micro Electro Mechanical System Design,* CRC, 2005.
3. K. Subramanian, *Micro Electro Mechanical Systems: A Design Approach*, Springer, 2008.
4. Korvink, Jan, and Oliver Paul. *MEMS: A practical guide of design, analysis, and applications*. Springer Science & Business Media, 2010.

MT3031D CARBON NANOSTRUCTURES

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (16 Lecture hours)

Allotropes of carbon, History of fullerenes, Fullerene based structures, Chemistry of fullerene, Carbon nanotube structure and defects, Physics of nanotubes, Special properties of carbon nanotubes, Synthesis- Growth mechanism, Arc discharge, Laser ablation, Chemical vapour deposition, Flame synthesis, Purification, Functionalization. Determination of nanotube properties, Graphene, structure and properties, imaging of graphene, defects and atomic dynamics, electronic structure of graphene, massless relativistic Dirac fermions, and chirality, Quantum hall effect, Anomalous QHE in bilayer Graphene, From graphene to Graphane, Electronic and magnetic properties, synthesis, applications. Graphene nanoribbon, graphene quantum dots.

Module 2: (12 Lecture hours)

Carbon dots, Carbon nanofibres and filaments, Diamond-like Carbon films (DLC), classification of DLC, properties and applications of DLCs, DLC/graphite transformation, Optical properties, electrical properties, mechanical properties, chemical resistance, tribological properties; deposition techniques of DLC films. Nanocrystalline diamond (NCD) films, pretreatment processes to enhance the nucleation of NCD films, Properties and applications of NCD films, amorphous nanocarbons, carbon black, lamp black, acetylene black, carbon nano onions. .

Module 3: (11 Lecture hours)

Potential applications of carbon nano materials , Energy storage, Molecular electronics with CNTs, Nanoprobes and sensors, Composite materials, water purification, Carbon nanotubes in Biomedical Engineering, Drug delivery systems, Cell and tissue labeling and imaging, . Toxicology of carbon nanomaterials: Status, trends, and perspectives.

Reference:

1. Peter J. F. Harris, "*Carbon Nanotubes and Related Structures*", Cambridge University Press, 2001.
2. Hashem Rafii-Tabar, "*Computational Physics of Carbon Nanotubes*", Cambridge University Press, 2007.
3. M. Meyyappan, "*Carbon Nanotubes: Science and Applications"*, CRC Press, 2004.
4. Michael J. O'Connell, "*Carbon Nanotubes: Properties and Applications*", CRC Press, 2006.
5. Enoki, Toshiaki, *"Physics and Chemistry of Graphene: Graphene to Nanographene*", World Scientific Pub Co Inc, 2010.
6. Rakesh Behari Mathur, Bhanu Pratap Singh, Shailaja Pande, *Carbon Nanomaterials: Synthesis, Structure, Properties and Applications*, Taylor & Francis, 2017.

MT3032D SEMICONDUCTOR NANOSTRUCTURES

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (10 Lecture hours)

Semiconductor nanoparticles: Electronic structure, size–dependent physical properties, Melting point, Solid-state phase transformations, Excitons, Band-gap variations-quantum confinement, Fine structure and Polarization properties of Band-Edge Excitons in semiconductor nanocrystals, Effect of strain on band-gap in epitaxial quantum dots, Single particle conductance.

Module 2: (13 Lecture hours)

Semiconductor nanoparticles: Synthesis and manipulation, Cluster compounds, Quantum-dots from MBE and CVD, wet chemical methods, Reverse micelles, Electro-deposition, Pyrolytic synthesis, Self-assembly strategies, nanocrystal doping, phase transitions and phase control. Nanocrystal assembly and encapsulation, Semiconductor nanowires, Fabrication strategies, Quantum conductance effects in semiconductor nanowires, Porous Silicon, Nanobelts, Nanoribbons, Nanosprings.

Module 3: (16 Lecture hours)

Semiconductor nanoparticles–applications, Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, Intraband Spectroscopy and Dynamics of colloidal semiconductor quantum dots, Surface-trap passivation in core-shell nanoparticles, Charge carrier dynamics and optical gain in nanocrystal quantum dots: from fundamental photophysics to quantum dot lasing, Carrier injection, LED and solar cells, Electroluminescence, Barriers to nanoparticle lasers, Mn-Zn-Se phosphors, Light emission from indirect semiconductors, Light emission form Si nanodots. Quantum dots and quantum dot arrays: synthesis, optical properties, photogenerated carrier dynamics, and application to photon conversion.

References:

1. Victor I. Klimov, "*Semiconductor and Metal nanocrystals*", Marcell-Dekker, 2004.
2. Hari Singh Nalwa, "*Encyclopedia of Nanotechnology*", American Scientific Publishers. 2004.
3. Bharat Bhusan, "*Springer Handbook of Nanotechnology*", Springer, 2007
4. A. A. Balandin, K. L. Wang, "*Handbook of Semiconductor Nanostructures and Nanodevices*", Vol 1-5, American Scientific Publishers, Stevenson Ranch, Calif, 2006, vol. 3, p. 45.
5. Guozhong Cao, "*Nanostructures and Nanomaterials - Synthesis, Properties and Applications*", Imperial College Press, 2004
6. Gunter Schimd "*Nanoparticles –From theory to application*", Wiley-VCH, 2004.

MT3033D INTERFACE AND COLLOID SCIENCE

Pre-requisites: Nil

.

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)

Solid and liquid surfaces, surface tension and surface energy, wetting, solid-liquid-fluid systems, surfactants and surfactant classifications, surface pressure, hydrophilic/lipophilic balance, adsorption and desorption, electrostatic forces, chemical and physical interactions, Induced dipole and hydrogen bonding at the interface, electrokinetic phenomena.

Module 2: (13 Lecture hours)

Introduction to colloids, formation and stability of colloids, solvent effects, coagulation concepts, Microbubbles, fabrication and applications of microbubbles, foams, thermodynamics of foam stability, emulsions, polymeric emulsifiers, microemulsions, nanoemulsions, liquid and solid aerosols.

Module 3: (13 Lecture hours)

Nano-/microparticles at the interface, stabilization of particles at the interface, structure and formation of particle layers at the interface, self-assembly and directed assembly of particles at the interface, particle-particle interactions, applications of particles at the interfaces, liquid marbles- physics and applications.

References:

1. Drew Myers, Surfaces, *Interfaces, and Colloids: Principles and Applications*, Second Edition, John Wiley & Sons, Inc.
2. Bernard P. Binks and Tommy S. Horozov, *Colloidal Particles at Liquid Interfaces*, 2006, Cambridge University Press.
3. Tsuge, Hideki. *Micro-and Nanobubbles: Fundamentals and Applications*. Pan Stanford, 2014.

MT4029D INTRODUCTION TO TEXTILE ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Introduction to textile engineering- Textile Fiber- Classification of Textile Fiber- Natural fiber- Synthetic Fiber-Fiber Availability- Cost Production- Life-Expectancy- Chemical Treatment- Fiber properties –Primary properties of textile fibers-Secondary properties of textile fiber-Molecular arrangement-Orientation-Crystallinity-Amorphousness

Module 2: (13 Lecture hours)
Structure of fiber –X-ray diffraction method-Infra-red radiation method-Electron microscopic method-Optical microscopic method-Thermal analysis-Nuclear magnetic resonance methods-Density-General physical property-The chemistry of fiber material

Module 3: (13 Lecture hours)
Moisture absorption-Measurement of moisture- oven dry method -IR drying method-Capacitance/Resistance method-Moisture and Fiber Properties-Factors Affecting the Regain of Textile Material-Textile characteristic of fiber-Elastic recovery-Behaviour of fiber.

References:

1. Hussain, Tanveer, et al. *Textile Engineering: An Introduction* Walter de Gruyter GmbH & Co KG, 2016.
2. Nawab, Yasir, Syed Talha Ali Hamdani, and Khubab Shaker, eds. *Structural Textile Design: Interlacing and Interlooping.* CRC Press, 2017.
3. Rouette, Hans-Karl, and Beate Schwager. *Encyclopedia of textile finishing*. Vol. 20. Berlin: Springer, 2001.
4. Horrocks, A. Richard, and Subhash C. Anand, eds. *Handbook of technical textiles*. Elsevier, 2000.

MT4030D HIGH PERFORMANCE MATERIALS

Pre-requisites: Nil

L	T	P	C
3	0	0	3

Total hours: 39

Module 1: (13 Lecture hours)
Overview of Smart Materials, Introduction and Principles of Piezoelectric effect, Ferroelectric effect, Triboelectric effect, Piezoceramic Materials, Piezoelectric Polymers, Magnetostriction, Magneto-resistance effect, electro-active Materials, electro-active polymers, aspects of shape memory, shape memory materials, shape memory polymers, rheological fluids.

Module 2: (13 Lecture hours)
Sensors and actuators using piezoelectric materials, shear sensing, accelerometers, effect of various factors on sensing, active fiber sensing, magnetostrictive sensing, smart materials and structural health monitoring, Smart sensors, Piezoelectric Actuators, Amplified Piezo Actuation, Magnetostrictive Actuation, Polymeric Actuators, Shape Memory Actuators.

Module 3: (13 Lecture hours)
Smart composites, introduction to composite material, Micro and Macro-mechanics, modelling laminated composites based on classical laminated plate theory, effect of shear deformation, dynamics of smart composite beam, finite element modelling of smart composite beams, piezoelectric transducers, energy harvesting materials, self-healing polymers.

References:

1. Brian Culshaw, *Smart Structures and Materials*, Artech House, 2000.
2. Gauenzi, P., *Smart Structures*, Wiley, 2009.
3. Zuo-Guang Ye, *Handbook of dielectric, piezoelectric and ferroelectric materials synthesis, properties and applications,* Wood head Publishing Limited and CRC Press LLC,2008.
4. Ramadan, Khaled S., D. Sameoto, and S. Evoy. *"A review of piezoelectric polymers as functional materials for electromechanical transducers*." *Smart Materials and Structures* 2014.
5. Otsuka, Kazuhiro, and Clarence Marvin Wayman, eds. *Shape memory materials.* Cambridge university press, 1999.