Materials Science and Metallurgical Engineering
School of Engineering & Technology (UIET)

B.Tech.
Materials Science and Metallurgical Engineering

SYLLBUS
2025

CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY
KANPUR

UNIVERSITY INSTITUTE OF ENGINEERING & TECHNOLOGY

SCHOOL OF ENGINEERING & TECHNOLOGY

Vision

To achieve excellence in engineering education, empower students to be technically competent professionals and entrepreneurs with strong ethical values so as to significantly contribute as agents for universal development and societal transformation

Mission

To provide affordable quality education at par with global standards of academia and serve society with harmonious social diversity

To encourage new ideas and inculcate an entrepreneurial attitude amongst the students, and provide a robust research ecosystem

To practice and encourage high standards of professional ethics and accountability among students

Bachelor of Technology in Materials Science and Metallurgical Engineering

Program Outcomes (POs)

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 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 modeling 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 local development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings of national need.
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 as per global development need.

PO 11	**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 of regional development.
PO 12	**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 to technological change.

Program Specific Outcomes (PSOs)

PSO-1	Students can opt career as Scientist/Metallurgist globally.
PSO-2	Providing a platform to the undergraduate students to interact with scientists and engineers of national and international repute by deputing them to industrial and R&D centers of excellence for carrying out their Project work.
PSO-3	Able to apply the engineering knowledge to suit the present-day requirements of local, national industries and academia.
PSO-4	Professionally empowering the student as technical manpower in the industry or as an entrepreneur for production analytics and innovations for national development.
PSO-5	To impart science-based engineering education to develop professional skills that will prepare the students for immediate employment in the Metallurgical and Materials branch of engineering in industry global development need.

Program Educational Outcomes (PEOs)

1. Graduate will have applied their materials development skills and knowledge of foundation principles to the design and implementation of practical systems of global development.
2. Graduates will be successfully employed in the core field of Metallurgical and Materials industry and will be actively engaged in learning, understanding and applying new ideas and technologies as the field evolves in national development.
3. To develop the design capability among students so that they have the ability to participate in creative, synthetic and integrative activities in the field of Metallurgical and Materials Engineering local or regional level.
4. To develop a global view among students so that they can appreciate diversity in the world and in intellectual pursuits.

Curricular Components

Category of courses	Credits offered
Basic Science Core	**29**
Engineering Science Core	**32**
Humanities and Social Science Core	**16**
Departmental Core	**72**
Departmental Electives	**09**
Open Electives	**06**
Projects and Seminars	**16**
Total	**180**

Program: B.Tech. (Materials Science and Metallurgical Engineering)
Semester-wise Course Structure

1st Year – Semester 1

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MTHS101	Mathematics-I	3	1	0	4
2.	PHYS101	Physics-I	3	1	3	5
3.	ESCS101	Basic Electrical & Electronics Engg.	3	1	3	5
4.	CHMS101	Chemistry-I	3	1	3	5
5.	TCAS101	Engineering Drawing	3	0	3	5
6.	UHVS101	Universal Human Values –I (SIP)				0
		Total	**15**	**4**	**12**	**24**

1st Year – Semester 1I

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MTHS102	Mathematics-II	3	1	0	4
2.	PHYS102	Physics-II	3	1	3	5
3.	ISCS101	Programming & Computing (C & UNIX)	3	1	3	5
4.	TCAS102	Workshop Practice & IDEA Lab	3	0	6	5
5.	HSSS101	Professional Communication	3	1	0	4
		Total	**15**	**4**	**12**	**23**

2nd Year – Semester II1

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MTHS201	Mathematics-III	3	1	0	4
2.	ESCS201	Engineering Mechanics	3	1	0	4
3.	ESCS202	Basic Thermodynamics	3	1	0	4
4.	MSES201	Crystal Structure of Materials	3	0	3	4
5.	MSES202	Nature and Properties of Materials	3	1	0	4
6.	EVSS201	Environmental Science	2	0	0	2
7.	SSTS201	Summer Internship - I	0	0	2	2
		Total	**17**	**4**	**5**	**24**

2nd Year – Semester IV

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES203	Phase Equilibria in Materials	3	0	3	4
2.	MSES204	Metallurgical Thermodynamics	3	1	0	4
3.	MSES205	Principles of Metal Extraction and Refining	3	1	0	4
4.	ESCS203	Introduction to Machine Learning	3	0	2	4
5.	HSSS201	Communication Practicum	1	0	2	3
6.	UHVS201	Universal Human Values –II	3	0	0	3
		Total	**16**	**2**	**7**	**22**

3rd Year – Semester V

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES301	Phase Transformation in Metals	3	0	3	4
2.	MSES302	Mechanical Behaviour of Materials	3	1	0	4
3.	MSES303	Manufacturing Processes	3	1	0	4
4.	MSES304	Iron Making	3	1	0	4
5.		Elective - I	3	0	0	3
6.	HSSS302	Industrial Management	3	0	0	3
7.	SSTS301	Summer Internship - II	0	0	2	2
		Total	**18**	**3**	**5**	**24**

3rd Year – Semester VI

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES305	Transport Phenomenon and Rate Processes	3	1	0	4
2.	MSES306	Diffusion in Solids	3	1	0	4
3.	MSES307	Materials Characterization	3	0	3	4
4.	MSES308	Heat Treatment of Metals	3	1	0	4
5.	MSES309	Steel Making	3	1	0	4
6.	HSSS301	Industrial Economics	3	0	0	3
		Total	**18**	**4**	**3**	**23**

4th Year – Semester VII

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES401	Corrosion and Degradation of Materials	3	1	0	4
2.	MSES402	Fuel, Refractories and Furnaces	3	1	0	4
3.	MSES403	Polymers and Composite Materials	3	1	0	4
4.	MSES404	Application of Transport Phenomenon in Metal Processing	3	1	0	4
5.		Elective - II	3	0	0	3
6.	PRTS401	Project -I	0	0	10	5
7.	SSTS401	Summer Training	0	0	2	2
		Total	**15**	**4**	**12**	**26**

4th Year - Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.		Elective –III	3	0	0	3
2.		Open Elective – I / Elective –IV	3	0	0	3
3.		Open Elective – II / Elective – V	3	0	0	3
4.	PRTS402	Project -II	0	0	10	5
		Total	**9**	**0**	**10**	**14**

Total Credits – 180

List of Departmental Elective Courses

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES501	Electrochemical Technology in Materials Processing	3	0	0	3
2.	MSES502	Recycling of Metallurgical and Electronic Waste	3	0	0	3
3.	MSES503	Engineering Polymers	3	0	0	3
4.	MSES504	Welding and Joining of Metals	3	0	0	3
5.	MSES505	Electronic Ceramic Materials	3	0	0	3
6.	MSES506	Materials Engineering	3	0	0	3
7.	MSES507	Modern Steel Making and Alloying	3	0	0	3
8.	MSES508	Electronic Materials for Industry	3	0	0	3
9.	MSES509	Principles of Powder Processing	3	0	0	3
10.	MSES510	Nano Materials and Their Properties	3	0	0	3
11.	MSES511	Computing Methods in Materials Engineering	3	0	0	3
12	MSES512	Artificial Intelligence and Machine Learning in Materials Engineering	3	0	0	3
13.	MSES513	Electronic Properties of Materials: Computational Approach	3	0	0	3
14.	MSES514	Surfaces and Coatings	3	0	0	3
15.	MSES515	Functional Materials	3	0	0	3
16.	MSES516	Introduction to Bio Materials	3	0	0	3

List of Open Elective offered by various Departments of UIET

Name of Departments	**OEC – I (Odd Semester)**	**OEC – II (Even Semester)**
Computer Science and Engineering.	Artificial intelligence CSES528, 3(3-0-0)	Data Structures CSES208, 3(3-0-0)
	Python CSES524, 3(3-0-0)	Python CSES524, 3(3-0-0)
Electronics Engineering	Micro Processors & Applications: ECES304, 3(3-0-0)	Power Electronics ECES501, 3(3-0-0)
Mechanical Engineering	Optimization Method in Engineering MEES507, 3(3-0-0)	Robotics/Mechatronics MEES501, 3(3-0-0)
	Non-Conventional Energy Resources: MEES503, 3(3-0-0)	Design and manufacturing of Composites: MEES508, 3(3-0-0)

Courses for Minor Degree in Electronic Materials

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES201	Crystal Structure of Materials	3	0	3	4
2.	MSES202	Nature and Properties of Materials	3	1	0	4
3.	MSES307	Materials Characterization	3	0	3	4
4.	MSES505	Electronic Ceramic Materials	3	0	0	3
5.	MSES508	Electronic Materials for Industry	3	0	0	3
		Total	**15**	**1**	**6**	**18**

Courses for Minor Degree in Materials Engineering

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES201	Crystal Structure of Materials	3	0	3	4
2.	MSES202	Nature and Properties of Materials	3	1	0	4
3.	MSES307	Materials Characterization	3	0	3	4
4.	MSES403	Polymers and Composite Materials	3	1	0	4
5.	MSES506	Materials Engineering	3	0	0	3
		Total	**15**	**2**	**6**	**19**

Courses for Minor Degree in Materials Science and Metallurgical Engineering

Sl. No.	Course Code	Course Title	L	T	P	Credits
1.	MSES201	Crystal Structure of Materials	3	0	3	4
2.	MSES202	Nature and Properties of Materials	3	1	0	4
3.	MSES205	Principles of Metal Extraction and Refining	3	1	0	4
4.	MSES303	Manufacturing Processes	3	1	0	4
5.	MSES308	Heat Treatment of Metals	3	1	0	4
		Total	**15**	**4**	**3**	**20**

Detailed Syllabus

SEMESTER – I

Course Code: MTHS101 **Breakup: 3 –1 – 0 – 4**
Course Name: Mathematics-I

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Test the convergence & divergence of infinite series
CO2	Understand concepts of limit, continuity and differentiability of function of two variables
CO3	Find the maxima and minima of multivariable functions
CO4	Evaluate multiple integrals, concepts of beta & gamma functions
CO5	Apply the concepts of gradient, divergence and curl to formulate engineering problems

Course Details:

Unit-I
Sequences & Series: Definition, Monotonic sequences, Bounded sequences, Convergent and Divergent Sequences Infinite series, Oscillating and Geometric series and their Convergence, n^{th} Term test, Integral test, Comparison Test, Limit Comparison test, Ratio test, Root test, Alternating series, Absolute and Conditional convergence, Leibnitz test.

Unit II
Differential Calculus: Limit Continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers**.**

Unit III
Integral Calculus: Review of curve tracing, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions, Dirichlet's integral; Applications of Multiple integrals such as surface area, volumes

Unit –IV
Vector Calculus: Differentiation of vectors, gradient, divergence, curl and their physical meaning; Identities involving gradient, divergence and curl Line and surface integrals Green's, Gauss and Stroke's theorem and their applications

Unit–V
Probability and Statistics: Concept of probability, random variable and distribution function: discrete and continuous, Binomial, Poisson and Normal Distributions.

Text and Reference Books:

1. C.L.Liu : Discrete Mathematics, , McGraw Hill, 2^{nd} Edition, 1985.
2. B.Kolman, R.C.Busby, and S.C.Ross, Discrete mathematical structures, 5/e, Prentice Hall, 2004
3. J.L.Mott, A.Kandel and T.P.Baker : Discrete mathematical structures For computer scientists & Mathematicians , Prentice–Hall India, 1985.
4. J.P.Trembley, R. Manohar, Discrete mathematical structures with applications to computer science, McGraw –Hill, Inc. New York, NY, 1975.

Course Code: PHYS101 **Breakup: 3 –1 – 3 – 5**
Course Name: Physics-I

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the behaviour of Physical bodies
CO2	Understand the basic concepts related to the motion of all the objects around us in our daily life
CO3	Gain the foundation for applications in various applied fields in science and technology
CO4	Understand the concepts of vectors, laws of motion, momentum, energy, rotational motion, central force field, gravitation, collision and special theory of relativity
CO5	Empower the students to develop the skill of organizing the theoretical knowledge and experimental observations into a coherent understanding

Course Details: (Theory)

Unit 1
Revision of vectors, vector differentiation, ordinary derivatives of vectors, space curves continuity and differentiability, partial derivatives of vectors, gradient, divergence, curl, vector differentiation and their geometrical interpretation, various coordinate systems: polar coordinate, orthogonal curvilinear coordinate system, unit vectors and tangent vectors in curvilinear systems, special orthogonal curvilinear coordinate system, cylindrical coordinate system and spherical polar coordinate systems.

Unit 2
Inertial and non-inertial frames, fictitious force, Coriolis force, Newton's laws of motion and its applications, friction, conservative and non-conservative force, work energy theorem, conservation of linear momentum and energy, variable mass system (Rocket motion), simple harmonic motion, small oscillation, equilibrium, condition for stability of equilibrium, energy diagram, small oscillation in a bound system, working of Teetertoy.

Unit 3
Concept of centre of mass and calculation of center of mass for different objects, system of particles and collision, conditions for elastic and inelastic collision, collision in center of mass frame, rigid body kinematics, rotational motion, moment of inertia, theorems on moment of inertia, calculation of moment of inertia of bodies of different shapes.

Unit 4
Central force field, properties of central force field, inverse square law force, gravitational field and potential; Kepler's laws of planetary motion and its application
Wave mechanics, wave particle duality, De-Broglie matter wave, Schrodinger wave equations (time dependent and time independent), uncertainty principle and its applications

Unit 5
Frame of reference, Galilean transformation, Michelson-Morley experiment, postulates of special theory of relativity, Lorentz transformations, Length contraction, time dilation, velocity addition theorem, variation of mass with velocity, Einstein's mass energy relation, relativistic relation between energy and momentum, rest mass of photon.

Text and Reference Books:

1. Vector Analysis by M. R. Spiegel, Schaum's Outlines, 2021
2. Introduction to Mechanics: R. D. Kleppner and J. Kolenkow, Cambridge University Press, 2nd edition, 2014
3. A textbook of Mechanics by J. C. Upadhyay,Ram Prasas Publications; 1st edition, 2017
4. Mechanics by D. S. Mathur, S. Chand; New edition, 2000
5. Theory & Problems of Theoretical Mechanics by M. R. Spiegel, Schaum's Outline Series, 2017
6. Introduction to Special Theory of Relativity by Robert Resnick, Wiley, 1st edition 2007.
7. Concept of physics (Part-I) by H. C. Verma, Bharti Bhawan Publisher, 2022.
8. Quantum Mechanics by L.I. Schiff, McGraw-Hill Education (India) Pvt Limited, 2017.
9. A Textbook of Quantum Mechanics by P.M. Mathews and K. Venkatesan, McGraw-Hill Education (India) Pvt Limited, 2010.
10. Introduction to Quantum Mechanics by D.J.Griffiths, 3E, Cambridge University Press, 2018.

Course outcomes (CO): At the end of the lab course, the student will be able to:

CO1	Perform basic experiments related to mechanics
CO2	Be familiar with various measuring instruments and also would learn the importance of accuracy of measurements.

Course Details: (Practical)

1. Graphical Analysis (Ref. UIET Laboratory Manual)

2. Trajectory of projectile (Ref. UIET Laboratory Manual) Apparatus Used (Trajectory Apparatus, Metal Balls, Channels, Vernier Callipers, Carbon & Graph Paper)

3. Moment of Inertia of Bicycle wheel (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Bicycle Wheel, Masses, Thread, Stopwatch, Meter Scale, Vernier Callipers)

4. Spring Oscillations (Ref. UIET Laboratory Manual) Apparatus Used (Spring Oscillation Apparatus, Stop Watch, Masses)

5. Coupled Pendulum (Ref. UIET Laboratory Manual) Apparatus Used (Coupled Pendulum Setup, Stop Watch, Scale)

6. Bifilar Suspension System (Ref. UIET Laboratory Manual) Apparatus Used (Bifilar Suspension System Setup, Stop Watch, Masses)

7. Frequency of AC Mains by Melde's Method (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Electrical Vibrator, String, Pulley, Small Pan, Weight Box & Physical Balance)

8. Kater's (Reversible) Pendulum (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Kater's Pendulum, Stop Watch)

9. Inertia Table (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Inertia Table, Stop Watch, Vernier Callipers, Split Disc, Balancing Weights, and Given Body (Disc))

10. Moment of Inertia of Flywheel (Ref. Book by J. C. Upadhyay and UIET Laboratory Manual) Apparatus used (Fly wheel, weight hanger, slotted weights, stop watch, metre scale)

Course Code: ESCS101 **Breakup: 3 –1 – 3 – 5**
Course Name: Basic Electrical & Electronics Engineering

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Predict the behaviour of any electrical and magnetic circuits
CO2	Formulate and solve complex AC, DC circuits
CO3	Realize the requirement of transformers in transmission and distribution of electric power and other applications
CO4	Have knowledge of some basic electronic components and circuits
CO5	Understand the basics of diode and transistor circuits
CO6	Understand the working of some I C based circuits
CO7	Study logic gates and their usage in digital circuits

Course Details: (Theory)

Unit – I

Sinusoidal steady state circuit analysis, voltage, current, sinusoidal & phaser presentation single phase AC circuit – behavior of resistance, inductance & capacitance & their combination, impedance concept of power, power factor; Series & parallel resonance – band width & quality factor, Three phase circuits – phase voltage & current, line & phase quantities, phasor diagram, balanced & unbalanced loads, Measurement of R, L, and C.

Unit –II

Network Theory: Network theorems – Thevenin's, Norton, maximum power transfer theorem, star delta transformation, circuit theory concept – mesh & nodal analysis.

Unit – III

Magnetic circuit concepts: self-inductance, magnetic coupling analysis of single tuned & double tuned circuit involving mutual inductance, introduction to transformer.

Unit – IV

Basic Instruments, electrical measurement – measurement of voltage , current , power & energy, voltmeters& ammeter , wattmeter , energy meter , three phase power measurement , electronics instrument –multimeter, CRO(analog & digital),An overview of voltage regulator.

Unit – V

Introduction to basic electronics devices – junction diode, BJT, amplifier, op-amps & instrumentation amplifier with mathematical operation

Number System: Introduction to binary, octal, decimal & hexadecimal systems, representation of negative, numbers, 1's, 2's, 9's, 10's complement and their arithmetic.

Text Books

1. Edward Hughe "Electrical and Electronic Technology", 10th Edition, Pearson Education Asia, 2019.
2. P. Kothari, I J Nagrath, "Electric Machines", 5th Edition, Tata McGraw Hill, 2017.
3. P. Malvino, "Electronic Principles", 7th Edition, Tata McGraw Hill, 2007.
4. A Textbook of Electrical Technology - Volume I (Basic Electrical Engineering) 23Rev Ed Edition, S. Chand Publishing.2020

Reference Books

1. S. K. Bhattcharya, "Basic Electrical and Electronics Engineering", Pearson, 2012.
2. Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall of India Private Limited, 2nd Edition, 2003.
3. David Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.
4. Michael Tooley A., "Electronic circuits: Fundamentals and Applications", 3rd Edition, Elsevier Limited, 2006.

Course Name: Basic Electrical & Electronics Engineering Lab
Course Details: (Practical)

1. Familiarization with the Electronic Instruments.

2. Familiarization with electronic components and Bread board.

3. To verify the Thevenin theorem.

4. To verify the Superposition theorem.

5. Measurement of voltage and frequency with CRO.

6. To study half wave rectifier.

7. To study full wave bridge rectifier.

8. To study full wave bridge rectifier with filter.

9. To study and verify the truth table of different logic gates using digital IC.

10. To study different type of transformer and there operation.

11. To study basic wiring and design a switchboard/extension board.

12. To study the polarity test of a single phase transformer.

13. To study the open & short circuit test of a transformer and calibration losses.

14. To study the load test and efficiency of a single phase transformer.

Course Code: CHMS101 **Breakup: 3 –1 – 3 – 5**
Course Name: Chemistry - I

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the concept related to atoms and molecules, chemical bonding coordinate compounds and its applications
CO2	Concept of chemical kinetics, electrochemistry, photochemistry and their applications
CO3	Understand the concept of spectroscopy and its applications in various fields
CO4	Understand the basics of stereochemistry, organic reactions and its mechanism for various types of reactions
CO5	Various experiments helps the student to learn the basics of experiments to apply in day today life as well as in industry

Course Details: (Theory)

UNIT-I - Atoms and Molecules:

Need for wave mechanical picture of atomic structure [Photoelectric effect, de Broglie concept of matter waves], Derivation of Schrodinger wave equation [as an example particle moving in uni-dimensional potential well]

Chemical Bonding - Orbital concepts in bonding, V.B. and M.O. theory, M.O. diagrams, Intermolecular interactions

UNIT-II - Reaction Dynamics:

Order, Molecularity, Rate law, Integrated rate equations, Methods of determining of order of reaction, Complex reaction kinetics- chain reactions and reversible reactions in detail, Catalysis and enzyme catalysis

UNIT-III - Electrochemistry:

Arrhenius theory of electrolytic dissociation, Transport number, Kohlrausch's law, Solubility product, Redox reaction, Electrochemical and concentration cells.

UNIT-IV- Stereochemistry:

Introduction, Chirality, Enantiomers, Diastereomers, Projection formula of a tetrahedral carbon, Geometrical isomerism, Conformers

UNIT- V- Application of Spectroscopic Techniques:

Basic working principle on measurement technique: IR, UV visible spectroscopy and NMR

UNIT-VI - Organic Reactions:

Concepts Electron displacement effects, Organic intermediates, Types of reactions [addition, elimination and substitution reactions]

UNIT-VII - Photochemistry:

Principles of photo chemistry, Photoexcitation of organic molecules, Jablonski diagram, Laws of photochemistry and quantum yield, some examples of photochemical reactions, Chemistry of vision and other applications of photochemistry

UNIT-VIII - Transition Metal Chemistry:

Structure of coordination compounds corresponding to coordination number up to 6, Types of ligands, chelation, Isomerism [geometrical, optical, ionization, linkage and coordination], Theories of bonding in coordination compounds- crystal field theory, Valence bond theory.

Recommended Books:

Physical Chemistry-

1. Physical Chemistry, P. Atkins and J De Paul, International student edition , 8th edition, Oxford University Press, (2006)
2. Principles of physical chemistry, B. R. Puri, L.R. Sharma and M.S. Pathania, Shoban Lal Nagin Chand and Co., Jalandhar, 43 edition, Vishal Publishing ***Co***. (2017)

Organic Chemistry-

1. Organic Chemistry, R. T. Morrison and R.N. Boyd, 6th edition, Prentice hall of India (P) Ltd. New Delhi (2016)
2. A Textbook of Organic Chemistry, Arun Bahl and B.S. Bahl, S., 22th edition, S.Chand Publishers, New Delhi (2019)

Inorganic Chemistry-

1. Concise Inorganic chemistry, J.D. Lee, 5th edition, (1997).
2. Inorganic Chemistry, J.E. Huyee, E.A. Keiter and R.L. Keiter. 4th edition, Prentice Hall, Upper Saddle River,(2017)

Engineering Chemistry-

1. Engineering chemistry , Shashi Chawala, Dhanpat Rai & Co.(2013)
2. Engineering chemistry , P. C.Jain and Monika Jain. 16th edition, Dhanpat Rai Publishing Company **(**2015)

Course Name: Chemistry Lab- I

Course Details: (Practical)

1. To estimate the strength of the given unknown solution of Mohr's salt (Ferrous ammonium sulphate (FeSO4.(NH4)SO4.6H2O) using KMnO4 solution as an intermediate.
2. To prepare a sample of p-nitroacetanilide.
3. To prepare a sample of Aspirin.
4. Preparation of Tris (Thiourea) Copper (I) sulphate.
5. Preparation of Hexaamine Nickel (II) chloride [Ni(NH3)6]Cl2.
6. Estimation of commercial caustic soda: Determination of the amounts of sodium carbonate and sodium hydroxide present together in the given commercial caustic soda.
7. Estimation of calcium ions present in tap water.
8. To determine the partition coefficient of acetic acid between n-butanol and water.
9. To study the photochemical reduction of a ferric salt (Blue printing).
10. To determine the viscosity of a given liquid room temperature using Ostwald's viscometer.
11. To separate Ag(I), Hg (I) and Pb(II) ions by paper chromatography and calculate their RF values.
12. Understanding reaction kinetics and calculating the rate and order of a reaction.
13. To study the kinetics of first order reaction (methyl acetate hydrolysis catalysed by o.5 N HCl solution).

Course Code: TCAS101 **Breakup: 3 –0 – 3 – 5**

Course Name: Engineering Drawing

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the basics of engineering graphics
CO2	Develop skills to prepare basic engineering drawings
CO3	Understand the concept of projection and acquire visualization skills
CO4	Gain imaginative skills to understand section of solids and developments of surfaces

Course Details:

Introduction- Drawing instruments and their uses, BIS conventions, lettering dimensioning and free hand practicing.

Orthographic projections: Lines, planes and surfaces of objects, Sectional views, Auxiliary views, Space geometry: lines and planes, True lengths and shapes, Properties of parallelism, Perpendicularity and intersections of lines and planes, Simple intersections of solids and development of lateral simple solids**.**

Isometric Projections: Introduction , isometric scale, isometric projection of simple plane figures, isometric projection of tetrahedron, hexahedron (cube), right regular prisms , pyramids, cylinders, cones, spheres, cut spheres and combinations of solids.

Introduction to computer graphics: Some problems on above topics on computer graphics.

Text Books and References:

1. Narayana,K.L. & Kannaiah,P. "Engg.Graphics". Tata McGraw Hill, New Delhi (2012).
2. Bhatt,N.D. (2014) "Elementary Engg. Drawing" Charotar Book stall. Anand.
3. Lakshminarayanan ,V and Vaish Wannar , R. S. "Engg.Graphics".Jain Brothers , New Delhi (2006).
4. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication.
5. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
6. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers.

SEMESTER – II

Course Code: MTHS102 **Breakup: 3 –1 – 0 – 4**
Course Name: Mathematics-II

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Solve the consistent system of linear equations
CO2	Determine the power series expansion of a given function
CO3	Solve arbitrary order linear differential equations with constant coefficients
CO4	Apply Laplace transforms to solve physical problems arising in engineering
CO5	Find eigen values, eigen vectors & diagonalize a matrix
CO6	Understand concept of vector space & linear transformation

Course Details:

Unit–I
Matrix Algebra: Elementary operations and their use in finding Rank, Inverse of a matrix and solution of system of linear equations. Orthogonal, Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Normal & Unitary matrices and their elementary properties

Unit–II
Vector Space, Linear transformation, Linear dependent and linear independent, Eigen-values and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix

Unit-III
Ordinary Differential Equations of second order: Solution of linear differential equations with Constant coefficients. Euler-Cauchy equations, Solution of second order differential equations by changing dependent and independent variables; Method of variation of parameters, Introduction to series solution method, Frobenious Methods

Unit- IV
Ordinary differential equations of higher orders: Matrix method

Unit-V
Laplace Transform: Laplace and inverse Laplace transform of some standard functions, Shifting theorems, Laplace transform of derivatives and integrals. Convolution theorem, Initial and final value theorem; Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function. Applications of Laplace transform.

Text and Reference Books:

1. C.L.Liu : Discrete Mathematics, , McGraw Hill, 2nd Edition, 1985.
2. B.Kolman, R.C.Busby, and S.C.Ross, Discrete mathematical structures, 5/e, Prentice Hall, 2004
3. J.L.Mott, A.Kandel and T.P.Baker : Discrete mathematical structures For computer scientists & Mathematicians , Prentice–Hall India, 1985.
4. J.P.Trembley, R. Manohar, Discrete mathematical structures with applications to computer science, McGraw –Hill, Inc. New York, NY, 1975.

Course Code: PHYS102 **Breakup: 3 –1 – 3 –5**
Course Name: Physics-II

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	understand the vector integration which they can apply in electricity and magnetism
CO2	Understand the concepts of wave optics such as the phenomena of interference, diffraction and polarization of light
CO3	Understand the concepts of electrostatics, magnetostatics, electromagnetic induction, Maxwell's equations and electromagnetic waves
CO4	Apply the concepts of physics in the engineering courses

Course Details: (Theory)

Unit 1
Vector integration, Stokes' theorem, divergence theorem, electrostatics: Coulomb's law, superposition of electric forces, electric flux, Gauss's law, electric field, potential, calculation of electric fields due to different charge distribution, gradient and curl of electric field, electric dipoles and multipoles, potential energy of a dipole placed in external electric field, Laplace's equation, Poisson's equation.

Unit 2
Magnetostatics, motion of charge in electric and magnetic field, Lorentz force, magnetic flux, torque on a current coil in uniform magnetic field, magnetic dipole, potential energy of a magnetic dipole, Biot-Savart law, Ampere's law, calculation of magnetic field due to different current distribution, divergence and curl of magnetic field.

Unit 3
Electromagnetic induction, Faraday's law, Lenz's law, self-induction, mutual induction, growth and decay of current in L-R circuit, electromagnetic waves, displacement current, Maxwell's equations in free space and matter, verification of Faraday's law of electromagnetic induction and Ampere's law in vacuum by using plane electromagnetic waves and derivation of velocity of light (c) in terms of permittivity and permeability of free space, Poynting vectors, Poynting theorem.

Unit 4
Coherent sources, Interference, Fresnel's biprism, interference in uniform and wedge shaped thin films, necessity of extended source, Newton's rings and its applications, Fresnel and Fraunhofer diffraction at single slit and double slits, absent spectra, diffraction grating, spectra with grating, dispersive power, resolving power of grating, Rayleigh's criterion of resolution

Unit 5
Dispersion of light, angular dispersion, dispersive power, irrational dispersion, angular and chromatic dispersion, deviation without dispersion, dispersion without deviation, polarization of light, Fresnel's theory of optical activity and polarimeter, fundamental idea of optical fiber, types of fibers.

Text and References Books:

1. Introduction to Electrodynamics by D.J. Griffiths, 3E, Prentice-Hall of India Private Limited, 2002.
2. Vector Analysis by M. R. Spiegel, Schaum's Outlines, 2021
3. Optics by Ajoy Ghatak, McGraw Hill Education (India) Private Limited, 7th (2020)

4. A textbook of Optics by Subrahmanyam, Brijlal and Avadhanulu, S Chand; 23rd Rev. (2006).
5. Classical electrodynamics by J. D. Jackson,Wiley, 3rd edition, 1998.
6. Concept of Modern Physics by Aurthur Beiser, McGraw-Hill Education,6th (2021).
7. Introduction to fiber optics by Ajoy Ghatak and K. Tyagrajan, 1E, Cambridge University Press, 2012.

Course Name: Physics Lab-II

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Gain practical knowledge about electricity and magnetism and measurements such as resistance, voltage, current etc
CO2	Gain experimental knowledge of interference, diffraction and polarization of light and measurement of the wavelengths of the monochromatic light with the help of Newton's ring experiment, Fresnel's biprism experiment, etc.
CO3	Understand the concept of semiconductor physics through the four probe experiment
CO4	Gain knowledge about the various optical devices: prism, grating, spectrometer.
CO5	Understand the basic concept of modern physics through the determination of Planck's constant

Course Details: (Practical)

1. Newton's Ring (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Traveling Microscope, Support for Glass Plate inclined at 450 to the Vertical, Short Focus Convex Lens, Sodium Lamp, Plano Convex Lens, An Optically Plane Glass Plate)

2. Prism Spectrometer (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Spectrometer, Glass Prism, Reading Lens, Mercury Lamp)

3. Plane Transmission Grating (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Spectrometer, Diffraction Grating, Mercury Lamp)

4. Ballistic Galvanometer (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Ballistic Galvanometer, Morse key, Damping key, Condenser, Rheostat, Volt Meter, Storage Battery, Connection Wires)

5. Carey Foster's Bridge (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Carey Foster's Bridge, Laclanche cell, Resistance Box, Galvanometer, Plug Key, Copper Strip)

6. Fresnel's Biprism (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Sodium Lamp, Biprism, Convex Lens, Optical Bench with Four Uprights)

7. Variation of Magnetic Field (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Stewart and Gee type Tangent Galvanometer, Storage Battery, Commutator, Ammeter, Rheostat, One way Plug Key, Connection Wires)

8. Polarimeter (Ref. Book by K. K. Dey, B. N. Dutta) Apparatus Used (Sodium Lamp, Polarimeter, Physical Balance)

9. Planck's Constant (Ref. Book by S.K. Gupta and UIET Laboratory Manual) Apparatus Used (Power supply, photocell, connecting wires)

10. Energy Band Gap by Four Probe Method (Ref. Book by S.K. Gupta and UIET Laboratory Manual) Apparatus Used (An experimental kit)

Course Code: ISCS101 **Breakup: 3 – 1 – 3 – 5**
Course Name: Programming & Computing (C & UNIX)

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Recollect various programming constructs and to develop C programs
CO2	Understand the fundamentals of C programming
CO3	Choose the right data representation formats based on the requirements of the problem
CO4	Implement different Operations on arrays, functions, pointers, structures, unions and files

Course Details:
Basic concepts of Computers, Basic UNIX Concepts and Vi - Editor
Introduction to C: Basic Programming concepts, Program structure in C, Variables and Constants, Data types, Conditional statements, control statements, Functions, Arrays, Structures, Introduction to pointers and Introduction to File Systems.

Text Books and References:

1. Programming in C, Schaum Series, 3rd edition, BPB Publication, Byron S. Gottfried
2. The 'C' Programming, Denis Ritchi, Second edition, PHI, 1988
3. Mastering C, Venugopal, Second edition, TMH, 2006
4. Let Us C, Yashavant Kanetkar, 18th Edition, BPB, 2021
5. Programming in ANSI C, Balaguruswami, Eighth Edition, TMH, 2019

Computer Programming Lab:

Learning OS Commands
Practice of all Internal and External DOS Commands, Writing simple batch programs, Exposure to Windows environment, Practice of UNIX commands and Vi editor, Writing simple shell script
C Programming:
Practicing programs to get exposure to basic data types, algebraic expressions, Conditional statements, Input Output Formatting, Control structures, arrays, functions, structures, pointers and basic file handling

Course Code: TCAS102 **Breakup:** **3 – 0 – 6 – 5**

Course Name: **Workshop Practice & IDEA Lab**

Course outcomes (CO): At the end of the course, the student will be able to:

CO-1	To Study on different machine tools and their operations.
CO-2	Basic knowledge of casting processes and their applications.
CO-3	Recognize the different types metal forming process and their operations.
CO-4	Introduction to basic fabrication processes such as welding
CO-5	To study on Modern trends in manufacturing, Unconventional machining Processes and Automation

Course Details:

Historical perspectives; Classification of Manufacturing process.

Machining: Basic principles of lathe machine & operations performed on it. Basic description of machines & operations of shaper-planer, drilling, milling, grinding.Unconventional machining processes , Machine tools.

Casting processes:pattern & allowances. Moulding sands & its desirable properties. Mould making with the use of a core. Gating system. Casting defects & remedies. Cupola furnace. Die-casting & its uses.

Metal forming: Basic metal forming operations & uses of such as-forging, rolling, wire& tube drawing/making & extrusion, & its products/applications, press work & die & punch assembly, cutting & forming, its application. Hot working vs Cold working. Powder metallurgy: powder metallurgy process & its applications, plastic-products manufacturing, galvanizing & electroplating.

Welding: Importance & basics concepts of welding, classification of welding processes. Gas welding, types of flames, Electric arc welding. Resistance welding. Soldering & brazing and its uses. Modern trends in manufacturing, Automation. Introduction to NC/CNC/DNC,FMS,CAD/CAM,CIM and factory of future.

Text Books and References:

1. Chapman,W A J & Arnold ,E "Workshop Technology,1972 ; vol. I,II&III" Viva Low Priced Student Edition.
2. Raghuwanshi,B S "Workshop Technology ,2015; vol. I&II" Dhanpat Rai & Sons
3. Chaudhary, Hajra "Elements of Workshop Technology, 2008 ; vol. I&II" Media Promoters & Publishers.

Course code: TCA – S102P

Course Name: Workshop Practice Lab & IDEA Lab

Course Details:

1. Foundry (1 turn)
2. Welding (3 turns)
   a. Gas Welding (1 turn)
   b. Arc Welding (2 turns)
      (i). Lap Joint (1 turn)
      (ii) Butt Joint (1 turn)
3. M/C Shop (4 Turns)
4. Fitting & Sheet Metal Work (1 turn+1 turn)
5. Carpentry Shop(1 turn)
6. Black-smithy shop(1 turn)

Text Books and References:

4. Chapman,W A J & Arnold ,E "Workshop Technology,1972 ; vol. I,II&III" Viva Low Priced Student Edition.
5. Raghuwanshi,B S "Workshop Technology ,2015; vol. I&II" Dhanpat Rai & Sons
6. Chaudhary, Hajra "Elements of Workshop Technology, 2008 ; vol. I&II" Media Promoters & Publishers.

Course Code: HSSS101 **Breakup: 3 –1 – 0 – 4**
Course Name: Professional Communication
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Enhance their communication skills for tackling the professional challenges of a diverse workplace
CO2	Learn effective writing skills and be able to write clear technical reports
CO3	Improve their verbal and non-verbal communication
CO4	Be fluent orally in the use of the nuances of the English language
CO5	Learn good interpersonal skills and be proficient with the soft skills required for national and global placements

Course Details:
Unit -1 Basics of Technical Communication
Technical Communication**:** features; Distinction between General and Technical communication; Language as a tool of communication; Levels of communication: Interpersonal, Organizational, Mass communication; Flow of Communication: Downward, Upward, Lateral or Horizontal (Peer group); Importance of technical communication; Barriers to Communication.

Unit - II Constituents of Technical Written Communication

Words and Phrases: Word formation. Synonyms and Antonyms; Homophones; Select vocabulary of about 500-1000 New words; Requisites of Sentence Construction: Paragraph Development: Techniques and Methods - Inductive, Deductive, Spatial, Linear, Chronological etc; The Art of Condensation- various steps.

Unit - III Forms of Technical Communication
Business Letters: Sales and Credit letters; Letter of Enquiry; Letter of Quotation, Order, Claim and Adjustment Letters; Job application and Resumes. Reports: Types; Significance; Structure, Style & Writing of Reports; Technical Proposal; Parts; Types; Writing of Proposal; Significance; Technical Paper, Project. Dissertation and Thesis Writing: Features, Methods & Writing.

Unit - IV Presentation Strategies

Defining Purpose; Audience & Locale; Organizing Contents; Preparing Outline; Audio-visual Aids; Nuances of Delivery; Body Language; Space; Setting Nuances of Voice Dynamics; Time-Dimension.

Unit - V Value- Based Text Readings
Following essays form the suggested text book with emphasis on Mechanics of writing,
The Aims of Science and the Humanities by M.E. Prior
The Language of Literature and Science by A.Huxley
Man and Nature by J.Bronowski
The Mother of the Sciences by A.J.Bahm
Science and Survival by Barry Commoner
Humanistic and Scientific Approaches to Human Activity by Moody E. Prior
The Effect of Scientific Temper on Man by Bertrand Russell.

Text and Reference Books:

1. V.N. Arora and Laxmi Chandra, Improve Your Writing ed. Oxford Univ. Press, New Delhi
2. Meenakshi Raman & Sangeeta Sharma, Technical Communication – Principles and Practices, Oxford Univ. Press 2007, New Delhi.
3. Barun K. Mitra, Effective Technical Communication, Oxford Univ. Press, 2006, New Delhi
4. R.C. Sharma & Krishna Mohan, Business Correspondence and Report Writing, Tata McGraw Hill & Co. Ltd., New Delhi.
5. M.Rosen Blum, How to Build Better Vocabulary, Bloomsbury Pub. London.
6. Norman Lewis, Word Power Made Easy, W.R. Goyal Pub. & Distributors, Delhi.
7. Krishna Mohan, Developing Communication Skills Meera Banerji-Macmillan India Ltd. Delhi.
8. L.U.B. Pandey & R.P. Singh, Manual of Practical Communication, A.I.T.B.S. Publications India Ltd.; Krishan Nagar, Delhi.

SEMESTER – III

Course Code: MTHS201 **Breakup: 3 –1 – 0 – 4**
Course Name: Mathematics - III

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Obtain the Fourier series expansion of a given function
CO2	Apply Fourier transform for solving Boundary Value Problems
CO3	Determine the solution of linear partial differential equations (PDE) by variable Lagrange's method & some nonlinear PDEs
CO4	Understand and use of complex variable & analyticity
CO5	Expand a function of Laurent series
CO6	Evaluation of real integrals using residues

Course Details

Unit – I

Function of a Complex variable: Complex numbers- power and roots, limits, continuity and derivative of functions of complex variable, Analytic functions, Cauchy - Reimann equations, Harmonic function, Harmonic conjugate of analytic function and methods of finding it, Complex Exponential, Trigonometric, Hyperbolic and Logarithm function.

Unit – II

Complex Integration: Line integral in complex plane(definite and indefinite), Cauchy's Integral theorem, Cauchy's Integral formula, Derivatives of analytic functions, Cauchy's Inequality, Liouville's theorem, Morera's theorem, Power series representation of analytic function and radius of convergence, Taylor's and Laurent's series, singularities, Residue theorem, Evaluation of real integrals, Improper Integrals of rational functions.

Unit-III

Fourier series: Trigonometric Fourier series and its convergence. Fourier series of even and odd functions, Fourier half-range series; Parseval`s identity, Complex form of Fourier series;

Unit-IV

Fourier Transforms: Fourier integrals, Fourier sine and cosine integrals, Fourier transform, Fourier sine and cosine transforms and their elementary properties, Convolution theorem, Application of Fourier transforms to BVP

Unit-V

Partial Differential Equations: Formation of first and second order partial differential equations. Solution of first order partial differential equations: Lagrange`s equation, Four standard forms of non-linear first order equations.

Text and Reference Books:

1. C.L.Liu : Discrete Mathematics, , McGraw Hill, 2nd Edition, 1985.
2. B.Kolman, R.C.Busby, and S.C.Ross, Discrete mathematical structures, 5/e, Prentice Hall, 2004
3. J.L.Mott, A.Kandel and T.P.Baker : Discrete mathematical structures For computer scientists & Mathematicians , Prentice–Hall India, 1985.
4. J.P.Trembley, R. Manohar, Discrete mathematical structures with applications to computer science, McGraw –Hill, Inc. New York, NY, 1975.

Course Code: ESCS201 **Breakup: 3 – 1 – 0 – 4**

Course Name: Engineering Mechanics

Course outcomes (CO): At the end of the course, the student will be able to:

CO-1	Determine the resultant force and moment for a given system of forces
CO-2	Determine the Centre of Gravity and Moment of Inertia of surfaces and solids
CO-3	Determine the shear force, Bending moment of beams and analyze the trusses and problems related to frictions
CO-4	Determine the stresses in beam for pure bending and effect of torsion in shafts
CO-5	Calculate the motion characteristics of a body subjected to a given force system

Course Details:

General Coplanar force systems : Basis concepts, Law of motions, principle of transmissibility of forces, Transfer of a force to parallel position, Resultant of a force system, simplest resultant of two dimensional concurrent & non concurrent force systems, free body diagrams, equilibrium & its equations, applications.

Trusses & Cables : Introductions, simple truss & solutions of simple truss, method of joints & method of sections.

Friction : Introductin , Laws of coulomb friction, equilibrium of bodies involving dry friction, belt friction, applications.

Centre of gravity , centroid, Moment of Inertia : Centroid of plane, curve, area ,volume & composite bodies, moment of inertia of plane area, parallel axis theorem, perpendicular axis theorem, principal moment inertia, mass moment of inertia of circular ring, disc, cylinder, sphere and cone about their axis of symmetry.

Beams: Introductions, shear force and bending moment, differential equations for equilibrium, shear force & bending moments diagrams for statically determinate beams.
Kinematics of rigid body: Introduction, plane motion of rigid bodies, velocity & acceleration under translation & rotational motion, Relative velocity, projectile motion.

Kinetics of rigid bodies: Introduction, force, mass & acceleration, work & energy, impulse & momentum, D'Alembert principles & dynamic equilibrium. Virtual work.

Text Books and Reference :

1. Beer F.P. & Johnston ,F.R. " Mechanics For Engineers" 11th edition 2017, McGraw Hill.
2. Shames, I.H. " Engg. Mechanics" 4th edition2005 , P H I.
3. Meriam , J. L. " Statics" 7th edition 2011, J. Wiley.
4. Meriam , J. L. " Dynamics" 7th edition 2011, J. Wiley.

Course Code: **ESCS202** **Breakup:** **3 – 1 – 0 – 4**
Course Name: **Basic Thermodynamics**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the fundamentals of engineering mechanics and their applications
CO2	Gain knowledge of various types of motion related to body
CO3	Understand the basic concepts of friction and application of friction
CO4	Identify appropriate structural system for studying a given problem and isolate it from its environment
CO5	Carry out kinematic and kinetic analyses for particles and systems of particles
CO6	Apply the principles of mechanics to practical Chemical engineering problems

Course Details:

Introduction: Definition and scope of thermodynamics, macroscopic and microscopic viewpoint, system, properties, processes and cycles, homogeneous and heterogeneous systems, thermodynamic equilibrium, quasi-static process, phases of a substance, unit systems, specific volume, pressure.
Temperature: Zeroth law of thermodynamics, measurement of temperature, different temperature scales.
Properties of pure substances: Pure substance, p-v diagram, p-T diagram, T-s diagram, h-s diagram or Mollier diagram, quality or dryness fraction, steam table. Energy and its transfer: Energy, different forms of energy, energy transfer by heat, energy transfer by work, different forms of work transfer - pdV work or displacement work, shaft work, flow work, etc., pdV work in various quasi-static processes, specific heat and latent heat.
First Law of Thermodynamics: Energy balance, energy conversion efficiency, energy analysis of open and closed systems, PMM1.
Second Law of Thermodynamics: Cyclic heat engine, thermal reservoirs, Kelvin-Planck statement, Clausius' statement, refrigerator and heat pump, equivalence of Kelvin-Planck and Clausius' statement, PMM2, conditions for reversibility, Carnot cycle, Carnot's theorem, corollary of Carnot's theorem, absolute thermodynamic temperature scale, efficiency of the reversible heat engine.
Entropy: Clausius' theorem, temperature-entropy plot, Clausius inequality, entropy change in an irreversible process, entropy principle, entropy generation in a closed and open system, entropy and direction, entropy and disorder.
Availability: Available energy, available energy in a cycle, quality of energy, law of degradation of energy, maximum work in a reversible process, second law efficiency.
Thermodynamic relations: Maxwell's equations, TdS equations, Joule-Kelvin effect, Clausius- Clapeyron equation, Gibbs phase rule for non-reactive system.
Power and refrigeration cycles: simple steam power cycle, comparison of Rankine and Carnot cycles, characteristics of an ideal working fluid in vapour power cycles. Carnot gas power cycle, Refrigeration cycle – reversed heat engine cycle, vapour compression refrigeration cycle, components in a vapour compression plant, refrigerants.

Text Books and Reference:
1. P K Nag, Engineering Thermodynamics, Sixth edition, McGraw Hill Education, Delhi (2017).
2. Y A Cengel, M A Boles, M Kanoglu, Thermodynamics An Engineering Approach, Ninth edition, McGraw Hill Education, Delhi (2019).
3. Y V C Rao, An Introduction to Thermodynamics, Universities Press, Hyderabad (2003).

Course Code: **MSES201** **Breakup:** **3 – 0 – 3 – 4**

Course Name: **Crystal Structure of Materials**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Classify Materials Based on Structure and Properties
CO2	Explain Types of Chemical Bonding in Solids
CO3	Understand Crystal Geometry and Lattice Concepts.
CO4	Analyze Crystal Structures and Defects in Materials
CO5	Apply X-Ray Diffraction Techniques to Determine Crystal Structures

Course Details:

Introduction to materials: Classification of materials, Concept of amorphous, single crystals and polycrystalline materials, crystallinity and its effect on physical properties.

Chemical bonding: Ionic, covalent, metallic, and secondary bonding in materials,

Crystal Structure: Unit cells, Bravais lattices and crystal structures, Crystal systems, Miller indices of crystal direction & planes, crystal symmetry, point groups, space groups, close packing in solids, coordination and radius ratio concepts, Reciprocal Lattices.

Crystal structure of solids: metals and alloys, ionic and covalent solids, ceramics and polymers.

Crystal Imperfections: Point, line and surface defects; Coherent, semi-coherent and incoherent interfaces, surface energy and equilibrium shapes of crystals. Volume defects, Frenkel defect, Schottkey defect in ionic crystals, Stacking Faults.

Crystal structure determination by x-ray diffraction: Braggs Law, Powder Method.

Text Books and Reference:

1. Materials Science and Engineering: An Introduction, W. D. Callister, (WILEY), 2006
2. The Science and Engineering of Materials, Donald R. Askeland (Chapman & Hall), 2010
3. Materials Science and Engineering, V. Raghvan, 2004, PHI

Course Name: **Crystal Structure of Materials Lab**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Students will learn about various crystal structures
CO2	Students will learn how atoms coordinate in different crystal systems.

Course Details

Basic crystal structures, Crystal planes & directions, Atomic packing,
Determination of crystal structures (cubic), Mechanical testing.

Course Code: MSES202 **Breakup: 3 –1 – 0 – 4**

Course Name: Nature and Properties of Materials

Course outcomes (CO): At the end of the course, the student will be able to develop:

CO1	Apply Quantum Mechanical Principles to Material Behavior
CO2	Analyze the Electrical and Magnetic Properties of Materials
CO3	Evaluate Thermal and Optical Properties of Solids
CO4	Understand Mechanical Behavior of Engineering Materials
CO5	Establish Structure–Property Relationships and Material Design Principles

Course Details

Basics of quantum mechanics, quantum mechanical treatment of electrical, optical and thermal properties of materials.

Electronic Properties: Free electron theory, Fermi energy, density of states, elements of band theory, semiconductors, Hall effect, dielectric behaviour, piezo-electric, ferro-electric and pyro-electric materials

Magnetic Properties: Origin of magnetism in metallic and ceramic materials, para-magnetism, diamagnetism, ferromagnetism and ferrimagnetism

Thermal Properties: Specific heat, thermal conductivity and thermal expansion, thermoelectricity

Optical Properties: Refractive index, absorption and transmission of electromagnetic radiation in solids, electro-optic and magneto-optic materials, spontaneous and stimulated emission, gas and solid state lasers.

Mechanical Properties: Stress-strain response of metallic, ceramic and polymer materials, yield strength, tensile strength and modulus of elasticity, toughness, plastic deformation, fatigue, creep and fracture

Structure properties correlation, Material Selection, Synthesis & Design.

Text Books and Reference:

1. Materials Science and Engineering: An Introduction, W. D. Callister, (WILEY), 2006
2. The Science and Engineering of Materials, Donald R. Askeland (Chapman & Hall), 2010
3. Materials Science and Engineering, V. Raghvan, 2004, PHI

Course Code: EVSS201 **Breakup: 2 –0 – 0 – 2**
Course Name: Environmental Science

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	To make students realize the importance and their role in the protection and maintenance of a healthy environment for sustainable development
CO2	To learn how the natural world works, to understand how humans interact with the environment, and to find ways to deal with environmental problems and live more sustainably.

Course Details:

UNIT-I - Scope and Importance of environmental studies, Need for public awareness, Segments of environment, biodiversities: Genetic diversity, Species diversity, Ecosystem diversity, Landscape diversity, Causes of pollution and detrimental effects.

UNIT-II - Eco systems- Types of systems, energy flow in an ecosystem, Balanced ecosystem, Human activities- Food, shelter, economic and social security, Effects of human activities on environment- Agriculture, housing, Industry, mining and transportation activities, Basics of Environmental Impact Assessment, Sustainable Development.

UNIT-III - Types of natural resources: Water resources-Availability and quality aspects, Water borne diseases, Fluoride problems in portable water, Mineral resources, Food resources, Land resources, Forest Wealth, Material cycles- Carbon, Nitrogen and Sulphur cycle.

UNIT-IV - Energy- Different types of energy (Renewable and Non-renewable), Convectional and non- conventional energy-sources. Electromagnetic radiation, Hydro Electric, Fossil fuel based, Nuclear, Solar, Biomass and Bio-gas, Hydrogen as an alternative future source of energy.

UNIT-V - Environmental pollution and their effects, Water pollution, Land pollution, Noise pollution, public Health aspects, Air pollution. Current environmental issues of importance and their impact on environment: Population Growth, Climate change and global warming effect, Urbanization, Automobile pollution, Acid rain, Ozone layer depletion.

UNIT-VI - Preventive measures and control of pollution, Air and Water pollution control, Sold waste management, Case studies.

UNIT-VII - Role of Government in environment protection, Legal Aspects, Initiatives and protection Acts, public awareness, Initiatives by Non-governmental Organizations (NGOs), Role of IT services, Disaster management.

UNIT-VIII - Field work/ Activities/ Visit.

Text and References Books:

1. Environmental Studies- Benny Joseph, TATA Mcgaw Hill publication.
2. Environmental Studies- Dr. D.L. Manjunath, pearson Education.
3. Environmental Studies- R. Rajgopalan, Oxford publication.
4. Environmental Science and Technology- M. Anji Reddy, BS publication.
5. Principles of Environmental Science and Engineering- P. Venugopalan Rao, PHI.
6. Environmental Science and Engineering- Meenakshi, Prentice Hall of India.

SEMESTER – IV

Course Code: MSES203 **Breakup: 3 – 0 – 3 – 4**

Course Name: Phase Equilibria in Materials
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Apply Phase Rule and Lever Rule to Binary Systems
CO2	Analyze Solidification Mechanisms and Microstructural Evolution
CO3	Evaluate Complex Phase Reactions and Intermediate Phases
CO4	Interpret and Construct Ternary Phase Diagrams
CO5	Relate Phase Diagram Knowledge to Engineering Alloys

Course Details

Phase rule, Lever rule & free energy of phase mixtures, Binary isomorphous systems, equilibrium phase rule, Lever rule & free solidification, non-equilibrium solidification, dendritic growth, coring, CuNi alloys & zone refining. Binary eutectic & hypoeutectic systems - solidification of eutectic, hypoeutectic & hypereutectic alloys. Solidification of peritectic, hypoperitectic & hyperperitectic alloys, Morphologies of eutectic systems: Binary monotectic & syntectic systems, Stability of regular solution & miscibility gap, intrinsic stability of solution & spinodal, Hume-Rothery rules & intermediate phases, e.g., laves, sigma, electron compounds, binary eutectoid, peritectoid, metatectic & monotectic systems, Ternary phase diagrams, Gibbs triangle isothermal concept of tie-lines, rules for construction of tie-lines, three-phase equilibrium, concept of tie-triangle Application and properties of stainless steels, high speed steels, Hadfield steels, super alloys, light metal alloys, refactory systems.

Text Books and Reference:

1. Physical Metallurgy, V. Raghvan (PHI), 2015
2. Materials Science and Engineering, V. Raghvan, 2004, PHI
3. Phase Diagrams in Metallurgy, Frederic N. Rhines (Mc Graw Hill), 1956
4. Introduction to Physical Metallurgy, Sidney H Avner (TMH), 1974

Course Name: Phase Equilibria in Materials Lab
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understanding of importance of Phase Diagram concepts through experiments
CO2	Understand basics of metallography and processes of the metallography through experiments

Course Details

Metallographic Sample Preparation of common metals & Observation of Microstructure.

Course Code: **MSES204** **Breakup:** **3 – 1 – 0 – 4**

Course Name: Metallurgical Thermodynamics

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand and Apply the Laws of Thermodynamics
CO2	Analyze Thermodynamic Functions and Relations
CO3	Evaluate Solution Behavior and Phase Equilibria
CO4	Assess Thermodynamics of Reactions and Defects in Materials
CO5	Explore Electrochemical Principles and Applications

Course Details

Laws of Thermodynamics: First law – energy conservation, Second law – entropy, Enthalpy, Gibbs and Helmholtz free energy, Criterion for equilibrium, Entropy & disorder, most probable microstate, configurationally entropy & thermal entropy, Gibbs Helmholtz equation, Third law of thermodynamics, Variation of Gibbs energy with temperature & pressure, Clausius - Clapeyron equation, Thermodynamic properties of mixtures of ideal & imperfect gases, Maxwell's relations; Chemical potential; Applications to metallurgical systems, solutions, ideal and regular solutions, Raoults & Henry's laws, activity of a component, Gibbs — Duhem equation, Non-ideal solutions, Regular solutions, Quasi-chemical model of solution, Gibbs phase rule, phase equilibria, binary phase diagram and lever rule, free-energy vs. composition diagrams; Binary systems involving compound formation, Solubility of gases in metals, Formation of oxide phases of variable composition, Equilibrium constant, Activity, Ellingham and phase stability diagrams; Thermodynamics of point defects, surfaces and interfaces, adsorption and segregation phenomena. Electrochemistry: Single electrode potential, Electrochemical cells, Nernst equation, Potential-pH diagrams.

Text Books and Reference:

1. Introduction to Metallurgical Thermodynamics, David R. Gaskell, McGRAW-Hill
2. Textbook of Materials and Metallurgical Thermodynamics, A. Ghosh (PHI), 2009
3. Introduction to Thermodynamics, Y. V. C. Rao, 2001, New Age

Course Code: **MSES205** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Principles of Metal Extraction and Refining**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Sources and Preparation of Raw Materials
CO2	Analyze Mineral Beneficiation and Agglomeration Techniques
CO3	Perform Material and Energy Balances in Metallurgical Processes
CO4	Understand Principles and Applications of Extractive Metallurgy
CO5	Evaluate Pyro-metallurgical Operations and Refining Techniques

Course Details

Sources of raw material, Comminution techniques, tabling, jigging, size classification, flotation, gravity and other methods of mineral beneficiation; Agglomeration: sintering, pelletizing and briquetting. Material and Energy balances in metallurgical processes; Principles and processes of hydrometallurgy, electrometallurgy and extractive metallurgy for the extraction of non-ferrous metals – aluminium, copper, zinc and titanium. Principles of pyro-metallurgy – roasting, agglomeration, smelting, refining & secondary refining.

Text Books and Reference:

1. Principles of Extractive Metallurgy, H. S. Ray & A. Ghosh, 1991, New Age
2. Principles of Extractive Metallurgy" (Volumes I, II & III) – T. Rosenqvist
3. Extractive Metallurgy" – J. D. Gilchrist

Course Code: ESCS203 **Breakup: 3 – 0 – 2 – 4**

Course Name: Introduction to Machine Learning
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand core ML concepts and implement regression models
CO2	Apply logistic regression and evaluate classification models.
CO3	Explain neural networks and build basic deep learning models.
CO4	Use unsupervised learning and dimensionality reduction techniques
CO5	Execute the ML pipeline with model tuning and deployment basics
CO6	Develop ML models using Python tools with ethical awareness

Course Details:

UNIT I: Introduction to Machine Learning and Supervised Learning
Definition and types of machine learning, applications in engineering, components of ML systems, data characteristics, training and testing concepts, linear regression with single and multiple variables, cost function, gradient descent, normal equation, feature scaling, polynomial regression, underfitting and overfitting, introduction to ML tools.
UNIT II: Classification and Logistic Regression
Classification vs regression, logistic regression, sigmoid function, decision boundaries, cost function, regularization, multiclass classification, model evaluation using confusion matrix, ROC curve, precision, recall, and F1-score.
UNIT III: Neural Networks and Deep Learning
Artificial neurons, neural network architecture, activation functions, forward and backpropagation (conceptual), loss functions, introduction to deep learning, implementation basics using Keras and TensorFlow, ethical concerns.
UNIT IV: Unsupervised Learning and Dimensionality Reduction
Unsupervised learning concepts, k-means clustering, number of clusters, hierarchical clustering, PCA for dimensionality reduction, visualization of data, anomaly detection, association rule learning (introductory).
UNIT V: ML Workflow and Model Optimization
ML workflow stages, EDA, feature engineering, train-validation-test splits, cross-validation, model selection, bias-variance tradeoff, hyperparameter tuning, introduction to ensemble methods, basics of deployment and MLOps.
UNIT VI: Python Tools for Machine Learning
Introduction to Python using Google Colab, basic use of NumPy, Pandas, Matplotlib, Scikit-learn, implementation of regression and classification models, model evaluation, working on a real-world mini project, ethical considerations.

Text and Reference Books:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media.
2. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python, O'Reilly Media.
3. Tom M. Mitchell, Machine Learning, McGraw-Hill Education.
4. Ethem Alpaydin, Introduction to Machine Learning, MIT Press.
5. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning, Springer.

Course Code: HSSS201 Breakup: 1 – 0 – 2 –3
Course Name: Communication Practicum

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the nuances of English language for enhancing presentation skills
CO2	Speak in standard English with clarity and fluency and to write business messages professionally
CO3	Speak and communicate clearly in different professional contexts which would improve their chances of employability
CO4	Understand the importance of ethical practices in their professional life

Course Details:

Unit 1- Presentation techniques
Meaning and importance of presentation technique
Presentation skills required for business organization: Negotiation, Persuasion & Time management
Types of business presentations- meetings, seminars, conferences

Unit 2- Oral presentations
Effective oral delivery- Phonetics
Interviews, Group discussions, debates, speeches Listening skills, Reading Skills

Unit 3- Written communication
Style and tone of writing business messages and documents Persuasive, sales and goodwill messages, delivering bad news Writing e-mails and short messages, Resume writing

Unit 4- Non Verbal communication Nonverbal communication techniques
Business manners, ethics and personality development Power point presentations

Text and Reference Books:

1. Bove`e, Thill and Schatzman, Business Communication Today, Pearson Education (Singapore), (2003)
2. H. Dan O'Hair, James S. O'Rourke and Mary John O'Hair, Business Communication-a framework of success", South Western College Publishing, (2001)
3. Raymond V. Lesikar, Marie E. Flatley, Basic Business Communication, Tata McGraw Hill Publishing Company Ltd., (2002)

Course Code: UHVS201 **Breakup: 3 –0 – 0 – 3**
Course Name: Universal Human Values - II

Objectives:

1. To help students distinguish between values and skills, and understand the need, basic guidelines, content and process of value education.
2. To help students initiate a process of dialog within themselves to know what they 'really want to be' in their life and profession
3. To help students understand the meaning of happiness and prosperity for a human being.
4. To facilitate the students to understand harmony at all the levels of human living, and live accordingly.
5. To facilitate the students in applying the understanding of harmony in existence in their profession and lead an ethical life

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the significance of value inputs in a classroom, distinguish between values and skills, understand the need, basic guidelines, content and process of value education, explore the meaning of happiness and prosperity and do a correct appraisal of the current scenario in the society
CO2	Distinguish between the Self and the Body, understand the meaning of Harmony in the Self the Co-existence of Self and Body.
CO3	Understand the value of harmonious relationship based on trust, respect and other naturally acceptable feelings in human-human relationships and explore their role in ensuring a harmonious society
CO4	Understand the harmony in nature and existence, and work out their mutually fulfilling participation in the nature.
CO5	Distinguish between ethical and unethical practices, and start working out the strategy to actualize a harmonious environment wherever they work.

Catalogue Description:

Every human being has two sets of questions to answer for his life: a) what to do? and, b) how to do?. The first set pertains to the value domain, and the other to the skill domain. Both are complimentary, but value domain has a higher priority. Today, education has become more and more skill biased, and hence, the basic aspiration of a human being, that is to live with happiness and prosperity, gets defeated, in spite of abundant technological progress. This course is aimed at giving inputs that will help to ensure the right understanding and right feelings in the students in their life and profession, enabling them to lead an ethical life. In this course, the students learn the process of self exploration, the difference between the Self and the Body, the naturally acceptable feelings in relationships in a family, the comprehensive human goal in the society, the mutual fulfillment in the nature and the coexistence in existence. As a natural outcome of such inputs, they are able to evaluate an ethical life and profession ahead.

Course Details

UNIT-1

Course Introduction - Need, Basic Guidelines, Content and Process for Value Education Understanding the need, basic guidelines, content and process for Value Education, Self-Exploration–what is it? - its content and process; 'Natural Acceptance' and Experiential Validation- as the mechanism for self exploration, Continuous Happiness and Prosperity- A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities-

the basic requirements for fulfillment of aspirations of every human being with their correct priority, Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfill the above human aspirations: understanding and living in harmony at various levels.

UNIT-2

Understanding Harmony in the Human Being - Harmony in Myself Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - Sukh and Suvidha, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Swasthya; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Swasthya.

UNIT-3

Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship Understanding harmony in the Family- the basic unit of human interaction , Understanding values in human-human relationship; meaning of Nyaya and program for its fulfillment to ensure Ubhay-tripti; Trust (Vishwas) and Respect (Samman) as the foundational values of relationship, Understanding the meaning of Vishwas; Difference between intention and competence, Understanding the meaning of Samman, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Samadhan, Samridhi, Abhay, Sah-astitva as comprehensive Human Goals, Visualizing a universal harmonious order in societyUndivided Society (AkhandSamaj), Universal Order (SarvabhaumVyawastha)- from family to world family!.

UNIT-4

Understanding Harmony in the Nature and Existence - Whole existence as Co-existence Understanding the harmony in the Nature, Interconnectedness and mutual fulfillment among the four orders of nature- recyclability and self-regulation in nature, Understanding Existence as Co-existence (Sah-astitva) of mutually interacting units in all-pervasive space, Holistic perception of harmony at all levels of existence.

UNIT-5

Implications of the above Holistic Understanding of Harmony on Professional Ethics- Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in Professional Ethics: a) Ability to utilize the professional competence for augmenting universal human order, b) Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, technologies and management models, Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a) At the level of individual: as socially and ecologically responsible engineers, technologists and managers, b) At the level of society: as mutually enriching institutions and organizations.

The primary resource material for teaching this course consists of:

a. The Textbook

R R Gaur, R Asthana, G P Bagaria, A Foundation Course in Human Values and

Professional Ethics, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1

b. The Teacher's Manual

R R Gaur, R Asthana, G P Bagaria, A Foundation Course in Human Values and Professional Ethics – Teachers Manual, 2nd Revised Edition, Excel Books, New Delhi, 2019

[The textbook as well as the teacher's manual is available in English, Punjabi and Telugu]

c. A website (http://www.uhv.org.in/) containing:

- Video of Faculty Development Program (Teachers' Orientation Programme)
- Presentation (PPTs) material for use in lectures and practice sessions
- Audio-visual material for use in the practice sessions

Other References

1. A Nagaraj, 1999, Jïvana Vidyã Ek Parichaya, Jïvana Vidyã Prakãsåna, Amarkantak.
2. A Nagaraj, 1999, Vyavahãrvãdï. Samãjashãstra, Jïvana Vidyã Prakãsåna, Amarkantak.
3. A Nagaraj, 2001, Ãvartansïla Arthasãstra, Jïvana Vidyã Prakãsåna, Amarkantak.
4. A Nagaraj, 2003, Mãnava Vyavahãra Darsåna, Jïvana Vidyã Prakãsåna, Amarkantak.
5. A Nagaraj, 1998, Samãdhãnãtmak Bhoutikvãd, Jïvana Vidyã Prakãsåna, Amarkantak.
6. A N Tripathy, 2003, Human Values, New Age International Publishers.
7. B L Bajpai, 2004, Indian Ethos and Modern Management, New Royal Class notes Co., Lucknow. Reprinted 2008.
8. B P Banerjee, 2005, Foundations of Ethics and Management, Excel Books.
9. D H Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1972, Limits to Growth – Club of Rome's report, Universe Books.
10. E F Schumacher, 1973, Small is Beautiful: A Study of Economics as if People Mattered, Blond and Briggs, Britain.
11. E G Seebauer and Robert L. Berry, 2000, Fundamentals of Ethics for Scientists and Engineers, Oxford University Press.
12. FAO, 2011, Global Food Losses and Food Waste – Extent, Causes and Prevention, ISBN 978-92-5-107205-9, Rome.
13. M Fukuoka, 1984, The One-straw Revolution: An Introduction to Natural Farming, Published (in India) by Friends Rural Centre, Rasulia.
14. Illich, 1974, Energy and Equity, The Trinity Press, Worcester, and Harper Collins, USA.
15. King Jigme Khesar of Bhutan, 2010, Royal Address at the Kolkata University Convocation, Kolkata (October 5, 2010).
16. M Govindrajran, S Natrajan and V S Senthil Kumar, 2004, Engineering Ethics (including Human Values), Eastern Economy Edition, Prentice Hall of India Ltd.
17. M K Gandhi, 1939, Hind Swaraj, Navjivan Publishing House, Ahmedabad.
18. P L Dhar, R R Gaur, 1990, Science and Humanism, Commonwealth Publishers.
19. S Palekar, 2000, How to Practice Natural Farming, Pracheen (Vaidik) Krishi Tantra Shodh, Amravati.
20. S George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991.

Relevant Websites, CDs and Documentaries

1. Universal Human Values website, http://www.uhv.org.in/
2. AKTU Value Education website, http://aktu.uhv.org.in/
3. Story of Stuff website, http://www.storyofstuff.com/
4. Al Gore, An Inconvenient Truth, 2006, Paramount Classics, USA
5. Charlie Chaplin, Modern Times, United Artists, USA
6. IIT Delhi, Modern Technology – The Untold Story
7. Anand Gandhi, Right Here Right Now, 2003, Cyclewala Production

(Note: A Teacher's Manual for teaching this course is also available)

SEMESTER – V

Course Code: **MSES301** **Breakup:** **3 – 0 – 3 – 4**

Course Name: **Phase Transformation in Metals**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Thermodynamics and Nucleation Kinetics of Phase Transformations
CO2	Analyze Growth Mechanisms During Phase Transformations
CO3	Apply Kinetic Models to Phase Transformation Analysis
CO4	Understand Microstructural Evolution Processes
CO5	Explore Advanced Solidification and Non-Equilibrium Structures

Course Details
Thermodynamic order of transformations, theory of nucleation -kinetics of homogeneous, transient & heterogeneous nucleation, Theory of thermally activated growth, interface controlled growth diffusion controlled growth, interface instability & Widmanstatten growth, Eutectoid growth, Discontinuous precipitation, massive transformation, transformation kinetics: Johnson-Mehl equation, Avrami model, Transformation kinetics in diffusion controlled transformations, Isothermal & continuous cooling transformation diagrams, Precipitation & particle coarsening, Kinetics of recrystallization, theory of grain growth, Effect of second phase particles Solidiflcation- nature & growth of solid liquid interfaces rapid solidification, glass transition, metallic glasses.

Text Books and Reference:
1. Materials Science and Engineering, V. Raghvan, 2004, PHI
2. Phase Transformation in Metals and Alloys, D. A. Porter & K. E. Easterling, 2009, CRC
3. Physical Metallurgy Principles — *Robert E. Reed-Hill, Reza Abbaschian*

Course Name: **Phase Transformation in Metals Lab**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	To learn through experiments the characteristics of different phases
CO2	To learn through experiments Fundamentals of phase transformation

Course Details

Heat Treatment of Steels, Metallographic sample preparation to study phase changes

Course Code: **MSES302** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Mechanical Behaviour of Materials**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Stress, Strain, and Elastic Behaviour
CO2	Analyze Plastic Deformation and Dislocation Mechanics
CO3	Evaluate Strengthening Mechanisms in Materials
CO4	Assess Fracture, Fatigue, and High-Temperature Failure
CO5	Relate Microstructure to Mechanical Properties Across Material Classes

Course Details

Strain tensor and stress tensor, Representation by Mohr's circle, elasticity, stiffness and compliance tensor, Yield criteria, Plastic deformation by slip and twinning. Dislocation Theory: Edge, screw and mixed dislocations, source and multiplication of dislocations, stress fields around dislocations; Partial dislocations, dislocation interactions and reactions. Strengthening Mechanisms: Work / strain hardening, strengthening due to grain boundaries, solid solution, precipitation and dispersion. Fracture behaviour, Griffith theory, linear elastic fracture mechanics, fracture toughness, fractography, ductile to brittle transition. Fatigue: Cyclic stress strain behaviour-low and high cycle fatigue, crack growth Mechanisms of high temperature deformation and failure; creep and stress rupture, stress exponent and activation energy. some case studies related to design, effect of structure on strength, ductility & toughness, mechanical behaviour of metals, ceramics, polymers & composites.

Text Books and Reference:

1. Mechanical Metallurgy, G. E. Dieter (McGraw-Hill), 2017
2. Mechanical Behavior of Materials, Meyers & Chawala (Prentice Hall), 1998

Course Code: **MSES303** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Manufacturing Processes**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand and Apply Metal Casting Principles
CO2	Analyze Metal Forming Processes and Their Applications
CO3	Evaluate Metal Joining Techniques and Metallurgy
CO4	Understand Powder Metallurgy Techniques
CO5	Apply Non-Destructive Testing Methods

Course Details

Metal Casting: Mould design involving feeding, gating and risering, casting practices, casting defects. Hot, Warm and Cold Working of Metals: Metal forming –fundamentals of metal forming processes of rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming. Metal Joining: Principles of soldering, brazing and welding, welding metallurgy, defects in welded joints in steels and aluminium alloys. Powder Metallurgy: production of powders, compaction and sintering. Thin films & coatings, growth of thin films from liquids, Physical vapour deposition (evaporation, sputtering), Chemical vapour deposition (thermal & plasma CVD), Non-destructive Testing (NDT): Dye-penetrant, ultrasonic, radiography, eddycurrent, acoustic emission and magnetic particle inspection methods.

Text Books and Reference:

1. Fundamentals of Manufacturing Processes, Lal & Choudhary (Narosa), 2014
2. Mechanical Metallurgy, G. E. Dieter (McGraw-Hill), 2017
3. Manufacturing Engineering and Technology - *Serope Kalpakjian, Steven Schmid*

Course Code: **MSES304** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Iron Making**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Historical Development and Fundamentals of Iron Making
CO2	Analyze Chemical Reactions and Thermodynamics in the Blast Furnace
CO3	Evaluate Raw Materials and Burden Preparation Techniques
CO4	Understand Slag Chemistry and Hot Metal Quality Control
CO5	Assess Alternative Iron Making Processes and Perform Process Calculations

Course Details

History of iron making, Raw materials for iron making, Shape of the furnace, Various reactions and zones in the blast Furnace, Thermodynamics of Iron making, Direct & indirect reduction, Refractories for iron & steel; performance evaluation of blast furnace, Burden preparation (sintering, pelletization, coke making). Testing and characterization of raw materials, Burden distribution in Blast Furnace, BF charge materials, Physical, thermal and chemical processes in BF, hot metal quality control, Structure and properties of slags and molten salts – basicity of slags - sulphide and phosphate capacity of slags; Alternative routes of iron making: Electro-thermal process, Sponge iron production, Smelting reduction processes, Material and heat balance in blast furnace, fuel rate calculations.

Text Books and Reference:

1. A first course in iron and steelmaking, D Mazumdar, University Press, Hyderabad India
2. Ironmaking and Steelmaking: Theory and Practice,Ahindra, A Ghosh and Amit Chatterjee, Prentice Hall of India, 2008.
3. Theory and Laboratory Experiments in Ferrous Metallurgy, R C Gupta, PHI Learning India
4. Modern Iron Making , V. R. Tuppari, 2010, Khanna Pub.
5. Introduction to Modern Steel Making, V. R. Tuppari, 2000, Khanna Pub.

Course Code: **HSSS302** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Industrial Management**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the concepts related to business and demonstrate the roles, skills and functions of management
CO2	Understand how the industrial company can be organized and managed
CO3	Understand the complexities associated with management of human resources in the organizations and integrate the learning in handling these complexities
CO4	Express leadership and entrepreneurial attributes through various case studies of local regions.

Course Details

Introduction to Industrial management, Brief history of industries in India, Brief definition of management, organization and administration. Characteristics of management, Principle of management, Function of management like, planning, organization, direction, co-ordination etc.

Level of management, skills of management, inter relation between skills and levels of management, scientific management, Introduction to Schools of Management thoughts, introduction to organization, study of basic type of organization for ex. Line and staff organization, project organization, metrics organization, Informal organization, Introduction to industrial Psychology, Motivation theory and study of Maxlow, Need, Hierarchy Theory, Planned Location, Planned Layout. Study of different forms of layout like line layout, process layout, product layout, combinational layout, sixth position layout etc.

Objective of planned layout, introduction to material management, scope of material management, study of inventory control method, introduction to different types of inventory control techniques, introduction to work study, motion study etc, introduction to conflict management.

Text Book and References:

1. Khanna O.P. : Industrial Engineering
2. T.R. Banga : Industrial Engineering and Management
3. Mahajan: Industrial and Process Management

SEMESTER – VI

Course Code: **MSES305** **Breakup:** **3 – 1 – 0 –4**

Course Name: **Transport Phenomenon and Rate Processes**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Fundamental Principles of Momentum Transfer
CO2	Analyze Heat Transfer Mechanisms
CO3	Apply Mass Transfer Concepts and Laws
CO4	Utilize Dimensional Analysis and Identify Key Dimensionless Numbers
CO5	Study Reaction Kinetics and Electrochemical Processes

Course Details

Momentum Transfer: Concept of viscosity, shell balances, Bernoulli's equation, mechanical energy balance equation, flow past plane surfaces and through pipes. Heat transfer: Conduction, Fourier's Law, 1-D steady state conduction. Convection: Heat transfer coefficient relations for forced convection. Radiation: Black body radiation, Stefan – Boltzman Law, Kirchhoff's Law. Mass Transfer: Diffusion and Fick's laws, Mass transfer coefficients. Dimensional Analysis: Buckingham Pi theorem, Significance of dimensionless numbers. Basic Laws of Chemical Kinetics: First order reactions, reaction rate constant, Arrhenius relation, heterogeneous reactions, oxidation kinetics. Electrochemical Kinetics: Polarization.

Text Books and Reference:

1. Kinetics of Metallurgical Reactions, Hem Shanker Ray (Oxford & IBH), 1993
2. Heat & Mass Transfer, H. S. Ray, 1995
3. Introduction to Transport Phenomena — *William J. Thomson*

Course Code: **MSES306** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Diffusion in Solids**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Fundamentals of Diffusion and Related Phenomena
CO2	Apply Phenomenological and Atomic Theories of Diffusion
CO3	Investigate Diffusion in Specialized Materials
CO4	Analyze Non-Bulk Diffusion Mechanisms
CO5	Examine Thermally and Electrically Driven Diffusion Processes

Course Details

Diffusion equations and mathematical solutions, Kirkendall effect, Uphill diffusion, Phenomenological diffusion theories Atomic theory of diffusion, theoretical and experimental investigation of diffusion in ionic solids and semiconductors, Pipe diffusion, Grain boundary and surface diffusion, thermal & electric-diffusion.

Text Books and Reference:

1. Diffusion in Solids, Paul G. Shewmon (McGraw Hill), 1963
2. Introduction to Diffusion in Solids — *Aloke Paul & S. Sundaresan*

Course Code: **MSE-S307** **Breakup:** **3 – 0 – 3 – 4**

Course Name: **Materials Characterization**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Fundamentals and Applications of Optical Microscopy
CO2	Gain Proficiency in Scanning Electron Microscopy (SEM)
CO3	Apply X-Ray Diffraction (XRD) for Crystallographic Analysis
CO4	Explore Transmission Electron Microscopy (TEM) and Associated Techniques
CO5	Utilize Spectroscopic and Thermal Analysis Techniques

Course Details

Materials Characterization

Fundamentals of optics, Optical microscope and its instrumental details, Variants in the optical microscopes and image formation, Phase contrast, Polarised light, Differential interference contrast, Fluorescence microscopy, Sample preparation and applications of optical microscopes, Introduction to Scanning electron microscopy (SEM), Instrumental details and image formation of SEM, Various imaging techniques and spectroscopy, Sample preparation and applications of SEM, Fundamentals of X-ray scattering, Bragg's law derivation and the factors affecting the intensity, Crystallite size, effect of strain on the intensity, Profile fit, indexing, peak broadening, Quantitative analysis, residual stress analysis, Instrumentation details and demo experiments of XRD, Introduction to transmission electron microscopy (TEM), Diffraction and image formation, Various imaging techniques and spectroscopy, Sample preparation and applications of TEM, Spectroscopic techniques like UV-vis, IR, Raman, Thermal analysis; DSC, DTA, TGA.

Text Books and Reference:

1. Elements of X-Ray Diffraction, B. D. Culity (Addison Wesley), 1978
2. Physical Methods for Metal Characterization, Pej Flewitt (Institutue of Physics Pub.), 2003
3. Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley
4. Transmission electron microscopy" D.B. Williams and C. Barry Carter, 4 volumes, Springer, 1996

Course Name: **Materials Characterization Lab**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	To learn through experiments the characteristics of different phases
CO2	To learn through experiments Fundamentals of phase transformation

Course Details

X-ray analysis, SEM analysis, TGA analysis, Semiconductor and Dielectric Materials Characterization

Course Code: **MSES308** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Heat Treatment of Metals**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Introduction of heat treatment operations
CO2	Fundametals of phase, phase transformation and stability of phases
CO3	Analyze various types of phase diagrams, TTT curve and Iron carbon diagram.
CO4	Understand about different heat treatment processes.
CO5	Study of basic principles to attain best combination of mechanical properties.

Course Details
Heat Treatment of Metals
Iron-carbon phase diagram, heat treatment of steel, hardenability of steels. TTT diagrams, CCT diagrams in steels, quench hardening & tempering of martensite Martensitic transformation nature of martensitic transformation, ham distortion, nucleation & growth of martensite, athermal, isothermal & burst transformations Spinodal decomposition Surface hardening processes, tool steels & their heat treatments, heat treatment of cast iron Thermochemical & thermo mechanical treatments Heat treatment of Ni-base superalloys & Ti alloys,

Text Books and Reference:

1. Physical Metallurgy, Lakhtin, 2005, CBS
2. Heat Treatment: Principles and Techniques — *T. V. Rajan, C. P. Sharma, Ashok Sharma*
3. Heat Treatment of Metals— *V. Raghavan*

Course Code: **MSE-S309** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Steel Making**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Modern Steelmaking Routes and Thermodynamics
CO2	Analyze Primary Steelmaking Processes
CO3	Comprehend Secondary Steelmaking Techniques
CO4	Evaluate Steel Quality Through Inclusion and Impurity Control
CO5	Understand Heat Transfer and Solidification in Casting

Course Details

Introduction: Various routes of modern steel making (BF-BOF, DRI-EAF, SR), Thermodynamics of steelmaking. Introduction to LD steel making (process, emulsion, decarburization, catch carbon technique, impurity & slag evolution), Hybrid steel making. Modern EAF/IF steel making. Secondary Steel making: Thermodynamics & kinetics of deoxidation, Secondary steel making: Vacuum treatment of steel and processes, gas stirring. Secondary Steel making: Ladle desulphurization, inclusion modification by calcium treatment. Inclusion control by optimizing upstream operating parameters. Heat transfer and segregation during casting. Ingot casting, continuous casting, defects in steel, Testing and inspection of the product in steel industry (basics of NDT techniques: Ultrasonic testing (UT), Magnetic particle inspection (MPI), Die penetrant testing (DPT)), C,H,N analyzer etc.

Text Books and Reference:

1. A first course in iron and steelmaking, D Mazumdar, University Press, Hyderabad India
2. Ironmaking and Steelmaking: Theory and Practice,Ahindra, A Ghosh and Amit Chatterjee, Prentice Hall of India, 2008
3. Steel Making, A K Chakrabarti, Prentice Hall, 2007
4. Introduction to Modern Steel Making, V. R. Tuppari, 2000, Khanna Pub.

Course Code: **HSSS301** **Breakup:** **3 – 0 – 0 – 3**

Course Name: **Industrial Economics**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	provide students with the analytical skills required for understanding problems in national industrial interest
CO2	examine the key questions on the internal organisation of firms
CO3	analyse various aspects of strategic interaction between firms and the determinants of industrial structure.
CO4	provide students with the ability to apply economic models of firm behaviour to analyse questions in business strategy, competition policy and regulation.

Course Details

Unit -I

Definition and scope of engineering economics
Concept of supply and demand
Price elasticity and cross elasticity of demand
Production
Engineering costs and cost estimation
Concept of time value of money
Cash flow analysis

Unit-II

Perfect competition
Monopoly
Monopolistic competition

Unit-III

National Income, GDP
Inflation, Deflation and treatment

Unit-IV

Functions of RBI
Indian Tax System

Text Books and Reference:

1. Henderson, M. James and Quandt, E. Richards, "Microeconomic Theory: A Mathematical Approach".
2. Koutsoyiannis, A., "Modern micro economics".ardwick, Philip., Khan Bahadure., Langmeed, John, "An Introduction to modern economics".
3. Samuelson, A. Paul, "Economics".
4. Shapiro, Edward. "Macro economics".

Newnan, G. Donald, Eschenbach, G.Ted, Lavelle, P. Jerome, "Engineering Economic Analysis"

SEMESTER – VII

Course Code: **MSES401** **Breakup:** **3 – 1 – 0 – 4**

Course Name: **Corrosion and Degradation of Materials**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	To understand the degradation process of various engineering materials used globally
CO2	To understand electrochemical corrosion process To understand degradation of polymers and ceramics under physiochemical conditions
CO3	To understand degradation of polymers and ceramics under physiochemical conditions

Course Details

Thermodynamics and kinetics of materials corrosion., Oxidation, common forms of corrosion, stress corrosion, corrosion fatigue, radiation damages, corrosion effects, corrosion susceptibility tests, electrochemical measurements of corrosion rates, corrosion prevention and economic consideration, high temperature oxidation and sulphidation, corrosion case history, physical aging in polymers, degradation of polymers and their effect on mechanical properties

Text Books and Reference:

1. Corrosion, M. G. Fontana, 1978, McGraw-Hill
2. Principles and Prevention of Corrosion — *Denny A. Jones*

Course Code: **MSES402** **Breakup:** **3 – 1 – 0 –4**

Course Name: **Fuel, Refractories and Furnaces**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Conventional and Emerging Energy Sources and Fuel Characterization
CO2	Study the Properties and Applications of Refractories
CO3	Analyze Furnace Types and Their Thermal Design
CO4	Evaluate Energy Efficiency and Heat Recovery Systems in Furnaces
CO5	Apply Modern Techniques for Furnace Control and Environmental Impact

Course Details

Conventional and newer sources of energy, Characterization of fuels: Analysis and calorific value with problems, Principles of conversion of fuels: Carbonization, Gasification and Hydrogenation, Principles of fuel combustion and Numerical problems. Liquid fuels, Classification of refractories and their service properties, Manufacture of common refractory like silica, alumina, fireclay, dolomite, magnesite. Types of furnaces and their role in high temperature applications, Fluid flow in furnaces: macroscopic energy balance and its application to Design of chimney and flow measuring devices Heat transfer in furnaces: Conduction, convection and radiation with suitable examples to design refractory lining, and heating of load through flame and convection. Flame temperature and heat utilization; concept of available heat and fuel consumption, Principles of waste heat recovery and design of heat exchangers and burners, Heat balance diagrams with illustrations, Fuel economy in industrial furnaces, Oxygen addition to combustion process, Energy efficient operation of furnaces with illustrations, Instrumentation and control in furnaces Concept of carbon credit (carbon-offset) and its relation with energy efficiency

Text Books and Reference:

1. Fuels, Furnaces and Refractories — *O. P. Gupta*
2. Fuels, Furnaces and Refractories — *J. D. Gilchrist*
3. Elements of Fuels, Furnaces and Refractories — *H. S. Ray, R. Sridhar, K. P. Abraham*

Course Code: **MSES403** **Breakup:** **3 – 1 – 0 –4**

Course Name: **Polymers and Composite Materials**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Fundamentals of Polymers and Polymerization
CO2	Establish Structure–Property Relationships in Polymers
CO3	Explore Polymer Processing Techniques
CO4	Introduce Composite Materials and Reinforcement Mechanisms
CO5	Study Composite Processing and Manufacturing Challenges

Course Details

Classification of polymers, Polymerization reactions. Polymer characterization, thermal, mechanical and electrical properties, polymer crystallinity, structure property correlations in polymers, Thermoplastics and thermosets, Processing of polymers, Thermoforming process. Extrusion, Compression molding, Injection molding. Transfer molding, Rotational molding, Blow molding, Composite materials: basic concepts, Classification of composite materials. strengthening mechanisms in composites, Reinforcing materials: fibres, whiskers and particles. Manufacture of glass fibres, fabrication of fibre reinforced plastics and metal matrix composites. Properties and application of composites. Processing of polymer composites, Hand-layup, Spray-layup, Compression molding Injection molding. Reaction injection molding, Autoclaving, Resin transfer molding, Filament winding, Pultrusion. Sheet molding, Pre-pegging and challenges in primary processing of composites, Secondary processing of polymer composites.

Text Books and Reference:

1. Composite Materials: Science & Engineering, K. K. Chawla (springer), 1987
2. Polymer Materials, C.M. Hall, MacMillan Education Ltd., London 1989.
3. Composite Materials,: Engineering and Science, F.L. Matthews and R.D. Rawlings, Chapman & Hall, London ,1994

Course Code: **MSES404** **Breakup:** **3 – 1 – 0 –4**

Course Name: **Application of Transport Phenomenon in metal processing**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Review Core Concepts of Transport Phenomena
CO2	Understand Turbulence and Dimensional Analysis in Reactor Design
CO3	Analyze Free Convection and Gas/Bubble-Driven Systems
CO4	Apply Transport Principles to Industrial Metallurgical Processes
CO5	Develop Problem-Solving Skills for Real-World Metallurgical Systems

Course Details

Review of heat, mass and momentum transfer, fundamentals of turbulence phenomena, turbuleny flows. dimensional analysis and reactor design, free convection phenomena and bubble/gas driven systems, applications of transport phenomena to (I) gas stirred ladle system (2) desulphurization of pig iron using Mg vapour (3) alloy addition kinetics (4) soaking & soaking furnaces.

Text Books and Reference:

1. Transport Phenomena in Materials Processing — *David R. Poirier, Gordon H. Geiger*
2. Transport Phenomena in Metallurgy — *G. H. Geiger, D. R. Poirier*

Departmental Elective Courses

Course Code: MSES501 **Breakup: 3 – 0 – 0 –3**

Course Name: Electrochemical Technology in Materials Processing

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Thermodynamics and Electrochemical Principles
CO2	Analyze Electrochemical Process Design and Economics
CO3	Apply Electrochemical Techniques in Metallurgical Operations
CO4	Examine Surface Treatment and Coating Technologies
CO5	Evaluate Electrochemical Technologies for Environmental and Energy Applications

Course Details

Thermodynamics of electrolyte, electrochemical potential, conduction of ions in solution, over potential. absorption, phase formation, economics of an electrolyte process, principles of cell design. electrochemical technology, electrowinning, electrorefining, metal electro forming Electrochemical machining, electroplating, anodizing, pickling, electrophoretic painting. Electrochemical treatment of minerals, batteries and cells, water treatment and environmental protection.

Course Code: MSES502 **Breakup: 3 – 0 – 0 –3**

Course Name: Recycling of Metallurgical and Electronic Waste
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Fundamentals of Materials Recycling
CO2	Classify and Characterize Industrial Wastes
CO3	Analyze Pre-Treatment and Separation Techniques
CO4	Apply Metallurgical Processes for Recycling
CO5	Assess Recycling Strategies for Specific Industrial Wastes

Course Details
Introduction to Materials Recycling and waste management, Categories of metallurgical and electronic waste, Key unit operations involved in pre-treatment of metallurgical and electronic waste, Application of pyrometallurgy, hydrometallurgy and electrometallurgy and refining for Material separation and enrichment of raw materials, Metallurgical waste recycling: Aluminium industrial waste, dross, scrap, red mud, spent pot lining, salt slag, Copper industrial waste, smelter slags, raffinates, spent electrolytes, Zinc industrial waste, zinc ash, zinc dross, flue dust and scraps, Iron and Steelmaking waste, scraps, ironmaking slag, steelmaking slag and wastewater. Electronic waste recycling: Waste Printed Circuit Board, delamination and metal recovery, Spent batteries and recovery of valuable materials from waste electrodes, Environmental impacts of materials recycling.

Course Code: **MSE-S503** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Engineering Polymers**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Structure and Synthesis of Polymers
CO2	Analyze Physical and Thermal Behavior of Polymers
CO3	Characterize Molecular and Rheological Properties
CO4	Evaluate Mechanical Properties and Viscoelastic Behavior
CO5	Apply Polymer Processing Techniques and Design Principles

Course Details

Classification & structure of polymers, polymer synthesis, copolymers,' Molecular structures & architecture, molecular weight distribution, rotational' isomeric states, chain configuration in dilute solution & condensed states, characterization of molecular weight & distribution, light scattering, Osmometry, Intrinsic viscositye1 permeation chromatography, solidification, glass formation, glass, spherulites, alloys, multicomponent metals, processing effects thermal effects of rheological behaviour, Time tempeure equivalence, WLF equation, Arrhenius behaiour, Mechanical behavior of solids, Viscoelasticity, Boltzmann superposition principle, failure behavior & criteria Glass transition, liner viscoelasticity, stress relaxation and dynamic experiment mechanical morals, superposition principle effect or structure on mechanical properties, rubber is elasticity, yield & fracture polymer working process such a extrusion, forming shaping injection molding, blow molding, sheet forming, film forming, thermoforming and callendering, advances in polymer working technology, effect of processes in structure and properties, material selection & design consideration.

Course Code: **MSE-S504** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Welding and Joining of Metals**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Metallurgical Fundamentals of Welding Processes
CO2	Analyze Heat Flow, Solidification, and HAZ Behavior
CO3	Evaluate Strengthening Mechanisms and Heat Treatments in Weldments
CO4	Identify Welding-Induced Defects and Distortion
CO5	Apply Design and Material Considerations for Weldability

Course Details

Introduction to welding metallurgy, phase diagrams, Phase transformation, TTT and CCT diagrams, Metal strengthening approaches, Heat treatment processes for weldments, Analysis of heat flow and temperature distribution in welding, Concept of solidification in welding, constitutional supercooling, Introduction to heat affected zones, Properties of HAZ, Residual stresses in welding, Preheat and postweld heat treatment, Types of welding distortion and its control, Cracks in welds, Weldability issues in materials, Welding defects, Design considerations in welding.

Course Code: **MSE-S505** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Electronic ceramic Materials**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Crystallography and Bonding in Ceramic Materials.
CO2	Analyze Structure Formation and Defects in Oxides
CO3	Examine Diffusion and Electrical Properties in Ceramics
CO4	Learn Powder Preparation and Ceramic Processing Techniques
CO5	Apply Advanced Sintering and Fabrication Methods for Functional Ceramics

Course Details

Crystallography: structures and structure determination, Bonding in solids: Difference in metals and ceramics, Rules for structure formation in oxides/ionic solids, Structures of important oxides, Defects in ceramics and defect chemistry, Defects equilibrium, Defects diffusion, Ionic and defect conductivity, Dielectric ceramics, Magnetic ceramics, Multiferroics, Preparation Methods: production of powders by chemical and physical mean, powder consolidation, addition in ceramic processing, sintering and sintering theory, cold and hot isostatic pressing, processing of electronic ceramic, sol-gel processing.

Course Code: **MSE-S506** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Materials Engineering**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Fundamental Structure of Materials
CO2	Analyze Mechanical Behavior and Failure Mechanisms
CO3	Interpret Phase Diagrams and Thermal Processing Principles
CO4	Explore Advanced Materials Processing Techniques
CO5	Select Materials for Engineering Applications

Course Details

Introduction, Crystal Structure, Imperfections in solids, Mechanical properties of materials, Failure of Materials, Basics of Fracture Mechanics, Fatigue failure theories, Phase diagrams, Thermal Processing and Heat Treatment of Steels / Metals, Crystal growth, Nondestructive evolution, Processing of glasses and polymers, Novel processing methods, Thin films, Materials selection for different engineering applications.

Course Code: **MSE-S507** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Modern Steel Making and Alloying**

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Alloy Steel Making Processes and Classifications
CO2	Apply Thermodynamics and Kinetics in Alloy Steel Production
CO3	Examine Secondary Metallurgy and Post-Solidification Treatments
CO4	Explore Ferroalloy Production Principles and Technologies
CO5	Evaluate Industry Practices and Recent Technological Developments

Course Details

Alloy steel making processes – special reference to stainless steel, high speed steel, manganese steel other special steels. Thermodynamics and kinetics of alloy steel making. Defects and remedies. Post solidification treatments. Secondary alloy steel making technologies. Problems. Overview of Indian ferro alloy sector and alloy steel sector. Basics of ferro alloys production – concept: thermodynamic principles and techniques. Existing production processes of important ferro alloys, Fe–Cr, Fe–Mn, Fe–Si. Recent advances in ferro alloy technology. Production of other ferro alloys – Fe–V, Fe–Ti, Fe–W, Fe–Ni, Fe–Mo, Fe–Zr, Fe–B, etc.

Course Code: **MSE-S508** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Electronic Materials for Industry**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand Dielectric and Ferroelectric Material Behavior
CO2	Analyze Magnetic Properties of Materials
CO3	Examine Semiconductor Physics and Material Processing
CO4	Explore Microfabrication and Device Structures
CO5	Apply Principles of Materials Design and Integration.

Course Details

Dielectric Materials-dielectric constant and polarization, polarization mechanism, linear and nonline dielectric, pyro-piezo,and ferroelectric properties, application magnetization-diamagnctisn paramagnelism, polypararnagnetism, ferro, antiferro, and ferri magntism. Soft and hard magnet materials, permanent magnet and transformers. Carrier statistics in semiconductor, semiconductor materials purification, and crystals growth, epitaxy, CVD and, MBE, Physical vapor deposition (sputtering, evaporation, etc), P-N junction, Schottky & MaS device structures, doping by implantaik and diffusion, ion implantation, patterning, etchlithography, empirical rule, alloy design, very large sea integration (VLSI).

Course Code: **MSES509** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Principles of Powder Processing**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Characteristics of Particulate Systems
CO2	Analyze Static and Dynamic Behavior of Particulate Systems
CO3	Explore Particle Production and Suspension Behavior
CO4	Perform Particle Size Analysis and Characterization
CO5	Study Powder Consolidation and Sintering Processes

Course Details

The particulate state- attributes & morphology of particles, distribution of particles in a single attribute, inspectation as a measure of global properties of particular ensembles, analysis of static & dynamic particulate systems by transformation attributes and measures, production of particles, particulates in suspension, stability, morphology and setting, size analysis, consolidation of powders, Sintering.

Course Code: **MSES510** **Breakup:** **3 – 0 – 0 –3**

Course Name: **Nanomaterials and Their Properties**
Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Fundamentals of Nanomaterials
CO2	Analyze the Structural and Thermodynamic Aspects of Nanomaterials
CO3	Explore Natural and Engineered Nanostructures
CO4	Evaluate the Physical Properties of Nanomaterials
CO5	Examine Nanomanufacturing Techniques and Applications

Course Details

Introduction to nanomaterials, Surface effects and physical properties of nanomaterials, Atomic bonding, Overview of nanostructures and nanomaterials; Carbon Nanostructures, Multi-scale hierarchy nanostructures, Nanomaterials in nature, Thermodynamics of Nanomaterials, Surfaces and interfaces in nanostructures, Nanomaterials science and nanomanufacturing, Properties of nanomaterials: Electrical, Magnetic, Optical and Mechanical. Nanomaterials applications.

Course Code: MSES511 **Breakup: 3 – 0 – 0 –3**

Course Name: Computing Methods in Materials Engineering

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Introduce Computational Foundations and Programming Skills
CO2	Apply Numerical Techniques to Engineering Problems.
CO3	Solve Engineering Equations Using Computational Tools
CO4	Utilize Software Tools for Materials and Process Simulation
CO5	Model and Simulate Mineral Processing and Process Systems

Course Details

Introduction to programming language, differentiation, integration, finding roots of equation and solving linear algebraic equations, Interpolation, extrapolation, application of regression analysis and curve fitting techniques, computer calculation of phase diagrams, numerical solution of partial differential equation pertinent to heat, mass and momentum transfer, computer application in solidification, potential energy diagrams, mass balancing, data reconciliation problem solving with material balance software package quantitative description of mineral processing units and its computer implementation, introduction to a general purpose modular, simulation for process analysis.

Course Code: MSES512 **Breakup: 3 – 0 – 0 –3**

Course Name: Artificial Intelligence and Machine Learning in Materials Engineering

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the Role of AI/ML in Materials Science
CO2	Establish Structure–Property–Processing Relationships
CO3	Apply Computational Methods for Materials Modeling
CO4	Implement Machine Learning Techniques in Materials Design
CO5	Leverage Materials Informatics and Data Science

Course Details

Introduction; basic aspects of AI/ML in Materials Engineering, Structure of Materials, Microstructure –property correlation, Processing of materials, Correlation between processing with materials structure, Materials design at different length scale: Basic Design Principles, Component level to atomic level aspects of material design, CALPHAD; Ab initio, Density Functional Theory (DFT), Monte Carlo (MC) or Molecular Dynamic (MD) followed Phase Field Simulations (PFM) for microstructural evolution. Machine Learning Approaches for Materials Design: Statistical Tools, Machine Learning, Computer vision, Microstructural evolution, Microstructure property correlation, Accelerating Materials Development and Deployment: Microstructure property correlation, Inverse design using AI/ML – from evolutionary algorithms to deep learning, Materials Knowledge and Materials Data Science: Advanced Deep Learning, AI/ML for materials characterization, AI/ML for autonomous experiments, Materials Informatics and Data Science.

Course Code: MSES513 **Breakup: 3 – 0 – 0 –3**

Course Name: Electronic Properties of Materials: Computational Approach

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Introduce Fundamental Theories of Electron Behavior in Materials
CO2	Develop Computational Skills for Quantum Materials Modeling
CO3	Explore Electronic Band Structure and Solid-State Concepts
CO4	Analyze Thermodynamic Properties of Electron Gases
CO5	Understand Modern Electronic Materials and Applications

Course Details

Electronic materials in various applications,Introduction to the Drude model and failure of the classical theory,Introduction to Quantum Physics, Basic introduction to Python programming, Numerically solving Schrodinger equation, Numerov method and WKB approximation, Free electron gas in ground state T=0 ,Free electron gas at finite temperature and electronic free energy calculation by numerical integration, Failure of free electron model (1 lecture), Introduction to the Bravais lattice and reciprocal lattice, Visualization of Bravais and reciprocal lattice, Kronig-Penney model ,Electrons in a periodic potential: Bloch theorem, Energy bands, Numerical methods for energy bands, Fermi surface, Semi-classical electron dynamics, Semiconductors and insulators, Semiconductors and insulators, Two dimensional materials for next generation device applications

Course Code: MSES514 **Breakup: 3 – 0 – 0 –3**

Course Name: Surfaces and Coatings

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Understand the fundamental principles and processes of surface coating
CO2	Analyze the mechanisms of coating formation, adhesion, and performance
CO3	Gain proficiency in the design and operation of deposition systems
CO4	Evaluate the properties and performance of coated materials
CO5	Apply surface coating technologies to industrial applications and for controlling wear.

Course Details

Introduction, CVD Coating: CVD reaction, Adhesion of CVD coating, CVD System, CVD of TiC, Chemical Vapour Deposition of Nitride Coating, Carbo-Nitride Coating, Chromium, Aluminium Oxide, Physical Vapour Deposition: Vacuum Evaporation Deposition, Reactive Evaporation Deposition, Cathodic Arc Evaporation Deposition, Sputtering, Magnetron Sputtering, Unbalanced Magnetron Sputtering, Radio Frequency and Pulsed DC sputtering, Sputter Deposition of Nitride Coating, Molybdenum Di sulphide coating, Electro Chemical Deposition: Electro Plating, Anodizing and Electro-Less Plating, Coating of Monolayer Abrasive grain by Electro Plating, Surface Coating by Wetting, Thermal Spray Process, Vacuum Technology for Deposition of Coating, Applications of Surface Coating, Characterization of Coating, Performance Evaluation of Coated Product: TiN Coated Tool, Diamond Coated Tool. Materials for wear resistant applications Processes for Controlling Wear.

Course Code: MSES515 **Breakup: 3 – 0 – 0 –3**

Course Name: Functional Materials

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Describe the structure, composition, and functionality of solid-state materials
CO2	Analyze crystal structures, imperfections, phase transitions, and diffusion processes
CO3	Explain the principles of magnetism and spintronics
CO4	Apply appropriate methods for characterization of solid-state materials
CO5	Evaluate the use of functional materials in advanced devices

Course Details

Introduction to solid state materials – From conventional to functional, Ceramics, Composites, Polymers and Glass, Introduction to Nanomaterials and functionality, Crystal Structure, Crystal imperfections, Alloys and melts, Structure – Property Correlation, Phase and Phase transitions, Homogeneous reactions and diffusion, Mechanical properties of solids, Thermal properties of solids, Heat Capacity, Expansion in solids, Negative and zero expansion ceramics – Their applications, Elasticity and compressibility, Viscosity, Introduction to magnetism, Magnetic properties of solids, Magnetism at nanoscale, Bulk and man-sized magnetic materials, Characterization of structure and properties of magnetic materials, Giant and Colossal Magnetoresistance, GMR and CMR materials, Spintronics, Spin diode and filters, Spintronics for data storage and energy harvesting, Introduction to Properties of Liquids & Melts, X-ray Spectra & Models of Liquids & Melts, Thermal Expansion & Heat Capacity, Transport Properties, Thermal & Electrical conduction, Sensors and detectors – Magnetic, Sensors – Optical and Electrical, Sensors – Thermal, Sensors – VOCs and electrochemical, Energy Devices – batteries, Energy devices – supercapacitors, Energy devices – solar cells, Piezoelectric devices.

Course Code: MSES516 **Breakup: 3 – 0 – 0 –3**

Course Name: Introduction to Bio Materials

Course outcomes (CO): At the end of the course, the student will be able to:

CO1	Describe the basic concepts of materials science and the salient properties of materials used in biomedical applications
CO2	Explain the concepts of biocompatibility, cell-material interactions, foreign body response
CO3	Apply in vitro and in vivo testing methods
CO4	Analyze the processing, microstructure, and properties of key biomaterials
CO5	Design and propose new materials and coatings for bioimplant applications

Course Details

Introduction to basic concepts of Materials Science; Salient properties of important material classes, Property requirement of biomaterials; Concept of biocompatibility, Structure and properties of biological cells & tissues, Cell-material interactions and foreign body response, Assessment of biocompatibility of biomaterials, In vitro biochemical assays (cellular adhesion, cellular viability using MTT, osteogenic differentiation using ALP assay; Biomnuneralisation using Osteocalcin assay), In vivo testing and histocompatibility assessment, Genotoxicity assessment (Physical damage to DNA by biomaterial eluates), Important biometallic alloys: Ti-based, stainless steels, Co-Cr-Mo alloys, Bioinert, Bioactive and bioresorbable ceramics, Processing and properties of different bioceramic materials with emphasize on hydroxyapatite, Synthesis of biocompatible coatings on structural implant materials, Plasma spraying of carbon nanotube reinforced hydroxyapatite on Ti-6Al-4V substrate; in-vitro cytocompatibility, Microstructure and properties of glass-ceramics, Biodegradable polymers, Design concept of developing new materials for bio implant applications.

Board of Studies of Materials Science and Metallurgical Engineering, as approved on 26.03.2025

1. Prof. Kantesh Balani, Professor and Head, Department of Materials Science and Engineering, IIT Kanpur. (External Expert)
2. Prof. Sunil Mohan, Metallurgical Engineering Department, IIT BHU (External Expert)
3. Dr. Arunabh Meshram, Assistant Professor, Department of Materials Science and Engineering, IIT Kanpur. (External Expert)
4. Dr. Prince Kumar Singh, Assistant Professor, Department of Metallurgical and Materials Engineering, IIT Ropar. (Alumni Expert)
5. Mr. P. C. Sinha, Vice- President, Aarti Steel International, Ludhiana (Industry Expert)
6. Dr. Anju Dixit, MSME Department, UIET, CSJMU, Kanpur
7. Dr. Vijay Kumar Kashyap, Coordinator, MSME Department, UIET, CSJMU, Kanpur (Convener)

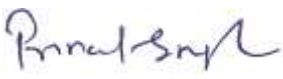
A meeting of the BOS was held on 16.06.2025, to discuss the course structure and syllabus of the B.Tech. (Materials Science & Metallurgical Engineering) program and its approval, after a rigorous discussion on each point of the syllabus, the members of the Board of Studies, unanimously approved the proposed syllabus.

Jun. 21, 2025

Prof. Kantesh Balani
IIT Kanpur
Member, BOS

Prof. Sunil Mohan
IIT- BHU, Varanasi
Member, BOS

Dr. Arunabh Meshram
IIT Kanpur
Member, BOS



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UIET, CSJMU
Member, BOS

Dr. Vijay Kumar Kashyap,
MSME, UIET, CSJMU
(Convener)

Date: 16.06.2025