Course Structure & Syllabus

of

B. Tech. Programme

in

Metallurgical & Materials Engineering

Academic Year – 2019-20

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, ODISHA

Burla, Sambalpur-768018, Odisha

www.vssut.ac.in

Vision

To be recognized as a center of excellence in education and research in the field of Metallurgical and Materials Engineering, so as to be the terminus for students, researchers and faculties for the pursuit of academic excellence, technical innovation, and industrial professionals for socio-economic upliftment of society to meet the global challenges.

Mission

Metallurgical and Materials Engineering Department of VSSUT Burla strives to achieve global excellence in education and research and preparing students for global competitiveness by fostering educational excellence through:

M1: Maintaining state of the art academic and research facilities by keeping up with the technological advancement to provide quality technical education for analysis, design and operation of metallurgical and materials systems.

M2. Fortifying collaboration with world class R&D organizations, national and international institutes, universities and industries and alumni for continuous evolution in teaching, research and consultancy practices to contribute in the national mission programs.

M3. Providing the students with academic environment of excellence, leadership, ethical guidelines so as to stimulate to pursue life-long learning by enhancing knowledge and skills for professional advancement.

Program Educational Objectives (PEOs)

PEO1: To acquire competency in solving real-life problems and to design/develop sustainable and cost-effective products according to the prevailing socio-economic context.

PEO2: To create awareness of societal impact and professional ethics so as to lead a successful career in industries or pursue higher studies or entrepreneurial endeavors.

PEO3: To offer techno commercially feasible and socially acceptable solutions to real life engineering problems in order to address the prevailing safety hazards, material degradation and environmental pollution in metallurgical industries

PEO4: To create a congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups in professional, industry and research organizations by applying engineering and material science principles.

PEO5: To demonstrate effective communication skill, ability to draw relevant conclusions for scholarly writing and presentation, professional attitude and a desire to learn.

PEO-Mission Mapping

	M1	M2	M3
PEO1	**2**	**3**	**1**
PEO2	**1**	**3**	**2**
PEO3	**3**	**3**	**1**
PEO4	**2**	**3**	**3**
PEO5	**1**	**2**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Program Outcomes (POs)

PO1: To apply knowledge of mathematics, science and engineering to solve complex problems in metallurgy and materials engineering.

PO2: To identify, formulate, and solve complex metallurgy and materials engineering problems using first principle of mathematics, basic science & engineering.

PO3: To design system components and processes for complex engineering problems to meet the specifications deliberating for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: To use research-based knowledge including design of experiments, analysis and interpretation of data, and available information to provide valid conclusions.

PO5: To create, select, and apply appropriate techniques, skills, and modern engineering tools necessary for relevant engineering practices

PO6: To design, implement & evaluate metallurgy and materials engineering projects to meet societal and environmental needs.

PO7: To recognize the sustainability and environmental impact of the engineering solutions

PO8: To follow prescribed norms, responsibilities and ethics in engineering practices.

PO9: To work effectively as an individual and in a team and in multidisciplinary settings.

PO10: To communicate effectively through oral, written and pictorial means with engineering community and the society at large.

PO11: To understand and apply engineering and management principles in executing project as a member and leader in a team in multidisciplinary environments.

PO12: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

At the time of graduation, the students will be able to:

PSO1: Analyze, frame, design and examine Metallurgical and Materials Engineering problems using basic knowledge of engineering.

PSO2: Establish themselves as practicing professionals in core sector or entrepreneurial actions by resolving real life engineering problems to offer techno-commercially feasible and socially acceptable solutions using contemporary knowledge and tools.

PSO3: Communicate ethically and effectively, aspire to learn and be able to handle problems with professional attitude so as to lead a successful career in industries or entrepreneurial endeavors or undertake research in broad area of industrial metallurgy, independently as well as in group.

Course Structure and Detailed Syllabus

FIRST YEAR: FIRST SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1.	BMA01001	Mathematics-I	3-1-0	4
2.	BCH01001	Physics/Chemistry	3-0-0	3
3.	BEC01001	Basic Electrical Engineering/Basic Electronics	3-0-0	3
4.	BIT01001	English For Business Communication/Programming for Problem Solving	3-0-0	3
5.	BCE01001	Engineering Mechanics/Basic Civil Engineering	3-0-0	3
SESSIONALS				
1.	BCH01002	Physics Lab/Chemistry Lab	0-0-3	1.5
2.	BEC01002	Basic Electrical Engineering Lab/Basic Electronics Lab	0-0-3	1.5
3.	BIT01002	English For Business Communication/Programming for Problem Solving	0-0-3	1.5
4.	BCE01002	Engineering Graphics & Design/ Workshop & Manufacturing Practices	0-0-3	1.5
NON-CREDIT				
1	BNC01001	Induction Programme and Participation in Clubs/Societies	0-0-0	0
		TOTAL	**15-1-12**	**22**

FIRST YEAR: SECOND SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1.	BMA02001	Mathematics - II	3-1-0	4
2.	BPH02001	Physics/Chemistry	3-0-0	3
3.	BEE02001	Basic Electrical Engineering/Basic Electronics	3-0-0	3
4.	BHU02001	English For Business Communication/Programming for Problem Solving	3-0-0	3
5.	BME02001	Engineering Mechanics/Basic Civil Engineering	3-0-0	3
SESSIONALS				
1.	BPH02002	Physics Lab/Chemistry Lab	0-0-3	1.5
2.	BEE02002	Basic Electrical Engineering Lab/Basic Electronics Lab	0-0-3	1.5
3.	BHU02002	English For Business Communication/Programming for Problem Solving	0-0-3	1.5
4.	BME02002	Engineering Graphics & Design/ Workshop & Manufacturing Practices	0-0-3	1.5
NON-CREDIT				
1	BNC02001	NSS/NCC/Yoga	0-0-0	0
		TOTAL	**15-1-12**	**22**

SECOND YEAR: THIRD SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1	BMA03001	Math-III	3-1-0	4
2	BMM03001	Metallurgical Thermodynamics and Kinetics	3-0-0	3
3	BMM03002	Introduction to Physical Metallurgy	3-0-0	3
4	BMM03003	Transport Phenomena	3-0-0	3
5	BHU03001	Economics for Engineers	3-0-0	3
SESSIONAL				
1	BMM03004	Metallurgical Thermodynamics and Kinetics Lab	0-0-3	1.5
2	BMM03005	Transport Phenomena lab	0-0-3	1.5
3	BMM03006	Introduction to Physical Metallurgy Lab	0-0-3	1.5
4	BMM03007	Fuel Testing Lab	0-0-3	1.5
NON CREDIT				
1	BNC03001	Essence of India Traditional Knowledge/ Environmental Sciences	0-0-0	0
		TOTAL	**15-1-12**	**22**

SECOND YEAR: FOURTH SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1.	BMA04001	Math IV	3-0-0	3
2.	BMM04001	Mineral Processing	3-1-0	4
3.	BMM04002	Unit Processes and Principles of Metal Extraction	3-0-0	3
4.	BMM04003	Phase Transformation	3-0-0	3
5.	BHU04001	Organizational Behavior	3-0-0	3
SESSIONAL				
1.	BMM04004	Phase Transformation Lab	0-0-3	1.5
2.	BMM04005	Mineral Processing Lab	0-0-3	1.5
3.	BMM04006	Process Metallurgy Lab	0-0-3	1.5
4.	BMM04007	Non-Destructive Testing lab	0-0-3	1.5
NON CREDIT				
1	BNC04001	Environmental Sciences/ Essence of India Traditional Knowledge	0-0-0	0
2	BNC04002	Summer Internship/ Training	0-0-0	0
		TOTAL	**15-1-12**	**22**

THIRD YEAR: FIFTH SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1.	BMM05001	Iron Making	3-0-0	3
2.	BMM05002	Heat Treatment	3-0-0	3
3.	BMM05003	Deformation Behaviour of Materials	3-0-0	3
4.		Professional Elective-I	3-0-0	3
5.		Open Elective-I	3-0-0	3
6.		Professional Ethics, Professional Law &Human Values / Financial Management, Costing, Accounting, Balance Sheet & Ratio Analysis	2-0-0	2
SESSIONAL				
1.	BMM05004	Heat Treatment Lab	0-0-3	1.5
2.	BMM05005	Foundry Lab	0-0-3	1.5
3.	BMM05006	Powder Metallurgy & Composite Materials Lab	0-0-3	1.5
		TOTAL	**17-0-9**	**21.5**

Professional Elective-I		
Sl.No.	Course Code	Subjects
1.	BMMPE501	Powder Metallurgy and composite Materials
2.	BMMPE502	Fuel, Furnace and Refractories
3.	BMMPE503	Alternative Routes of Iron Making

Open Elective-I		
Sl.No.	Course Code	Subjects
1.	BMMOE501	Nonequilibrium Processing of Materials
2.	BMMOE502	Mechanical Working of Metallic Materials

THIRD YEAR: SIXTH SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1.	BMM06001	Casting Process and Solidification	3-0-0	3
2.	BMM06002	Steel Making	3-0-0	3
3.		Professional Elective-II	3-0-0	3
4.		Professional Elective-III	3-0-0	3
5.		Open Elective-II	3-0-0	3
6.		Financial Management Costing, Accounting, Balance Sheet & Ratio Analysis/ Professional Ethics, Professional Law &Human Values	2-0-0	2
SESSIONAL				
1.	BMM06003	Computational Lab.	0-0-3	1.5
2.	BMM06004	Material Processing Lab	0-0-3	1.5
3.	BMM06005	Material Testing Lab	0-0-3	1.5
NON-CREDIT				
		Summer Industry Internship/Training/Project	0-0-0	0
		TOTAL	**17-0-9**	**21.5**

Professional Elective-II		
Sl.No.	Course Code	Subjects
1.	BMMPE601	Material Testing
2.	BMMPE602	Sintering Theory and Practice
3.	BMMPE603	Theory of Alloys
Professional Elective -III		
Sl.No.	Course Code	Subjects
1.	BMMPE605	Material Processing
2.	BMMPE606	Welding Technology
3.	BMMPE607	Failure analysis
Open Elective-II		
Sl.No.	Course Code	Subjects
1.	BMMOE601	Engineering Materials
2.	BMMOE602	Modelling of Materials Processes

FOURTH YEAR: SEVEN SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1.	BMM07001	Introduction to Surface Engineering	3-0-0	3
2.	BMM07002	Material Characterization	3-0-0	3
3.		Professional Elective- IV	3-0-0	3
4.		Open Elective-III	3-0-0	3
SESSIONAL				
1.	BMM07003	Material Characterization Lab	0-0-3	1.5
2.		Project – I	0-0-6	3
3.		Seminar on internship	0-0-3	1.5
		TOTAL	**12-0-12**	**18**

Professional Elective-**IV**		
Sl.No.	Course Code	Subjects
1.	BMMPE701	Non-ferrous Extractive Metallurgy
2.	BMMPE702	Thermo-Mechanical Processing of Materials
3.	BMMPE703	X-Ray Diffraction
4.	BMMPE704	Fabrication of Materials
Open Elective -**III**		
Sl.No.	Course Code	Subjects
1.	BMMOE701	Crystallography
2.	BMMOE702	Introduction to Nano Science and Nano Technology

FOURTH YEAR: EIGHT SEMESTER				
THEORY				
S/N	Code	Subject	L-T-P	Credits
1		Professional Elective-V	3-0-0	3
2		Professional Elective-VI	3-0-0	3
3		Open Elective-IV	3-0-0	3
SESSIONALS				
1		Project II	0-0-12	6
2		Seminar on Project	0-0-2	1
		TOTAL	**9-0-14**	**16**

Professional Elective-**V**		
Sl.No.	Course Code	Subjects
1.	BMMPE801	Advanced Materials
2.	BMMPE802	Finite Element Method
3.	BMMPE803	Modelling and Simulation
4.	BMMPE804	Numerical Methods in Engineering

Professional Elective-**VI**		
Sl.No.	Course Code	Subjects
1.	BMMPE805	Corrosion and Degradation of Metals
2.	BMMPE806	Biomaterials
3.	BMMPE807	Non-Metallic Materials
4.	BMMPE808	Hydro and Electrometallurgy

Open Elective-**IV**		
Sl.No.	Course Code	Subjects
1.	BEMMOE801	Alloy Design and Selection of Materials
2.	BEMMOE802	Manufacturing and Design of Composites

Total Credits: 165

FIRST SEMESTER

B. Tech.: Mathematics-I (Calculus and Linear Algebra) (BMA01001) [3-1-0]

Module 1: Calculus (8 Lectures)

Rolle's theorem, Mean value theorems (statements only) and applications. Introduction to improper integrals. Beta and Gamma functions and their properties.

Module 2: Calculus (8 Lectures)

Convergence of sequence and series, tests of convergence. Fourier series, arbitrary period, even and odd function, half range series.

Module3: Calculus (8 Lectures)

Limit, continuity and partial derivatives (two variables), maxima and minima. Vector and scalar point functions and fields, gradient of a scalar field, directional derivative, divergence of a vector field, curl of a vector field and applications

Module 4: Linear Algebra (8 Lectures)

Linear systems of equations, Gauss elimination, linear independence, rank of a matrix, Gauss-Jordan elimination. Vector Space; basis and dimension'

Module 5: Linear Algebra (8 Lectures)

Eigenvalues, eigenvectors, some applications of eigenvalue problems, symmetric, skew-symmetric and orthogonal matrices, diagonalization, quadratic forms, complex matrices and forms.

Text Book:

1) Erwin Kreyszig, Advanced Engineering Mathematics (9^{th} Edition), Wiley India Pvt. Ltd
2) S.C. Malik and S. Arora, Mathematical Analysis, New Age International

Reference Books:

1) George B. Thomas, Jr. and Ross L. Finney, Calculus and Analytic Geometry, Addison WesleyPublishing Company
2) B.V. Ramana, Higher Engineering Mathematics, McGraw Hill
3) A. Stroud, Advanced Engineering Mathematics, Industrial Press
4) S.K. Paikray,Text book of Matrix Algebra, Kalyani Publisher

Course Outcomes:

Upon completion of the subject the students will be able to:

CO1	Recognize basic knowledge of differential calculus, improper integral, Beta and Gamma functions which are useful in various fields of engineering
CO2	Analyse periodic phenomenon and describe Fourier series expansion of periodic function
CO3	Demonstrate functions of several variables that is essential in most of the branches of engineering
CO4	Apply Gauss elimination method and rank of a matrix in solving linear equations
CO5	Implement knowledge of eigenvalues and eigenvectors in a comprehensive manner

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	1	2	1	-	-	-	1	1
CO2	3	3	2	2	1	2	1	-	-	-	1	1
CO3	3	3	2	2	1	2	1	-	-	-	1	1
CO4	3	3	2	2	1	2	1	-	-	-	1	1
CO5	3	3	2	2	1	2	1	-	-	-	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	2	1	2	1	-	-	-	1	1

Subject: Chemistry (BCH01001) Credits: 4 [3-1-0]

Module–I (9 Hours)

Schrodinger Wave equations (not to be derived), Application to particle in ID box.
Molecular rotational (microwave) spectroscopy: Basic principle and application to diatomic molecules, selection rules.
Molecular vibrational (IR) spectroscopy: Basic principle, types of vibrations and vibrational frequency, application to Harmonic and anharmonic oscillators, selection rules, modes of vibration.
Electronic (UV-Visible) spectroscopy: Basis principle, types of electronic transitions, The Franck - Condon principle, and Jablonski diagram.

Module – II (9 Hours)
Thermodynamics of Chemical Processes:

Concept of Entropy and free energy, Chemical Potential, Equilibrium Conditions.

Phase equilibria:

Phase, Components, Degree of Freedom, Phase Rule Equation.

Phase Diagrams: One Component Systems – Water and Sulphur, Basic idea of (a) Peritectic system, (b) Eutectoid system, (c) Binary phase diagrams of Pb-Ag & Fe-C system.

Module–III (9 Hours)

Electrochemistry:

Electrode Potentials and its Relevance to Oxidation and Reduction, Types of electrodes, Galvanic cell, Measurement of EMF and application of EMF measurements, Types of reference electrodes (Hydrogen, Glass, Quinhydrone Electrodes,) Determination of pH, Electrochemical energy systems its types (Dry Cells, lead acid cell and Fuel Cells: Construction, reaction, advantages and applications).

Corrosion: Concept, types of corrosion, dry or chemical and wet or Galvanic/electrochemical Corrosion, Factors affecting corrosion.

Module–IV (9 Hours)

Kinetics of complex Chemical Reactions: Reversible, Consecutive and Parallel Reactions, Steady State Approximation, Chain reaction.

Module-V (9 Hours)

Chemistry of engineering materials:

Nanomaterials: Applications of nanomaterials.

Organometallics: Application of organometallics

Books Recommended:

1) P. W. Atkins, Elements of Physical Chemistry, 4th Edition, Oxford University Press
2) C. N. Banwell and E. M. MacCash, Fundamentals of Molecular Spectroscopy, 5th Edition,
3) P. K. Kar, S. Dash and B. Mishra, B.Tech. Chemistry Vol. I, Kalyani Publications

Course Outcomes:

CO1: Apply the basic concept of classical mechanics and quantum chemistry to real life applications & to understand the basic concept of electromagnetic radiation, spectroscopic techniques and their applications.

CO2: Should perceive the spontaneity/feasibility of a process applying thermodynamics concepts and to keep up with the idea of phase equilibria, phase rule and its application to one and two component system.

CO3: Define the application of electrochemistry to commercial electrochemical cell and corrosion.

CO4: Able to apply the basic concept of kinetics of a reaction to complex reactions.

CO5: To demonstrate the properties and applications of organometallics and nanomaterials.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	-	-	-	1	-	-	1	1	1
CO2	3	3	1	-	-	-	1	-	-	1	1	1
CO3	3	3	1	-	-	-	1	-	-	1	1	1
CO4	3	3	1	-	-	-	1	-	-	1	1	1
CO4	3	3	1	-	-	-	1	-	-	1	1	1

Program Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	3	1	-	-	-	1	-	-	1	1	1

BASIC ELECTRONICS (BEC01001)

MODULE	CONTENT	HOURS
MODULE 1	Introduction to Electronics: - Signals, Frequency Spectrum of Signals, Analog and DigitalSignals, Linear Wave Shaping Circuits: - RC LPF, Integrator, RC HPF, Differentiator. Properties of Semiconductors: - Intrinsic, Extrinsic Semiconductors, Current Flow in Semiconductors, Diodes: - p-n junction theory, Current-Voltage characteristics, Analysis of Diode circuits, Rectifiers, Clippers, Clampers, Special diodes- LED, Photo diode, Zener Diode.	**12**
MODULE 2	Bipolar junction Transistor (BJTs):- Device Structure and Operation, Current-Voltage Characteristics, BJT as an Amplifier and as a Switch. Introduction to Power Amplifiers: - A,B and Ctypes. JFET:- Physical Structure, Operation and Characteristics	**10**
MODULE 3	Feedback Amplifiers: - General Feedback Structure, Properties of Negative Feedback, Four Basic Feedback Topologies (block diagram only), Practical feedback circuit. Operational Amplifiers (OP-AMPs): - The Ideal OP-AMP, Inverting Configuration, Non-Inverting Configuration. OP-AMP Applications (Adder, Subtractor, Integrator, Differentiator).	**08**
MODULE 4	Digital Fundamentals:- Binary Numbers, Signed-binary numbers, Decimal-to-Binary & Binary-to-Decimal Conversion, Binary Addition, Subtraction, Multiplication and Division, Hexadecimal Number Systems, Logic Gates, Boolean Algebra, De Morgan's Theorems, Laws of Boolean Algebra, RS Flip Flop	**06**
MODULE 5	Introduction to Electronic Instruments: - CRO: CRT, Waveform Display, Applications of CRO, Electronic Multimeter, Audio Signal Generator: - Block diagram, Front Panel Controls. Principles of Communication:- Fundamentals of AM & FM, Block diagram of Transmitters	**06**
TEXT BOOK	**1.** Microelectronics Circuits, A.S Sedra, K.C. Smith, Oxford UniversityPress. Selected portions from chapters 1 to 3, 5, 8,13. **2.** Electronics Fundamentals and Applications, D Chattopadhyay and P.C. Rakshit, New Age International Publications. Selected portions fromchapters 4 to 12, 14, 16 to 18,20,21.	

REFERENCE BOOK	1. Integrated Electronics, Millman and Halkias, TMHPublications. 2. Electronic Devices & Circuit Theory, R.L Boylestad and L.Nashelsky, PearsonEducation.

COURSE OUTCOME: After completion of course student should be able to

1. Understand different types of signals and its application to semiconductor devices andcircuits.
2. Understand different BJTs and itsoperation.
3. Understand the Feedback Amplifiers and Operational Amplifiers.
4. Understand fundamentals of different Digital arithmetic operations and Digitalcircuits.
5. Understand some important Electronic Instruments and Communicationsystems.

Course Outcomes:

Upon completion of the subject the students will demonstrate the ability to:

CO1	**Implement different types of signals and its application to semiconductor devices and circuits.**
CO2	**Analyze the concept of different BJTs and its operation.**
CO3	**Express the concept of the Feedback Amplifiers and Operational Amplifiers.**
CO4	**Apply fundamentals of different Digital arithmetic operations and Digital circuits.**
CO5	**Demonstrate basic principles of important Electronic Instruments and Communication systems.**

Relationship of Course Outcomes (CO) to Program Outcomes (PO)
1 – Low 2 – Moderate 3 – High

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**2**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**-**	**1**
CO2	**3**	**2**	**2**	**3**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO3	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**-**	**1**
CO4	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO5	**3**	**3**	**3**	**3**	**2**	**1**	**3**	**-**	**-**	**-**	**-**	**1**

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	**3**	**2**	**3**	**3**	**2**	**1**	**2**	-	-	-	-	1

PROGRAMMING FOR PROBLEM SOLVING (BIT01001)

L-T-P: 3-0-0 **Cr.-3**

Module I: **(8 Lectures)**

Introduction to computing- Block architecture of a computer, fundamental units of storage: bit, bytes, nibbles, word size. Introduction to problem solving- Basic concepts of an algorithm, program design methods, flowcharts. Level of programming Languages, structure of C program, Compiling and Executing C program

Module II: **(8 Lectures)**

C Language Fundamentals- Character set, Identifiers, Keywords, Data Types, Constant and Variables, Statements. Input &Output - Input & Output Assignments, Formatted Outputs. Operators and Expressions-Operators, Precedence of operators. Decision Control Structure, Loop Control Structure and Case Control Structure.

Module III: **(8 Lectures)**

Functions: Monolithic vs Modular programs, User defined vs standard functions, formal vs Actual arguments, Functions category, function prototypes, parameter passing, Recursion.Arrays1D Array, 2D Array & Multi-Dimensional Array. Strings- Declaration & Initialization, String Handling Functions.

Module IV: **(8 Lectures)**

Pointer variable and its importance, Pointer Arithmetic, Passing parameters, pointer to pointer, pointer to function. Dynamic Memory Allocation. Structure, Nested Structure, Array of Structures, Pointer to Structure, Structure & Functions, Union, Array of Union Variables, Union inside Structure, Bit Fields. Storage Class.

Module V: **(8 Lectures)**

Preprocessor Directives- Types, Pragma Directives, Conditional Directives. typedef, Enumerated Data Type. Files- Reading data from Files, Reading data from Files, Writing data to Files, Error Handling during File Operations. Advanced Issues in Input & Output – using argc&argv.

Text Books:

1. Programming in ANSI C, E Balaguruswamy
2. Computer Fundamentals &Programming in C: ReemaThareja, Oxford University Press.

Reference Books:

1. Let us C- Y.Kanetkar, BPB Publications.
2. Programming with ANSI and Turbo C- Kamthane, A.N. Pearson Education
3. C How to Program- Deitel and Deitel, Pearson Education.
4. The C Programming Language- Brian W. Kernighan and Dennis M. Ritchie, PrenticeHall.

Course Outcomes:

Upon completion of the subject the students will demonstrate the ability to:

1. grasp the fundamentals of Computer and problem solving.
2. conceptualize fundamentals of C Programming along with control structures.
3. Implement different problems on functions and arrays.

4. Apply pointers structures and unions for problem solving.
5. Gain knowledge of pre-processor directives and file operations.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	2	-	-	3
CO2	3	3	3	3	2	-	-	-	2	-	-	3
CO3	3	3	3	3	2	-	-	-	2	-	-	3
CO4	3	3	3	3	2	-	-	-	2	-	-	3
CO5	3	3	3	3	2	-	-	-	2	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO1	PO1	PO1
Cours	3	3	3	3	2	-	-	-	2	-	-	3

Basic of Civil Engineering (BCE01001)

Module-II

Introduction to Civil Engineering – Various disciplines of Civil engineering, Importance of Civil engineering in infrastructure development of the country.

Introduction to types of buildings as per NBC, Selection of site for buildings, Components of a residential building and their functions, Introduction to Industrial buildings and types.

Building Planning – Basic requirements, elements, introduction to various building area terms, computation of plinth area, carpet area.

Module-II

Surveying – Principle and objectives, Instruments used, Horizontal measurements, Ranging (direct ranging only), Instruments used for ranging, Leveling – Definition, Principles, Instruments, Preparation of level book, problems on leveling, Modern surveying instruments – EDM, Total station, GPS (Brief discussion)

Building Materials – Bricks, properties and specifications, Cement – Types, properties, grades, other types of cement and uses, Cement mortar – Constituents, Preparation, Concrete – PCC and RCC, Grades, Steel – Use of steel in buildings, types.

Module-III

Building Construction – Foundations, Classification, Bearing Capacity of Soil and related terms (definition only), Masonry Works – classifications, definition of different technical terms, Brick masonry – types, bonds, general principle, Roofs – functional requirements, basic technical terms, roof covering material, Floors – function, types, flooring materials(brief discussion), Plastering and Painting – objectives, types, preparation and procedure of application.

Module-IV

Basic Infrastructure services – air conditioning & purpose, fire protection & materials, Ventilation, necessity & functional requirements, Lifts, Escalators.

Introduction to planning and design aspects of transportation engineering, Transportation modes, Highway engineering – historical development, highway planning, classification of highway, Railway Engineering – cross section of rail track, basic terminology, geometric design parameter(brief discussion only).

Module-V

Airport engineering – development, types, definition, characteristics of aircraft, basic terminology, Traffic engineering – traffic characteristics, traffic studies, traffic operations (signals, signs, markings), Urban engineering – classification of urban road.

Irrigation & Water Supply Engineering – Introduction, Types of Irrigation, different types of hydraulic structures, dam and weirs, types of dam, purpose and functions.

Text Books:

- Basic Civil engineering, Gopi, S., Pearson Publication

- Basic Civil Engineering, Bhavikatti, S. S., New Age.

Reference Books:

- Construction Technology, Chudley, R., Longman Group, England
- Basic Civil and Environmental Engineering, C.P. Kausik, New Age.
- American Society of Civil Engineers (2011) ASCE Code of Ethics – Principles Study and Application

Course Outcomes:

- Analyze the fundamental aspect of building planning.
- Summarize general aspect of building material and surveying.
- Explain about building constructions.
- Judge transportation modes and planning.
- Describe about Airport & Irrigation Structures.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	1	1	-						
CO2	3	2	1	1	1							
CO3	2	1			3							
CO4	3	2	1	2	1	3						
CO5	3	2	3	2	1	1	3	1	2	2	2	3

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	2	2	2	1	2	3	1	2	2	2	3

SESSIONAL

B Tech Chemistry Lab: BCH01002

List of Experiments to be done (Any ten Experiments)

1. Determination of amount of sodium hydroxide and sodium carbonate in a Mixture.
2. Determination of Total hardness of water by EDTA method.
3. Estimation of calcium present in the limestone.
4. Standardization of KMnO4 using sodium oxalate.
5. Determination of ferrous iron in Mohr's salt by potassium permanganate.
6. Determination of Rate constant of acid catalyzed hydrolysis of ester.
7. Determination of dissolved oxygen in a sample of water.
8. Conductometric titration of strong acid and strong base
9. Determination of Viscosity of lubricating oil by red wood Viscometer.
10. Determination of Flash point of given oil by Pensky Marten's Flash Point Apparatus.
11. Determination of available chlorine in bleaching powder.
12. Preparation of acidic and basic buffer solution and measurement of PH using PH meter

Book Recommended:

B. Tech Practical Chemistry- .

Course Outcomes:

CO1: Develop knowledge of concepts and applications of chemistry, important laboratory analytical techniques, and instrumentation.

CO2: Apply fundamental principles for environmental analytical methods.

CO3: Identify suitable analytical techniques for analysing a specific compound in a sample and ensure quality control.

CO4: Implement suitable techniques for sampling and handling of environmental and chemical samples.

CO5: Hands on training on using different laboratory apparatus and equipments including data analysis and conclusions.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	2	-	1	-	2	-	1	-	1	-
CO2	3	1	2	-	1	-	2	-	1	-	1	-
CO3	3	1	2	-	1	-	2	-	1	-	1	-
CO4	3	1	2	-	1	-	2	-	1	-	1	-
CO4	3	1	2	-	1	-	2	-	1	-	1	-

Program Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1-	PO11	PO12
CO	3	1	2	-	1	-	2	-	1	-	1	-

BASIC ELECTRONICS LAB (BEC01002)

Experiment No.	CONTENT
1	Familiarity with electronic components and devices(Testing of semiconductor diode, Transistor, IC Pins connection) Digital Multimeter should be used.
2	Study and use of CRO to view waveforms and measure its Amplitude and Frequency.
3	Frequency response of LPF and HPF.
4	V-I Characteristics of a Semiconductor Diode. Determining DC and AC resistance.
5	Clipper Circuit.
6	Clamper Circuit.
7	Half Wave and Full Wave Rectifier without Capacitor filter. Record of Waveforms, Measurement of Average and RMS value.
8	V-I (Output) Characteristics of N-P-N/P-N-P Transistor in CE Configuration.
9	OP-AMP: Inverting and Non-Inverting Configuration. Record of Waveforms.
10	Verification of Truth table of Logic gates (AND, OR,NOT, NAND, NOR, EX-OR)
SUPPLEMENTARY BOOK	1. Integrated Electronics, Millman and Halkias, TMHPublications. 2. Electronic Devices & Circuit Theory, R.L Boylestad andL. Nashelsky, PearsonEducation.

Course Outcomes:

Upon completion of the subject the students will demonstrate the ability to:

CO1	Implement Acquire basic knowledge on electronic devices and components
CO2	Analyze different electronics circuits using semiconductor diodes.
CO3	Analyze and develop the characteristics of BJT and FET Circuits.
CO4	Apply fundamentals Operational amplifier circuits.
CO5	Implement knowledge on basic digital logic gates

Relationship of Course Outcomes (CO) to Program Outcomes (PO) **1 – Low** **2 – Moderate** **3 – High**												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**2**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**-**	**1**
CO2	**3**	**2**	**2**	**3**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO3	**3**	**2**	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**-**	**1**
CO4	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO5	**3**	**3**	**3**	**3**	**2**	**1**	**3**	**-**	**-**	**-**	**-**	**1**

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	**3**	**2**	**3**	**3**	**2**	**1**	**2**	-	-	-	-	1

PROGRAMMING FOR PROBLEM SOLVING LAB

(BHU01002)

L-T-P: 0-0-3 **Cr.-1.5**

Topics to be covered:

1. Programs using Input – Output functions.
2. Programs on variable declaration, assignments, operators and typecasting.
3. Program on selection & iterative constructs.
4. Programs on functions.
5. Programs on arrays.
6. Programs on string manipulation.
7. Programs on pointers.
8. Programs on structure & union.
9. Programs on file handling.
10. A mini-project to be designed by students using features of C.

Course Outcomes

Upon completion of the subject the students will demonstrate the ability to:

CO1: Implement the basicsof C programming.
CO 2: Exercise conditional and iterative statements to develop programs.
CO 3: Exercise user defined functions to solve real time problems.
CO 4: Demonstrate the concept of pointers to access arrays, strings and functions.
CO 5: Create C programs on file manipulations**.**

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	-	-	2	3	-	-	3
CO2	3	3	3	3	2	-	-	2	3	-	-	3
CO3	3	3	3	3	2	-	-	2	3	-	-	3
CO4	3	3	3	3	2	-	-	2	3	-	-	3
CO5	3	3	3	3	2	-	-	2	3	-	-	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation
Program Articulation Matrix row for this Course

	PO	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO1**	**PO1**	**PO1**
Cours	3	3	3	3	2	-	-	2	3	-	-	3

Engineering Graphics & Design (BCE01002)

Course Content

Module-I

Introduction to Engineering Drawing: Drawing instruments, lines, lettering and dimensioning.

Scales: Plain, Diagonal and Vernier Scales.

Module-II

Curves: Parabola, Ellipse, Hyperbola, Cycloid, Epicycloid, Hypocycloid and Involute.

Module-III

Orthographic Projections: Concepts, Orthographic projections of points, Lines, Planes and Solids. Sections of solids; Development of surfaces

Module-IV

Isometric Projections: Principles, Isometric Scale, Isometric Views, Isometric Views of lines, Planes, Simpleand compound Solids.

Module-V

Introduction to Auto-Cad:

Curves: Parabola, Ellipse, Hyperbola, Cycloid, Epicycloid, Hypocycloid and Involute

Reference Books:

1 Engineering drawing by N.D. Bhatt and V.M Panchal, Charotar Publishing House, Anand.
Engineering Drawing by Venugopal, New Age publisher.

Course Outcomes:

1. Revise basics of engineering drawings and curves.
2. Use Orthographic projections of Lines, Planes, and Solids.
3. Apply Sectioning of various Solids and their representation.
4. Change Pictorial views to Orthographic Projections
5. Construct Isometric Scale, Isometric Projections and Views.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	1	1							
CO2	3	2	1	1	1							
CO3	2	1			2							
CO4	3	2	1	2	1	1						
CO5	3	2	2	2	1	1	3	1	2	2	2	2

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	2	2	2	1	1	3	1	2	2	2	2

SECOND SEMESTER

Mathematics-II (Differential Equations and Complex Variables) (BMA02001) [3-1-0]

Module 1: **Differential Equations** ***(8 Lectures)***

Exact ODEs, integrating factors, linear ODEs, Bernoulli equation, homogeneous linear odes of second order, homogeneous linear ODEs with constant coefficients, Euler-Cauchy equations, non-homogeneous ODEs, Applications of ODEs to electric circuits

Module 2: **Power Series Solution of Differential Equations** ***(8 Lectures)***

Series solution of differential equation (excluding Frobenius method), Legendre's equation, Legendre polynomials. Bessel's Equation, properties of Bessel's functions, Bessel Functions of the first and Second Kind.

Module 3: **Complex Variables** ***(8 Lectures)***

Complex valued function, differentiation, analytic function, Cauchy-Riemann equations, harmonic and conjugate harmonic functions, exponential function, trigonometric and hyperbolic functions, logarithm, general power

Module 4: **Complex Variables** ***(8 Lectures)***

Line integral in the complex plane, Cauchy's integral theorem, Cauchy's integral formula, power series, radius of convergence, Taylor and Maclaurin series, singularities and zeros, Laurent series, Cauchy residue theorem (statement only) and applications.

Module 5: **Elementary Numerical Methods** ***(8 Lectures)***

Solution of algebraic and transcendental equations by Newton-Raphson and secant method.

Interpolation: Lagrange's method, divided difference method, Newton's forward and backward method. Numerical Integration: Trapezoidal and Simpson's Rule. Numerical solutions of differential equations: Euler's method and improved Euler's method.

Text Book:

1) Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd, 9th edition.

Reference Books:

1) K.A. Stroud, Advanced Engineering Mathematics, Industrial Press
2) Milton Abramowitz and Irene A. Stegun, *Handbook of Mathematical Functions*, National Bureau ofStandards, Applied Mathematics Series - 55
3) J. Sinha Roy and S. Padhy, Ordinary and Partial Differential Equation, Kalyani

Publisher.

4) B.V. Ramana, Higher Engineering Mathematics, McGraw Hill

Course Outcomes:

Upon completion of the subject the students will be able to:

CO1	Develop adequate knowledge of the effective mathematical tools for the solutions of differential equations that models various physical processes
CO2	Describe power series solution of differential equations
CO3	Demonstrate analytic functions and applications of Cauchy-Riemann equations
CO4	Evaluate integration of complex valued functions, and apply Taylor and Laurent series expansions of functions in various fields of engineering problems
CO5	Compute roots of algebraic and transcendental equations, and also evaluate the integrals by Trapezoidal and Simson's rules

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	1	2	1	-	-	-	1	1
CO2	3	3	2	2	1	2	1	-	-	-	1	1
CO3	3	3	2	2	1	2	1	-	-	-	1	1
CO4	3	3	2	2	1	2	1	-	-	-	1	1
CO5	3	3	2	2	1	2	1	-	-	-	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	3	3	2	2	1	2	1	-	-	-	1	1

ENGLISH FOR BUSINESS COMMUNICATION (BHU02001)

Course Description

The course is designed to give students a comprehensive view of communication, its scope and importance in business, and to build the proficiency needed to succeed in today's technologically enhanced workplace. Effective communication is an integral part of life. This course focuses on improving the LSRW skills, i.e. listening, speaking, reading and writing of the students. Students will learn how to communicate effectively though the prescribed syllabus followed by an intensive practice in the language lab. This integrated approach of theory and language lab sessions will help students to communicate clearly with an impact, by improving their verbal and non-verbal communication style, as well as enhancing their competency in grammar and pronunciation. This course further tries to conversant students with the correct practices and strategies in drafting effective business correspondence.

Syllabus

Module 1: Fundamentals of Communication (6 Hours)

- Process of Communication, Types of Communication (Verbal & Non Verbal)
- Channels of Business Communication
- Barriers to Communication.
- Plain English
- Bias free language
- Cross Cultural Communication

Module 2: Communicative Grammar (6 Hours)

- Time and Tense
- Aspects (Perfective & Progressive)
- Verbs of State and Event
- Passive and Active Voice
- Conditionals

Module 3: Sounds of English (06 Hours)

- The Speech Mechanism and Organs of Speech
- Consonant Sounds of English
- Vowel Sounds of English
- Stress Pattern: Syllable, Stress and Intonation.
- Problem sounds for Indian Speakers

Module 4: Business Writing (06 Hours)

- Paragraph writing
- Sentence Linker
- Business Letters
- Report Writing
- Proposal writing

Module 5: Professional Writing (06 Hours)

- ❖ Notice, Circular and Memo writing
- ❖ Agenda & Minute writing
- ❖ Writing Cover letter
- ❖ Résumé (CV) Writing

Reference Books

1. Effective Technical Communication by M Ashraf Rizvi (Tata McGraw Hill)
2. Business Communication by Hory Sanker Mukerjee (Oxford University Press)
3. Better English Pronunciations by J. D.O Conner (Cambridge University Press)
4. A Communicative Grammar of English by G.N. Leech and Jan Svartik (OUP)
5. Business communication by Ramachandran, Lakshmi and Krishna (Macmillan)

Programme Outcomes of BTech Programme

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary

	environments.
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes

Upon completion of the course the students will demonstrate the ability to:

CO1	Analyse various components of human communication and to identify key elements and principles of organizational communication.
CO2	Apply correct usage of English grammar in writing and speaking.
CO3	Evaluate students' ability to articulate English key sounds as well as its basic rhythm, stress and intonation patterns correctly.
CO4	Compile, plan and structure various forms of business writing in a professional manner.
CO5	Write various business documents appropriate for different business and employment situations.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**1**	**3**	**-**	**-**
CO2	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**1**	**3**	**-**	**-**
CO3	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**1**	**3**	**-**	**-**
CO4	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**1**	**3**	**-**	**-**
CO5	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**1**	**3**	**-**	**-**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
Course	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**1**	**-**

ENGINEERING PHYSICS (BPH02001)

Module-I PROPERTIES OF MATTEER

Ideas of Elastic Constants (Y, K, η and σ), relation between elastic constants, torsion pendulum, determination of η, cantilever at one end.

Module-II OSCILLATION AND WAVES

Review of Simple Harmonic Oscillation and application to Compound pendulum, Damped Harmonic Oscillation, Forced Oscillation, Resonance, (Amplitude Resonance, Velocity Resonance, and Sharpness of Resonance).

Module-III OPTICS

Concept of Wave and wave equation, Superposition of Many harmonic waves, Interference, Concept of coherent sources (Division of wave front and division of amplitude), Interference in thin parallel film, Newton's ring (Theory, Application, Determination of Wavelength of Light, Refractive index of liquid)

Concept of Diffraction (Huygen's Principle), Types of Diffraction, Fraunhofer Diffraction due to a single slit and diffraction Grating, Determination of Wavelength, Dispersive Power and Resolving Power of a Plane Diffraction Grating, Polarization, Double Refraction, Half wave Plate, Quarter wave Plate.

Module-IV ELECTROMAGNETISM

Vector Calculus, Gradient, Divergence, Curl (Mathematical Concept), Gauss' Divergence Theorem and Stoke's Theorem (Statement Only), Derivation of Maxwell's Electromagnetic Equations in Differential form and Integral form, Electromagnetic Wave equations for $\vec{E}$ and $\vec{B}$ in vacuum and in conducting medium, Transverse nature of EM waves.

Module-V QUANTUM MECHANICS AND PHOTONICS

Wave particle duality, Matter Wave (de-Broglie Hypothesis), Wave Functions, Observables as Operators, Eigen Functions and Eigen Values, Normalization, Expectation Values, Schrodinger equation (Time Dependent and Time Independent), Particle in a box.

Lasers: Introduction and Characteristics of Lasers, Einstein's Coefficients and Relation between them, Lasing Action (Population Inversion, Three and Four level Pumping Schemes), Different types of Lasers (Ruby lasers, He-Ne Lasers).

Text Book:

1. Principle of Engg. Physics: Md. N. Khan and S. Panigrahi
2. Engg. Physics: H.K. Malik and A.K. Singh

Reference Books:

1. Oscillations and Waves: N. Subramanyam and Brij Lal
2. Optics: A. Ghatak

3. Electrodynamics: D.J. Griffith
4. Concept of Modern Physics: A. Beiser
5. Lasers: Theory and Applications: K. Thyagarajan and A.K. Ghatak

Course Outcomes:

Upon completion of the subject the students will be able to:

CO1	Explain the concepts of Stress, Strain, Elastic Modulus and Elastic Constant, Bending of Beams and identify the importance Elastic properties in Engineering Applications
CO2	Demonstrate simple harmonic Oscillator, Damped Harmonic and Forced Oscillators. Express Quality factor and resonance with applications
CO3	Explain the link between Simple Harmonic Motion and Waves. Understand the principle of superposition, the need of coherent sources, analyze the difference between Interference and Diffraction and their applications. Illustrate the concept of Polarization of light and its applications.
CO4	The basic mathematical concepts related to electromagnetic vector fields, Understand the concepts related to Gauss law, Electric and magnetic Flux, Faraday‘s law, induced emf, Displacement current, Ampere’s Circuital law and Maxwell‘s equations. Expalin the transverse nature of electromagnetic wave
CO5	Identify and understand the kinds of experimental results which are incompatible with classical physics, Interpret the wave function and apply operators to it to obtain information about a particle's physical properties Solve the Schrodinger equation to obtain wave functions for some basic, physically important types of potential in one dimension Describe the requirements for a system to act as a laser. To explain lasing with need of metastable state and population inversion To explain the drawbacks of three level laser system and its solution in four level laser system.

Table	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**POP11**	**PO12**
CO1	**3**	**3**	**2**	**2**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**1**
CO2	**3**	**3**	**3**	**2**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**2**
CO3	**3**	**3**	**3**	**3**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**2**
CO4	**3**	**3**	**3**	**2**	**1**	**-**	**-**	**1**	**-**	**1**	**-**	**2**
CO5	**3**	**3**	**2**	**3**	**2**	**-**	**-**	**2**	**-**	**2**	**-**	**2**

BASIC ELECTRICAL ENGINEERING (BEE02001)

MODULE-I (8 HOURS)

D.C circuit analysis and network theorems: Concept of network, Active and passive elements, voltage and current sources, concept of linearity and linear network, unilateral and bilateral elements, source transformation, Kirchoff's Law: loop and nodal methods of analysis, star delta transformation, network theorems: Thevenin's theorem, Norton's theorem, maximum power transfer theorem. Transients, in R-L, R-C and R-L-C circuits with DC Excitation.

MODULE-II (8 HOURS)

Single phase and three phase ac circuit: Sinusoidal, square and triangular waveforms-average and effective value, form the peak factors, concept of phasors, phasors representation of sinusoidally varying voltage and current, analysis of series-parallel RLC circuits. Apparent, active and reactive powers, power factor, power factor improvement, resonance in series and parallel circuits, bandwidth and quality factors, star and delta connections, balanced supply and balanced load, line and phase voltage/current relation, three phase power measurements.

MODULE-III (8 HOURS)

Magnet circuit & principle of electromechanical energy conversion: Analogy between electric and magnetic circuit, magnetic circuits with DC and AC excitation, magnetic leakage, BH curve, hysteresis and eddy current losses, magnetic circuit calculation, mutual coupling. Principles of dc motor & generator, types, emf equation of DC machine, torque equation of motor, Speed control of dc motor. characteristics and applications of DC motors.

MODULE-IV (8 HOURS)

AC MACHINES: Single Phase Transformer: Principle of operation, construction, emf equation, equivalent circuit, power losses, efficiency, Introduction to auto transformers. Three Phase Induction Motor: Type, principle of operation, slip-torque Characteristics, applications. Single Phase Induction Motor: Principle of operation and introduction to methods of starting, applications. Three Phase Synchronous Machines: Principle of operation of alternator and synchronous motor, emf equation, voltage regulation, applications.

MODULE-V (7 HOURS)

Measurement Instruments & Introduction to Power System: Types of instruments: construction and working principle of PMMC and MI type voltmeter and ammeters, single phase dynamometer type wattmeter and induction type energy meter, use of shunts and multipliers: general layout of electrical power system and function of its elements, concept of grid, Introduction to power converters.

TEXT BOOKS

[1]. Edward Hughes (revised by Ian McKenzie Smith), "Electrical & Electronics Technology", Pearson Education Limited. Indian Reprint 2002, 10th Edition.

[2]. D.Kulshreshtha, "Basic Electrical Engineering" TMH, 1st Edition.

REFERENCE BOOKS

[1]. C.L. Wadhwa, "Electrical Engineering", New Age International Publishers, 2nd Edition.

[2]. S. Parker Smith, "Problems in Electrical Engineering", Asia Publications, 10th Edition.

Course Outcomes:

Upon completion of the subject the students will demonstrate the ability to:

CO1	Implement principles of DC network, theorems and transients.
CO2	Analyze the concept of Single phase and three phase AC circuits.
CO3	Express the concept of magnetic circuit and DC machines.
CO4	Apply basic principles of AC machines and their working.
CO5	Demonstrate basic principles of measuring instruments and power system.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	1	2	1	-	-	-	-	1
CO2	3	3	2	1	1	2	1	-	-	-	-	1
CO3	3	3	2	1	1	2	1	-	-	-	-	1
CO4	3	3	2	1	1	2	1	-	-	-	-	1
CO5	3	3	2	1	1	2	1	-	-	-	-	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO**	**PO1**	**PO1**	**PO1**
Cours	3	3	2	1	1	2	1	-	-	-	-	1

ENGINEERING MECHANICS (BME02001)

Course Contents

Module - I (8 Hours)

Concurrent forces on a plane: Composition, resolution and equilibrium of concurrent coplanar forces, method of moment.General case of forces on a plane: Composition and equilibrium of forces in a plane, plane trusses, method of joints and method of sections, plane frame, equilibrium of ideal systems.

Module-II (8 Hours)

Friction: Problems involving dry friction, Ladder, WedgesPrinciple of virtual work.

Module - III (8 Hours)

Parallel forces on a plane: General case of parallel forces, center of parallel forces and center of gravity, centroid of composite plane figure and curves, Theorems of Pappus.

Moments of inertia: Plane figure with respect to an axis in its plane and perpendicular to the plane, Polar moment of inertia, parallel axis theorem

Module – IV (8 Hours)

Rectilinear translation: Kinematics, principle of dynamics, D Alembert's Principle,

Principle of work and energy for a particle and a rigid body in plane motion, Conservation of energy, Principle of impulse and momentum for a particle and a rigid bodies in plane motion, Conservation of momentum, System of rigid bodies, Impact, direct and central impact, coefficient of restitution.

Module – V (8 Hours)

Curvilinear translation: Kinematics, equation of motion, projectile, D Alembert's principle of curvilinear motion. Kinematics of rotation of rigid body.

Text Book:

1. Engineering Mechanics: S Timoshenko & Young; 4th Edition (International edition) McGraw Hill.

Reference Books:

1. Fundamental of Engineering mechanics (2nd Edition): S Rajesekharan& G ShankaraSubramanium; Vikas Pub. House Pvt ltd.
2. Engineering mechanics: K. L. Kumar; Tata MC Graw Hill.

Upon completion of the subject the students will be able to:

CO1	**Draw free body diagrams and determine the resultant of forces and/or moments.**
CO2	**Solve the problems involving dry friction.**
CO3	**Determine the centroid and second moment of area of sections.**
CO4	**Apply Newton's laws and conservation laws to elastic collisions and motion of rigid bodies.**
CO5	**Determine the various parameters in projectile motion.**

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**3**	**1**	**-**	**1**
CO2	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**3**	**1**	**-**	**1**
CO3	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**3**	**1**	**-**	**1**
CO4	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**3**	**1**	**-**	**1**
CO5	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**3**	**1**	**-**	**1**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	**3**	**3**	**2**	**1**	**2**	**-**	**-**	**-**	**3**	**1**	**-**	**1**

PHYSICS LABORATORY (BPH02002)

List of Experiments

1. Determination of acceleration due to gravity by using Bar pendulum
2. Determination of surface tension of water by capillary rise method
3. To draw the characteristics of a bipolar junction transistor
4. To determine the rigidity modulus of the material of a wire by using Barton's apparatus.
5. Determination of wave length of monochromatic light with the help of Newton's ring apparatus.
6. Determination of grating element of a diffraction grating using spectrometer.

Course Outcomes

Upon completion of the subject the students will demonstrate the ability to:

CO1	Express the idea of calculation of acceleration due to gravity at any place using the concept of oscillatory system and simple harmonic motion.
CO2	Demonstrate the working and operational technique to calculate the mechanical properties of fluid and other materials.
CO3	Evaluate the voltage, current, power and characteristics behaviour of the electronic devices.
CO4	Analyze the mechanical properties of any material with the idea of elasticity and its various applications.
CO5	Implement the measurement of different characteristic properties and related calculations of optical devices.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	1	3	2	1	1	3	3	1	1

BASIC ELECTRICAL ENGINEERING LABORATORY (BEE02002)

List of Experiments

1. Preliminary: Preparation of symbol chart for various systems & components as per ISS, to study the constructional & operational features for Voltmeter, Ammeter, Wattmeter, Frequency meter, multi-meter and Rheostat, Study of safety rules as per ISS
2. Measurement of the armature & field resistance of D.C. Machine by volt-amp method. & Starting and speed control of a D.C. shunt motor
3. Study of BH Curve
4. Determination of open circuit characteristics (O.C.C) of D.C shunt generator when separately excited at different speeds.
5. Measurement of earth resistance and insulation resistance.
6. Starting of Induction motor and measurement of three phase power & power factor by 2- wattmeter method.
7. Callibration of a single phase Energy Meter by directed loading & Phantom loading.
8. Obtaining the voltage, current, power and power factor of fluorescent lamp.
9. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.
10. Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform

Course Outcomes

Upon completion of the subject the students will demonstrate the ability to:

CO1	Express the safety rules as per ISS and symbols of different electrical components and the use of various electrical instruments in laboratory.
CO2	Demonstrate the working and operational characteristics of dc motor and dc generator.
CO3	Evaluate the voltage, current, power and power factor of fluorescent lamp.
CO4	Implement the measurement of earth resistance and insulation resistance and demonstrate the internal structure of different machines.
CO5	Analyze the connection and calibration of single phase energy meter, three phase power and power factor by two wattmeter method and basic idea about converters.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	3	2	1	1	3	3	1	1
CO2	3	3	2	1	3	2	1	1	3	3	1	1
CO3	3	3	2	1	3	2	1	1	3	3	1	1
CO4	3	3	2	1	3	2	1	1	3	3	1	1
CO5	3	3	2	1	3	2	1	1	3	3	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO1	PO1	PO1
Cours	3	3	2	1	3	2	1	1	3	3	1	1

Business Communication and Presentation Skills Lab (BHU02002)

Course Description

Good communication skills are indispensable for the success of any professional. The English language, in particular, has become essential in the lives of young engineers who aspire to build their careers anywhere in the world. In this regard the language laboratory plays an important role in developing the students' basic proficiency in English. Since a large number of engineering students completed their education from vernacular medium schools, they lack the basic English language proficiency which is a detrimental factor during recruitment drives in engineering colleges. In this context the language laboratory is very helpful in practicing and assessing students' speech in different communication environments. It provides them facilities to learn pronunciation, accent, stress and rudimentary communicative English grammar along with various practice sessions like presentations, group discussions, debates, case studies which are the part and parcel of corporate life.

Syllabus (Assignments)

1. Functional English grammar: Practice and exercises
2. Practice of English phonemes
3. Reading comprehension
4. Drafting business correspondence
5. Understanding the importance of body language
6. Oral presentations (Self Introduction, Extempore, Formal Presentation, power point presentations etc.)
7. Group discussion
8. Preparation for appearing an interview
9. Situational conversation practice

Reference Books

1. Effective Technical Communication by M Ashraf Rizvi (Tata McGraw Hill)
2. Business Communication by Hory Sanker Mukerjee (Oxford University Press)
3. Better English Pronunciations by J. D.O Conner (Cambridge University Press)
4. A Communicative Grammar of English by G.N. Leech and Jan Svartik (OUP)
5. Business communication by Ramachandran, Lakshmi and Krishna (Macmillan)

Programme Outcomes of BTech Programme

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes

Upon completion of the sessional the students will demonstrate the ability to:

CO1	Analyse various components of effective human communication and to apply them during various practice sessions.
CO2	Apply correct usage of English grammar in writing and speaking.
CO3	Articulate English key sounds as well as its basic rhythm, stress and intonation patterns correctly.
CO4	Compile, plan and structure various forms of business writing in a professional manner.
CO5	Confidently face various recruitment drives and qualify them.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	1	-	-	1	3	-	-
CO2	-	-	-	-	-	1	-	-	1	3	-	-
CO3	-	-	-	-	-	1	-	-	1	3	-	-
CO4	-	-	-	-	-	1	-	-	1	3	-	-
CO5	-	-	-	-	-	1	-	-	1	3	-	-

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	-	-	-	-	-	-	-	-	1	3	1	-

WORKSHOP & MANUFACTURING PRACTICES (BME02002)

Course content

1. **Carpentry Section**:

   Study of different Hand tools, measuring instruments and equipments used in Carpentry work. Safety

   precautions.

   Preparation of Job:
   Wooden rack/bench/chair/stool (any one)

   Includes the operations:

   Measuring, Marking, Sawing, Planing, Chiseling, Mortesing, Tenoning, making Half-lap joint,
   Mortese&Tenon joint and Nail joint.

2. **Fitting Section**:

   Study of different Hand tools, measuring instruments and equipments used in Fitting work. Safety
   precautions. Study of Drilling Machine and Grinding Machine.

Preparation of Job:

Paper Wt. / Square or Rectangular joint (male-female joint) (any one)

Includes the operations:

Measuring, Marking, Filing, Sawing, Drilling, Tapping, Dieing and Punching.

3. **Black Smith Section**:

   Study of different Hand tools, equipments, Open hearth furnace and Induction furnaces used in
   Blacksmith work. Different types of heat treatment processes. Safety precautions.

Preparation of Job:

Weeding hook/Hexagonal headed bolt/Chisel (any one)

Includes the operations:

Measuring, Marking, Cutting, Upsetting, Drawing down, Bending, Fullering and Quenching.

Course Outcomes:

Upon completion of the subject the students will be able to:

CO1	Acquire knowledge on different types of hand tool, measuring instruments and machine tools are used in Fitting, Carpentry and Smithy work.
CO2	Know about different types of operations and joints performed in different shops i.e. in Fitting and Carpentry.

CO3	Know about the forging temperature of different types of ferrous metals and different types of operation (e.g. upsetting, edging, flattening and bending etc.) carried out on hot metals to prepare jobs.
CO4	Acquire skills for the preparation of different types of jobs Carpentry/fitting/smithy shops by using different types of hand tools and machine tools.
CO5	Understand the importance of safety precaution in different shops.

	PO 1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**-**	**-**	**-**	**-**	**2**	**2**	**1**	**1**	**3**	**1**	**2**	**1**
CO2	**-**	**-**	**1**	**-**	**2**	**2**	**1**	**1**	**3**	**1**	**2**	**1**
CO3	**-**	**-**	**-**	**-**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**
CO4	**-**	**-**	**-**	**-**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**1**
CO5	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**2**	**1**	**1**	**1**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO	**-**	**-**	**1**	**-**	**2**	**2**	**1**	**1**	**3**	**1**	**2**	**1**

THIRD SEMESTER

Mathematics-III (Transforms, Probability and Statistics and Multi variate Analysis) [3-1-0]
(BMA03001)

Module 1: **Laplace Transforms** ***(10 Lectures)***

Laplace transforms, inverse transforms, linearity, shifting, transforms of derivatives and integrals, solution of ODEs, unit step function, Dirac's delta function, differentiation and integration of transforms, convolution, integral equations.

Module 2: **Fourier Transforms** ***(8 Lectures)***

Basic concept of Fourier integral, Fourier sine and cosine integral, condition of convergence, Fourier transformation, Fourier sine transform, Fourier cosine transform, properties.

Module 3: **Probability** ***(6 Lectures)***

Random variables, probability distributions, mean and variance, Binomial, Poisson and hyper- geometric distributions, Normal distribution.

Module 4: **Statistics** ***(8 Lectures)***

Random sampling, point estimation of parameters, maximum likelihood estimation, confidence intervals, testing of hypotheses for mean and variance, correlation and regression.

Module 5: **Multi-variate Analysis** ***(8 Lectures)***

Line integrals, double integrals, change of order, Green's theorem (statements only), surface integrals, triple integrals, Divergence theorem of Gauss (statements only), Stoke's theorem (statements only) and applications.

Text Book:

Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd, 9th edition

Reference Books:

1) B.V. Ramana, Higher Engineering Mathematics, McGraw Hill
2) K.A. Stroud, Advanced Engineering Mathematics, Industrial Press

Course Outcomes:

Upon completion of the subject the students will be able to:

CO1	Develop adequate knowledge of Laplace and Fourier transforms, and apply this idea to solve differential equations
CO2	Describe unit step function and Dirac's delta function which are useful in engineering problems
CO3	Apply Binomial, Poisson and Normal distributions in probabilistic models

CO4	Demonstrate random sampling and estimation of parameters
CO5	Evaluate multiple integrals and with various applications

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	2	1	-	-	-	1	1
CO2	3	3	2	2	1	2	1	-	-	-	1	1
CO3	3	3	2	2	1	2	1	-	-	-	1	1
CO4	3	3	2	2	1	2	1	-	-	-	1	1
CO5	3	3	2	2	1	2	1	-	-	-	1	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	2	1	2	1	-	-	-	1	1

Subject Code: BMM03001		Metallurgical Thermodynamics and Kinetics	
Pre-Requisite:	Mathematics-I, Mathematics - II	Co-requisite:	Chemistry, Physics, Introduction to Physical Metallurgy

Module -I	[8 hours]
	Importance of Thermodynamics, Definition of Thermodynamics; concept of state and path functions, Equation of states, thermodynamic processes, Phase diagram of a single component system, Internal energy, heat capacity, enthalpy.
Module -II	[8 hours]
	First law of thermodynamics, Second law of thermodynamics, entropy, and entropy changes for various processes, free energy and its significance, free energy change as a function of temperature, reversible and irreversible process, criteria of equilibrium, auxiliary functions, combined statements, Maxwell's relations, transformation formula, Gibbs-Helmoltz equation, Concept of standard state.
Module -III	[8 hours]
	Fugacity, activity, equilibrium constant, Concept of Third law of thermodynamics, temperature dependence of entropy, statistical interpretation of entropy, relation between C_p and C_v, consequences of third law, Ellingham – Richardson diagrams.
Module -IV	[8 hours]
	Solutions: partial molal quantities, ideal and non-ideal solutions, Roult's law; Henry's law, Gibbs – Duhem equation, regular solution, Chemical potential, Free energy – composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines.
Module -V	[8 hours]
	Introduction of metallurgical kinetics: heterogeneous reaction kinetics: gas-solid, solid-liquid, liquid-liquid and solid-solid systems, Concept of Johnson-Mehl equation, thermal analysis, Thermodynamics of electrochemical cells, solid electrolytes.

TEXT BOOK(S):

1.	Introduction to the Thermodynamics of Materials by D.R. Gaskell; Taylor and Francis.
2.	Textbook of Materials and Metallurgical Thermodynamics by A. Ghosh; Prentice Hall of India Pvt. Ltd.

REFERENCE BOOK(S):

1.	Problems in Metallurgical Thermodynamics and Kinetics by Upadhyaya, G. S., & Dube, R. K.; International Series on Materials Science and Technology, Elsevier.
2.	Introduction to Physical Metallurgy by Avner S.H., McGraw Hill.

COURSE OUTCOMES:	
CO1	Analyze and incorporate the modern thermodynamic models for description of chemical reaction and phase transformation in materials
CO2	Demonstrate reaction kinetics and stability criteria of different metals based on its energy content and temperature.
CO3	Define the use thermodynamic laws in day-to-day applications in both domestic and industrial sector.
CO4	Analyze and express the kinetics of the mass transport in solids including the process of surface and interfaces
CO5	Work independently with the literature in search, choice and checking of correctness of the necessary information

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	3	2	2	1	3	3	3	2
CO2	3	3	3	3	3	3	2	---	3	2	2	2
CO3	3	3	2	3	3	3	3	1	2	3	3	3
CO4	3	1	2	2	2	2	2	2	2	3	3	2
CO5	3	3	2	3	2	3	2	3	3	3	2	2

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	3	3	2	2	3	3	3	2

Subject Code: BMM03002	Introduction to Physical Metallurgy

Module -I	[*8 Hours*]
	Introduction, Atomic structure of materials, Symmetry aspects in crystals, crystal systems, crystal planes and directions, atomic packing efficiency, voids in common crystal systems, Solidification of pure metal, Homogeneous and heterogeneous nucleation processes, cooling curve, concept of super cooling, microstructures of pure metals, solidification of metal in ingot mould. Crystal imperfections,

Module -II	[*8 Hours*]
	Mechanical properties of metals, concept of plastic deformation of metals, CRSS, Slip and twinning Concept of cold working: Recovery; Recrystallization and grain growth; Hot working. Concept of equilibrium, Concept of alloy formation, types of alloys, solid solutions, factors governing solid solubility; Unary phase diagram, phase rule, binary phase diagrams: .

Module -III	[*8 Hours*]
	Isomorphous, Eutectic, Peritectic, Eutectoid, Peritectoid, Monotectic and Monotectoid system, Lever rule and its application, interpretation of solidification behavior and microstructure of different alloys belonging to those systems, effect of non-equilibrium cooling, coring and homogenization. Allotropic transformations, order disorder transformations.

Module -IV	[*8 Hours*]
	Concept of heat treatment of steels i.e., annealing, normalizing, hardening and tempering; Microstructural effects brought about by these processes and their influences on mechanical properties. Effect of common alloying elements on the Fe-Fe_3C and Fe-C diagrams.

Module -V	[*8 Hours*]
	Iron cementite and iron- graphite phase diagrams, microstructure and properties of different alloys (both steels and cast irons). Concept to hardenability, factors affecting hardenability. Alloy steels- Stainless steels. Physical metallurgy of non-ferrous alloys Cu-Al, Bronze, and Brass.

TEXT BOOK(S):

1.	Avner S.H., Introduction to Physical Metallurgy 1997 (New Delhi: McGraw Hill Education (India) Limited).
2.	Callister W D 2007 Callister's Materials Science and Engineering: Indian Adaptation adapted by R Balasubramaniam (New Delhi: Wiley)

REFERENCE BOOK(S):

1.	Physical metallurgy principle by Reza, Lara and Robert E Reed hill
2.	Foundations of Materials Science and Engineering; 5th Edition William F. Smith and Javad Hashemi 1088 pages; McGraw-Hill Education (April 9, 2009)

COURSE OUTCOMESS:	
CO1	After successful completion of the course, the learners would be able to Familiarize themselves with those terms, concepts, and definitions used to describe the properties and processes of common engineering metals.
CO2	Students will be reacquainted with fundamental principles of chemistry and physics which predetermine and control behavior of metals in response to external forces, whether mechanical, physical (electrical, magnetic, optical, thermal) or chemical in nature.
CO3	A fundamental understanding can be developed about the relationships between material composition, structure, and properties resulting from processing or service.
CO4	Students can understand the testing procedures used to characterize some of the more common physical properties for engineering metals, and how these properties should be used when specifying conditions where optimum performance without failure can be expected.
CO5	Students can get insight idea about atomistic and defect structures, and how they result in the microstructure and influence the properties of metals.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	3	3	3	3	2	1	1	3	2
CO2	2	3	1	3	3	3	3	2	2	2	2	2
CO3	3	2	1	3	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	3	2	1	1	1	2	2
CO5	3	3	3	3	3	3	2	1	1	1	2	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	3	2	3	3	3	3	2	2	2	2	2

Subject Code: BMM03003	Transport Phenomena
Pre-Requisite: **Calculus**	
Module -I	[*8 Hours*]
Fluid Flow: Classification of fluids, Energy balance, Laminar and Turbulent flows. Flow through pipes and ducts. Flow measurement, Application of dimensional analysis of fluid flow.	
Module -II	[*8 Hours*]
Heat Transfer I: Steady state and Transient conduction in solids. One-dimensional steady state problems of heat flow through composite walls, Cylinder and Spheres. Unsteady conduction in one-dimensional system.	
Module -III	[*8 Hours*]
Convective heat transfer, equation of energy, free and forced convections Concept of boundary layer, etc. as in problems and exercises. Use of Heisler charts and applications.	
Module -IV	[*8 Hours*]
Heat Transfer II: Radiation, Nature of thermal radiation, Black and Grey bodies, Stefan and Boltzmann law, Kirchhoff's laws, Intensity of radiation, lamberts law, View factor. Heat transfer between two black walls in an enclosure. Combined effect of convection, conduction and radiation. Overall heat transfer coefficient.	
Module –V	[*8 Hours*]
Mass Transfer and Kinetics: Steady state one-dimensional mass diffusion of component through stationary media. Convective mass transfer in fluids, concept of concentration boundary layer, Mass transfer coefficient.	
TEXT BOOK(S):	
1.	F.P. Incropera, D. P. Dewitt, T. L. Bergman and A. S. Lavine, Fundamentals of Heat and Mass Transfer, Wiley.
2.	H.S. Ray, Kinetics of Metallurgical Reactions
REFERENCE BOOK(S):	
1.	Heat and Mass Transfer: Fundamentals and Applications 5 Edition, Yunus A. Cengel, Afshin J. Ghajar
2.	Heat Transfer 10thEdition by JP Holman Mc Graw Hill.

COURSE OUTCOMESS:	
CO1	Students will be able to express the different mode of heat transfer and develop heat transfer equipment as per need.
CO2	Demonstrate basic equations and Laws for heat transfer problems
CO3	Apply heat transfer principles to design and calculate performance of thermal systems related to one dimensional, steady state or transient state for conduction and convection heat transfer.
CO4	Evaluate performance of thermal systems related to one dimensional, steady state natural and Forced Convection heat transfer by Theoretically and Experimentally.
CO5	Apply the concepts of Heat Transfer theory and application in Industrial and day to day life.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	3	1	1	1	1	3	1
CO2	3	3	3	1	1	3	1	1	1	1	3	2
CO3	3	3	3	3	2	3	1	1	1	1	3	2
CO4	3	3	3	3	2	3	2	1	1	1	3	2
CO5	3	3	3	3	3	3	3	2	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	2	2	3	2	1	1	1	3	2

Economics for Engineers (3-0-0)

Course Objectives:

- To understand the basic economic principle as a consumer in an economy
- To be able to know the utility measurement in the presence of risk and uncertainty
- To prepare the Engineering students to learn about the production process and analyse the cost/revenue data.
- To provide the foundation for engineers to make good decisions in business environment and learn about the market mechanism.
- To be able to make decision on project alternatives and justify projects on an economic basis

Syllabus:

Module-1:

Theory of Demand: Demand and Utility, Demand function and the factors determining demand, Law of Demand, Reasons for downward sloping demand curve, Exceptions to the law of demand. The market forces of Supply and Demand, Elasticity of demand and its application, Utility analysis: cardinal and ordinal measurability of utility, Assumptions of cardinal utility analysis, law of diminishing marginal utility, Consumer's equilibrium: Principle of equi-marginal utility

Module-2:

Indifference curve analysis of demand: Concepts, properties, Equilibrium of the consumer, Price Consumption Curve (PCC) and Income Consumption Curve, Decomposition of price effect into income effect and substitution effect, Revealed preference hypothesis, Individual choice under Risk and Uncertainty: St. Petersburg paradox and Bernoulli's hypothesis, Neumann-Morgenstern method of constructing utility index, Friedman-Savage hypothesis, Markowitz hypothesis

Module-3

Production function: short run analysis, Total product, Average product and Marginal product, output elasticity of input, law of variable proportion, Long run production function: Isoquants and concepts of returns to scale, Optimum factor combinations, Homogeneous Production Function, Cobb–Douglas production function, CES Production function, Cost Analysis: Concepts, Accounting cost, Fixed and variable cost, opportunity cost, Short run and long run cost curves, Relationships between average cost and marginal cost

Module-4

Market and its classifications, Perfect competition: Characteristics, Short run and long run equilibrium of firm under perfect competition. Monopoly market: Price and output determination. Modern theories of firms: Baumol's theory of sales revenue maximisation, Bain's limit pricing model

Module-5

Time value of money: use of cash flow diagram, Annual economic worth, present worth, future worth, Internal Rate of Return (IRR), Net Present Value (NPV), Payback period method, Analysis of public projects: Cost-Benefit analysis, cost effectiveness

Reference Books:

1. Koutsoyiannis, A. (1979). Modern Microeconomics. The Macmillan Press Ltd., London
2. Varian, H. R. (1992). Introduction to Micro Economic Analysis, Norton and company, New York
3. Salvatore, D. (2008). Microeconomics: theory and applications. Oxford University Press
4. Pindyck, R. S., D. N. Rubinfeld and P. L. Meheta (2009). Microeconomics, Pearson India, New Delhi
5. Panneerselvam, R. (2007). Engineering Economics, Prentice-Hall of India, New Delhi
6. Henderson, J. M. and R. E. Quant (2011). Microeconomic Theory: A Mathematical Approach, Indian Higher Education, New Delhi
7. Intriligator, M. D., R. G. Bodkin and C. Hsiao(1995). Econometric Models, Techniques, and Applications, Pearson India, New Delhi

Programme Outcomes of BTech Programme

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

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

Course Outcomes:

Upon completion of the subject the student will be able to :

CO1	Utilise economics principles in consumption process
CO2	Describe the utility measurement and measure the utility associated with risk
CO3	Efficient use of resources in production and take decision regarding optimum output
CO4	Describe market mechanism and analyse product market to take proper decisions
CO5	Implement economic principles in company related decision making

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	-	-	-	-	**2**	**2**	-	-	-	**3**	**3**
CO2	-	-	-	-	-	**3**	**2**	**2**	-	-	**2**	**1**
CO3	-	-	-	-	-	**3**	**3**	-	-	-	**3**	-
CO4	-	-	-	-	-	**2**	**2**	**1**	**1**	**1**	**3**	-
CO5	-	-	-	-	-	**1**	**2**	**1**	**2**	-	**3**	**1**

Program Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO	-	-	-	-	-	**3**	**2**	**1**	**1**	**1**	**3**	**2**

Subject Code: BMM03004	Subject Name: Metallurgical Thermodynamic & Kinetics Laboratory
Experiment - 1	To determine the tumbler and abrasion indices of iron ore, sample.
Experiment - 2	To determine the micuum indices of cock sample.
Experiment - 3	To determine the partial molal volume of each component in binary solution.
Experiment - 4	To determine the aquarium constant and free energy change for the C+CO2 =2CO reaction.
Experiment - 5	Reduction of iron ore pellets by cock powder and calculation of % reduction and % swelling.
Experiment - 6	Reduction of iron ore by non-coking coal power and calculation of % reduction and % swelling.
Experiment - 7	To carry out palletization of iron ore fines.
Experiment - 8	To carry out firing of pellets and measurement of their crushing strength.

COURSE OUTCOMESS:	
CO1	Analyze and demonstrate the transport processes.
CO2	Ability to analyze the heat, mass and momentum transfer analysis.
CO3	Ability to analyze the industrial problems along with appropriate boundary conditions.
CO4	Ability to develop steady and time dependent solutions along with their limitations.
CO5	Analyze and demonstrate the pelletization process.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	3	3	2	3	3	2	3
CO2	3	3	1	3	3	2	2	2	3	3	2	3
CO3	3	3	2	3	3	3	2	2	3	3	2	3
CO4	3	3	2	3	3	2	2	2	3	3	2	3
CO5	3	3	2	3	3	2	2	3	3	3	2	3

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	3	2	2	2	3	3	2	3

Subject Code: BMM03005	Transport Phenomena Laboratory
Experiment - 1	Study the type of flow by Reynolds experiment
Experiment - 2	Determination of total thermal resistance and thermal conductivity of a composite wall
Experiment - 3	Determination of thermal conductivity of Asbestos
Experiment - 4	Determination of thermal conductivity of a given metal rod
Experiment - 5	Determination of heat transfer coefficient in natural convection
Experiment - 6	Determination of heat transfer coefficient in forced convection
Experiment - 7	Determination of emissivity of a given surface
Experiment - 8	Determination of Stefan Boltzmann constant
Experiment - 9	Determination of overall heat transfer coefficient in parallel and counter flow runs and obtaining the effectiveness of the given heat exchanger
Experiment - 10	Determination of exchange capacity of a cationic resin in the softening of water

COURSE OUTCOMESS:	
CO1	Students will be able to classify different types of flow of fluid.
CO2	Students will be able to determine thermal conductivity of different materials...
CO3	Apply heat transfer principles to design and calculate performance of thermal systems related to one dimensional, steady state or transient state for conduction and convection heat transfer.
CO4	Evaluate performance of thermal systems related to one dimensional, steady state natural and Forced Convection heat transfer by Theoretically and Experimentally.
CO5	Apply the concepts of Heat Transfer and application in Industrial and day to day life.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	3	1	1	1	1	3	1
CO2	3	3	3	1	1	3	1	1	1	1	3	2
CO3	3	3	3	3	2	3	1	1	1	1	3	2
CO4	3	3	3	3	2	3	2	1	1	1	3	2
CO5	3	3	3	3	3	3	3	2	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	2	2	3	2	1	1	1	3	2

Subject Code: BMM03006	**Subject Name: Introduction to Physical Metallurgy Laboratory**
Experiment - 1	To make the crystal structures and to study these systems, with the help of ball models.
Experiment - 2	To study the principles and operation of metallurgical microscope.
Experiment - 3	To prepare specimen of some metals and alloys for microstructural examination.
Experiment - 4	To study the microstructure, grain size of the carbon steels.
Experiment - 5	To study the microstructure, of the given cast iron samples.
Experiment - 6	To study the microstructure, grain size of the selected nonferrous alloys.
Experiment - 7	To find out the grain size number of the given metals and alloys.
Experiment - 8	Colour metallography of different ferrous metals.

COURSE OUTCOMESS: Upon completion of the laboratory the student will	
CO1	Demonstrate the different features of optical microscope and their use in metallography
CO2	Develop fundamental skills to prepare best metallographic sample for metallography study
CO3	Develop skills to analyze the microstructure type and evaluate the corresponding property the sample will show
CO4	Define different microstructures and defects seen under a microscope
CO5	Characterize different samples both ferrous and nonferrous with the help of color etching techniques

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	3	3	3	2	-	-	-	-	1
CO2	2	3	1	3	3	3	3	-	-	-	-	1
CO3	3	2	1	3	3	3	3	-	-	-	-	1
CO4	3	3	3	3	3	3	2	-	-	-	-	1
CO5	3	3	3	3	3	3	2	-	-	-	-	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	3	2	3	3	3	3	-	-	-	-	1

Subject Code: BMM03007	**Fuel Testing Laboratory**
Experiment - 1	To determine the calorific value of coal and coke using bomb calorimeter.
Experiment - 2	Proximate analysis of coal and coke.
Experiment - 3	To determine flash point and fire point of a given sample such as kerosene oil. Diesel and petrol by Pensky- Martins /or other apparatus.
Experiment - 4	To determine the effect of temperature on kinematic viscosity of glycerin by redwood viscometer.
Experiment - 5	To determine the bulk and true density of coal sample by using density meter.
Experiment - 6	To determine the flow rate of oil with the help of flow meter.

COURSE OUTCOMESS:	
CO1	Able to measure the calorific value of solid fuels.
CO2	Analyze the percentage of moisture, volatile matter, ash and fixed carbon of coal and coke.
CO3	Evaluate the concept of flash and fire point of liquid fuels.
CO4	Analyze the kinematic viscosity of different liquid fuels.
CO5	Demonstrate the significance of testing of solid and liquid fuels.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	1	3	1	1	--	3	2	1
CO2	3	2	2	3	1	2	3	1	--	3	2	1
CO3	3	2	2	3	1	2	3	2	--	2	2	1
CO4	3	2	2	3	1	2	3	2	--	3	2	1
CO5	3	2	2	3	1	2	3	2	--	1	2	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	2	3	3	3	2	2	2	--

Fourth Semester

MATHEMATICS-IV (Numerical Methods)

Module I: Errors and Root Extraction *(8 Lectures)*

Definition and sources of error, Propagation of errors, finding roots of algebraic and transcendental equations by Bisection method, Newton's method, Secant method, fixed point iteration method.

Module I: Interpolation*(8 Lectures)*

Interpolation, Lagrange's interpolation, Newton's divided differences, Forward differences, Backward differences, Central differences, Interpolation error.

Module I: Numerical integration *(8 Lectures)*

Numerical integration: Newton-Cotes Integration formula (without derivation), Trapezoidal rule, Simpson's rule, Gaussian quadrature, Errors in Numerical Integration.

Module I: Numerical Solution of Differentianal Equations *(8 Lectures)*

Solution of ODE's: Euler's method, Improved Euler's method, Runge-Kutta Methods of order-2 and 4.

Module I: Numerical Solution of system of linear equations*(8 Lectures)*

Numerical Solution of system of linear equations, Gauss Elimination method, LU decomposition, Gauss-Jordan Elimination method, Gauss Jacobi and Gauss-seidal iteration methods

Text Books:

1. An introduction to numerical analysis, Jain, Iyengar and Jain, New AgeInternational
2. Numerical Analysis, B. S. Grewal, Khanna Publishers

Course Outcomes

Upon completion of the subject the students will be able to:

CO1	Recogniserecursive definitions and structural induction
CO2	Demonstrate equivalence of relations, recurrence relations and generating functions
CO3	Describe Euler and Hamilton paths, Planar graphs, Graph colouring with applications
CO4	Recognise Group structure, homomorphism, isomorphism and automorphism
CO5	Analyse Lattice theory and Boolean algebras

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	2	1	-	-	-	1	1
CO2	3	3	2	2	1	2	1	-	-	-	1	1
CO3	3	3	2	2	1	2	1	-	-	-	1	1
CO4	3	3	2	2	1	2	1	-	-	-	1	1
CO5	3	3	2	2	1	2	1	-	-	-	1	1

	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO1	PO1	PO1
Cours	3	3	2	2	1	2	1	-	-	-	1	1

ORGANIZATIONAL BEHAVIOUR Credit- 3-0-0 Class Hours - 30

Syllabus

Module I (6 hours)

Fundamentals of OB: Learning objectives, Definition, scope and importance of OB, why to study OB, Relationship between OB and the individual, Evolution of OB, Theoretical framework (cognitive), Behavioristic and social cognitive, Models of OB, New Challenges of OB Manager,Limitations of OB

Learning: Nature of learning, Determinant of learning, How learning occurs, Learning and OB

Case Study Analysis

Module II (6 hours)

Personality: Definition and importance of personality for performance, Nature and Determinants of personality, Theories of Personality, Personality Traits, Personality and OB

Perception: Meaning and concept of perception, Perceptual process, Importance of perception in OB Motivation: Definition & Concept of Motive & Motivation, Theories of Motivation (Herzberg's Two Factor model Theory, Maslow's Need Hierarchy, Aldefer's ERG theory)

Case Study Analysis

Module III (6 hours)

Communication: Importance, The Communication Process, Types of communication, Barriers to communication, Communication networks, Making communication effective

Groups in organization: Nature, Types of Groups, Why do people join groups? Stages of Group Development, Group cohesiveness, Group decision making and managerial implication,

Developing Work Teams, Team Building, Effective team building

Leadership: Concept of Leadership, Styles of Leadership, Theories of leadership (Trait theory,

Behavioral theory, Contingency theory), How to be an effective leader, Success stories of today's Global and Indian leaders.

Case Study Analysis

Module IV (6 hours)

Conflict: Nature of conflict, Sources of Conflict, Conflict resolutions, Stages of conflict episode,Conflict management technique

Transactional Analysis (TA): Meaning of TA, Ego states, Types of transactions, Life position

Case Study Analysis

Module V (6 hours)

Organizational Change: Why organizational change? Types of Organizational Change, Planned change, Kurt Lewin's-Three step model, Resistance to Change, Managing resistance to change. Organizational Culture: Meaning & definition, Types of culture, creating, sustaining and

changing a culture, Concept of workplace spirituality.

International OB: Introduction to International business, Individual and group behavior in International organization, How culture influence International OB?

Case Study Analysis

Reference Books

1. Stephen P. Robbins, Organizational Behaviour, Printice Hall of India, New Delhi, 2013
2. K. Aswathappa, Organizational Behaviour, Himalaya Publishing House, Bombay, 2018
3. Nelson, D. L., and Quick, J. C. (2007)., Understanding Organizational Behaviour (3rded.).,
Thompson South-Western Publication
4. Pareek, U. (2012), Understanding Organizational Behaviour (3rded.)., Oxford University Press.

Programme Outcomes of BTech Programme

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES: At the end of this course, the students will be able to

CO1	Explain the transition process of management thought from traditional period to modern approaches.
CO2	Transfer the different motivational theories and evaluate motivational strategies used in a variety of organizational settings.
CO3	Identify and analyze the factors affecting individual and group behavior and evaluate the appropriateness of various leadership styles.
CO4	Evaluate the appropriateness of various conflict management strategies used in organizations and develop strategies for resolving group conflict.
CO5	Explain how organizational change and culture affect working relationships within organizations.

Course Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	-	-	-	-	2	2	2	1	1	3	2
CO2	-	-	-	-	-	1	1	1	3	1	-	
CO3	-	-	-	-	-	2	1	-	3	3	3	-
CO4	-	-	-	-	-	-	1	-	1	2	1	1
CO5	-	-	-	-	-	3	1	**1**	2	1	**3**	3

Program Articulation Matrix

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO	-	-	-	-	-	2	1	1	3	2	3	2

Subject Code: BMM04001		**Subject Name: Mineral Processing**	
Pre-Requisite:	Mathematics-I**,** Mathematics - II	Co-requisite:	Unit process of extraction
Module -I		[8 hours]	
	Introduction to mineral beneficiation, sampling, liberation studies and its importance. Comminution: Fundamentals of comminution, crushing: construction and operational features of jaw, gyratory, cone and roll crushers.		
Module -II		[8 hours]	
	Grinding: Theory of ball mill, rod mill, Critical speed of the mill, open circuit and closed circuit, circulating load, Size separation: Sieving and screening, laboratory sizing and its importance, representation and interpretation of size analysis data, industrial screening.		
Module -III		[8 hours]	
	Classification: Movement of solids in fluids, free setting and hindered settling of particles, different types of classifiers, e.g. sizing and sorting classifiers used in mineral industry. Concentration: Gravity separation, concentration criteria, jigging, flowing film concentration and tabling, dense media separation.		
Module -IV		[8 hours]	
	Froth flotation: Theory, reagents used in floatation processes, machines and practice. Magnetic and electrostatic separation: Theory and application of magnetic and electrostatic separation techniques in mineral industry.		
Module -V		[8 hours]	
	Dewatering and drying: Theory and practice of thickening; filtration and drying. Agglomeration techniques: Sintering, palletizing, briquetting and their applications in ferrous and non-ferrous metal industries, testing of agglomerates, important mineral deposits in India.		
TEXT BOOK(S):			
1	Principle of Mineral Dressing by A. M. Gaudin.		
2	Mineral Processing Technology by Berry A. Willis.		
REFERENCE BOOK(S):			
1	Rate Processes In Metallurgy by Mohanty, A. K.; PHI Learning.		
2	Callister W D 2007 Callister's Materials Science and Engineering: Indian Adaptation adapted by R Balasubramaniam (New Delhi: Wiley).		
COURSE OUTCOMES:			
CO1	Analyze and demonstrate the mineral beneficiation process in an economical way.		
CO2	Evaluate different mineral beneficiation process according to the nature of the minerals and selectively apply the most suitable process of beneficiation.		
CO3	Develop the technology to use the available low-grade ores and minerals.		
CO4	Use of wastes and recovery of associated minerals and metals, which will satisfy the “go		

	green slogan".
CO5	Analyze and demonstrate the in-plant studies in order to improve the productivity of mineral beneficiation plants.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	3	2	3	3	3	3	3	2	3
CO2	2	1	3	3	3	3	3	3	3	3	2	3
CO3	3	2	2	3	3	3	3	2	3	3	3	3
CO4	1	1	2	2	3	3	3	3	3	2	3	3
CO5	2	2	3	3	3	3	2	2	2	3	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	1	3	3	3	3	3	3	3	3	3	3

Subject Code: BMM04002	Subject Name: Unit Process and Principle of Extraction
Module -I	[*8 Hours*]
	Overview of Extractive Metallurgy processes; Pyro-metallurgy, Hydrometallurgy and Electrometallurgy; Thermodynamic and Kinetic Principles of metal extraction; Ellingham diagrams, Calcinations; Roasting; Predominance Area Diagram, Roasting Practices, Smelting, Formation and function of slag and their calculations,
Module -II	[*8 Hours*]
	Metallo-thremic and carbothermic reduction of oxides, Smelting Furnaces, Matte Smelting, Pyro metallurgical processes using vacuum Hydrometallurgy: Leaching; Theory of Leaching; Role of oxygen in leaching operation; Bacterial and microbial leaching; Contact reduction of metals in aqueous solutions;
Module -III	[*8 Hours*]
	Gaseous reduction of metals in aqueous solutions; Ion exchange, Solvent Extraction and Electrolysis, Electrometallurgy: laws of electrolysis, electrolyte Structure of solvent media; Electrolysis of aqueous solution; Electrolysis of fused salts; Cell design; Electro refining
Module -IV	[*8 Hours*]
	Halide Metallurgy and Halogenation., Basic approaches of refining, preparation of pure compounds; Purification of crude metals produced in bulk;
Module –V	[*8 Hours*]
	Concept of activity, chemical potential, fugacity, real and idle solution, and thee significance in metal extraction, Numerical problems relevant to Pyro, Hydro and Electrometallurgical processes
TEXT BOOK(S):	
1.	Principles of Extractive Metallurgy: A. Ghosh & H.S. Ray, IIN Publications, Kolkata 1984
2.	Principles of Extractive Metallurgy: Rosenquist, T., McGrawhill - Kogakusha International – 1983
REFERENCE BOOK(S):	
1.	Mineral Processing and Extractive Metallurgy by Corby G. Anderson (Editor), Robert C. Dunne (Editor), John L. Uhrie (Editor)
2.	Metallurgy a Brief Outline of the Modern Processes for Extracting the More Important Metals by W. Borchers.

COURSE OUTCOMESS:

CO1	Illustrate flowsheet of process route for any types of ore.
CO2	Student can able to apply thermodynamics principles when dealing with any type of ore.
CO3	Students can clearly analyze the proper requirement of different raw materials for metal production.
CO4	Student can solve existing issue and new issues which occurs in a plant.
CO5	Analyze the best route and techniques for metal extraction and refining economically n profitably.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	3	2	3	2	1	1	1	3	2
CO2	3	3	3	3	2	3	3	1	1	1	2	3
CO3	3	3	2	3	3	3	2	1	1	1	2	3
CO4	3	3	3	3	2	3	1	1	1	1	2	3
CO5	3	3	3	3	3	3	1	1	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	3	2	3	2	1	1	1	2	3

Subject Code: BMM04003		Subject Name: Phase Transformation	
Pre-Requisite:	Introduction to Physical Metallurgy	Co-requisite:	Thermodynamics & Kinetics of Materials
Module -I		[8 hours]	
	Classification of phase transformations. Thermodynamics and Kinetics: Introduction, Equilibrium, Gibbs free energy change with single component system, Thermodynamic parameters in binary system, Binary phase diagrams, Free energy Vs Composition phase diagrams.		
Module -II		[8 hours]	
	Diffusion: Driving force for diffusion, atomic mechanisms of diffusion, interstitial diffusion: steady state diffusion, Non-steady state diffusion, Solutions to the diffusion equation substitutional diffusion, High diffusivity paths. Crystal interfaces: Interfacial free energy, Boundaries in Single-phase solids, Bond breaking model, Interphase interfaces in solids: interface coherency, interfacial energy effects, misfit strain effects.		
Module -III		[8 hours]	
	Nucleation and growth: Homogeneous nucleation, homogeneous nucleation rate, Heterogeneous nucleation, Heterogeneous nucleation rate, Growth of a pure solid, Diffusional transformations in solids: Overall transformation kinetics: TTT diagrams, Precipitation in age hardening alloys, Particle coarsening, Spinodal decomposition.		
Module -IV		[8 hours]	
	Ferrite: Nucleation and growth, Pearlitic transformation: mechanism, nucleation and growth, Bainitic transformation: mechanism, nucleation and growth, Effect of alloying elements on hardenability, CCT diagrams, massive transformations, ordering transformations.		
Module -V		[8 hours]	
	Diffusionless transformations: Martensitic transformations: characteristics, crystallography, theories of Martensitic nucleation, martensite growth. Recovery, Recrystallization and grain growth.		
TEXT BOOK(S):			
1.	Phase transformations in metals and alloys by D.A. Porter, K.E. Easterling and Sharif, CRC press.		
2.	Phase transformation in materials by Romesh C Sharma, CBS publishers & Distributors.		
REFERENCE BOOK(S):			
1.	Solid State Phase Transformations by V Raghavan, PHI.		
2.	Materials Science and Engineering by W D Callister and adapted by R Balasubramaniam (New Delhi: Wiley)		

COURSE OUTCOMESS: Upon completion of the course, the students will be ability to:	
CO1	develop enhanced critical thinking, analytical and problem-solving skills in materials science and engineering based on concepts of metallurgical thermodynamics and kinetics.
CO2	demonstrate the basic principles underlying liquid to solid and solid-state phase transformations in a range of materials.
CO3	implement the importance of phase transformations for controlling microstructure and properties in engineering alloys.
CO4	define the driving forces and kinetic barriers for phase transformations in solid state.
CO5	produce the desired properties of materials which are affected by the atomistic diffusion processes.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	--	--	--	--	--
CO2	3	3	3	3	3	3	3	--	--	--	--	--
CO3	3	3	3	3	3	3	3	--	--	--	--	--
CO4	3	3	3	3	3	3	3	--	--	--	--	--
CO5	3	3	3	3	3	3	3	--	--	--	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	3	3	3	3	--	--	--	--	--

Subject Code:	**BMM04004**	**Subject Name: Phase Transformation Laboratory**
Experiment - 1	Measurement of volume fraction, surface area in two phase and single-phase materials.	
Experiment - 2	To study the Recovery, Recrystallization and Grain growth behavior of given material.	
Experiment - 3	To study the phase transformation of Pb-Sn eutectic alloy using DSC.	
Experiment - 4	Draw the cooling curves of Pb-Sn alloy with the help of DTA.	
Experiment - 5	To study the precipitation Hardening behavior mechanism in Al-alloys.	
Experiment - 6	Nucleation of Ice from Water: A Modelling Approach.	
Experiment - 7	Study of nucleation and growth in Eutectoid steel.	
Experiment - 8	To study the surface hardening treatments like carburizing/Boronizing on steels.	

COURSE OUTCOMESS: Upon completion of the course, the students will be able to:	
CO1	analyze the role of phase transformations on the development of microstructure and properties of metallic materials.
CO2	produce the microstructures resulting from near-equilibrium vs. far-from-equilibrium thermal treatments
CO3	apply the fundamental principles that determines the evolution of structures from liquid melt as well as diffusional processes.
CO4	demonstrate the experimental techniques in correlating the structure with the desired properties.
CO5	implement the mechanism of phase transformation in surface hardening treatments.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	3	3	2	--	--	--	3	--	--
CO2	2	2	1	3	3	2	--	--	--	2	--	--
CO3	2	2	2	2	2	3	--	--	--	2	--	--
CO4	2	2	2	2	2	2	--	--	--	3	--	--
CO5	2	2	2	2	3	2	--	--	--	2	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	2	3	2	--	--	--	2	--	--

Subject Code- BMM04005	**Mineral Processing Laboratory**
Experiment - 1	To determine and analyze the size distribution of a fixed granular solid by using a test sieve stack and a vibratory shaker.
Experiment - 2	Crushing of ore/coal in the jaw crusher and average size determination by sieving.
Experiment - 3	To study the jaw crusher and determine the actual capacity and reduction ratio, and verification of Rittinger's law of crushing.
Experiment - 4	Crushing of ore/coal in a roll crusher and average size determination by sieving.
Experiment - 5	To study the effect of grinding with grinding time in ball mill.
Experiment - 6	To separate a mixture of two minerals of different densities by gravity concentration using Wilfley Table and determine the weight and density of each fraction of the products
Experiment - 7	Beneficiation of ore pulp mix using floatation cell.
Experiment - 8	Study of magnetic separator and effect of field on the efficiency of the process.

Laboratory Outcomes:	
CO1	To analyze and identify different minerals.
CO2	To demonstrate the principles of density separation.
CO3	To calculate and analyze the role of average size and reduction ratio on mineral beneficiation process.
CO4	To demonstrate and analyze different crushing laws to define the relationship between the energy consumption and final product size.
CO5	Demonstrate the role of gravity separation using wilfley table.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	3	2	2	2	3	3	3
CO2	2	2	2	3	2	2	2	2	3	3	2	3
CO3	3	3	1	3	3	3	2	2	3	3	2	3
CO4	3	3	3	3	3	3	2	2	3	3	2	3
CO5	1	1	3	3	3	2	2	3	3	3	2	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	3	3	3	2	2	3	3	2	3

Subject Code: BMM04006	Subject Name: Process Metallurgy Laboratory
Experiment - 1	To study the calcination process using carbonate ore and roasting process using sulphide ore.
Experiment - 2	To find out percentage reduction of given iron ore using coal and coke separately.
Experiment - 3	To find out percentage swelling of given iron ore using coal and coke separately.
Experiment - 4	To carryout palletisation of iron ore fines and to measure its green strength and strength after hardening.
Experiment - 5	To carry out extraction of metals from oxide and sulphide ore using hydrometallurgy route.
Experiment - 6	To carry cementation process /contact reduction process of copper from leach liquor (copper sulphate).
Experiment - 7	To carryout electro refining/electro plating of metals like cu/nickel/zinc.
Experiment - 8	To prepare a sand mould for casting.
Experiment - 9	To perform casting of low melting point metals and to study the ingot microstructure from different zones.
Experiment - 10	To carry out purification of two liquid compounds using distillation process.

COURSE OUTCOMESS: Upon completion of the laboratory the student will be able to:	
CO1	Produce a suitable product from carbonate and sulphide ore for subsequent metal production
CO2	Evaluate the property of iron ore pellet and lump iron ore so as to select the best raw materials from iron making
CO3	Develop skills to produce metal using hydrometallurgy route
CO4	Develop skills to produce metal by melting and casting route and can evaluate the macor structure of ingot.
CO5	Develop skills to produce pure metals out of a given ore.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1	3	3	3	2	-	-	-	-	1
CO2	2	3	1	3	3	3	3	-	-	-	-	1
CO3	3	2	1	3	3	3	3	-	-	-	-	1
CO4	3	3	3	3	3	3	2	-	-	-	-	1
CO5	3	3	3	3	3	3	2	-	-	-	-	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO	3	3	2	3	3	3	3	-	-	-	-	1

Subject Code: BMM04007	Subject Name: Non-destructive Testing Laboratory
Experiment - 1	To study the microstructure of given material without destroying it (Replica method).
Experiment - 2	To inspect the discontinuous in the material using ultrasonic testing.
Experiment - 3	To inspect the discontinuous in the material using Dye penetrate testing.
Experiment - 4	To inspect the discontinuous in the material using Magnetic particle testing
Experiment - 5	To inspect the discontinuous in the material using ultrasonic testing
Experiment - 6	To inspect the discontinuous in the material using leak testing
Experiment - 7	To study the discontinuous in the material using Eddy current testing
Experiment - 8	To study the discontinuous in the material using Radiography testing

COURSE OUTCOMESS:	
CO 1	Have a complete theoretical and practical understanding of the radiographic testing, interpretation and evaluation.
CO 2	Select appropriate materials for specific engineering applications considering manufacturing and working conditions
CO 3	Select the appropriate technique and exposure time for a better imaging.
CO 4	Differentiate various defect types and characterize them.
CO 5	Follow proper safety precautions to avoid radiation hazards

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	3	3	3		3
CO2	3	3	3	3	3	3	3	3	2	3	1	3
CO3	3	3	3	3	3	1	3	3	1	3	3	3
CO4	3	3	3	3	3	3	3	1	3	--	3	1
CO5	3	3	3	3	3	3	3	3	3	3	3	

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	3	3	3	2	3	2	2	2	2

FIFTH SEMESTER

Subject Code: BMM05001	Subject Name: Iron Making
Pre-Requisite:	**Basic idea about thermodynamics**
Module -I	[8 hours]
History of Iron making in India, Indian and other resources of raw materials required for iron making. coke making. Blast furnace plant and -Modern blast furnace, plant layout, Details of construction of blast furnace and its main accessories; gas cleaning system, hot blast generation. Blast furnace refractories and blast furnace cooling system.	
Module -II	[8 hours]
Agglomeration of iron ore fines, sintering and pelletizing, evaluation of properties of blast furnace, burden materials and application to blast furnace performance. Blast furnace plant operation, blowing in, blowing out and banking of blast furnace, role of burden charging and distribution in iron extraction, irregularities in Blast furnace operation and their remedies.	
Module -III	[8 hours]
Blast furnace products their quality control and disposal, coke rate and fuel efficiency of B.F. operations Modern trends in Blast Furnace Practice-Production of super flux sinter, pellets, super flux and cold bonded pellets. Auxiliary fuel injection in the blast furnace. High temp. blast, humidified and oxy generated blast, high top pressure, Desulphurization of hot metal.	
Module -IV	[8 hours]
Chemical processes in Blast Furnace, Reactions in Tuyere, hearth and bosh zone. Reduction and coke gasification, Reactions in stack and exit gases. Thermodynamics of Blast furnace process requirement in Blast furnace, temp. profile in the furnace. Free energy and equilibrium consideration in Blast furnace a brief discussion on blast furnace stoichiometry and enthalpy balance, testing of agglomerates	
Module -V	[8 hours]
Alternate route for iron making charcoal blast furnace, low shaft furnace and electro thermal processes of iron making. Direct reduction processes, their classification, choice of DR process. Introduction to Production of Ferro-alloys. Production of various ferro-alloys Fe-Mn, Fe-V, Fe-Cr etc. uses of ferro-alloys in iron and steel industry	
EXT BOOK(S):	
1.	Modern Iron Making - Dr. R.H. Tupkary
2.	Principles of Blast Furnace iron making - Dr. A K Biswas
REFERENCE BOOK(S):	
1.	Ahindra Ghosh and Amit Chatterjee: Ironmaking and Steelmaking Theory and Practice, Prentice-Hall of India Private Limited, 2008.

2.	Metallurgical Thermodynamics, Kinetics and Numericals by Dr. S. K. Dutta and Prof. A. B. Lele

COURSE OUTCOMESS:	
CO1	Can make a division regarding ferrous metal and alloys
CO2	Apply theoretical knowledge to solve as well as try to minimize the irregularities in blast furnace and other furnace
CO3	Can apply knowledge to increase the efficiency of smelting process
CO4	Can apply knowledge to reduce the fuel consumption
CO5	Can think of some other alternative routes of iron making

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	3	3	2	1	1	---	---	---	1
CO2	3	3	3	1	1	1	1	1	1	---	---	2
CO3	1	2	1	2	2	3	3	---	---	1	---	3
CO4	2	2	3	1	3	3	1	1	1	1	1	3
CO5	3	1	3	1	3	3	1	1	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO11	PO11	PO12
Course	2	2	2.2	1	2	2	1	1	1	1	1	2

Subject Code: BMM05002			Heat Treatment
Pre-Requisite:		Co-requisite:	
Module -I			[*8hours*]
	Objective and variables of heat treatments, Classification of steels, Heat treatment of steel – annealing, normalizing, hardening, tempering; Phase transformation mechanisms, Fe-Fe_3C, Fe-C phase diagrams, TTT, CCT diagrams, Microstructure evolution during austenite decomposition, Microstructure evolution during reheating, Strengthening mechanisms in steel.		
Module -II			[*8hours*]
	Effects of Alloying Elements on Heat Treatment Processing of Iron–Carbon Alloys, Effect of Alloying Elements on Austenite Transformations, Definition of Hardenability, Factors Influencing Depth of Hardening, Determination of Hardenability, Grossmann's Hardenability Concept, Jominy End-Quench Hardenability Test, Hardenability Bands, Application of Hardenability Concept for Prediction of Hardness after Quenching, Hardenability in Heat Treatment Practice.		
Module -III			[*8hours*]
	Heat Treatment with Gaseous Atmospheres: Carburizing, Reactions with Hydrogen and with Oxygen, Nitriding and Nitro-carburizing, Quenching: Metallurgical Transformation Behavior during Quenching, Quenching Processes, Determination of Cooling Characteristics, quenching as a Heat Transfer Problem, Process Variables Affecting Cooling Behavior and Heat Transfer.		
Module -IV			[*8hours*]
	Distortion of Heat-Treated Components: Basic Distortion Mechanisms, Residual Stresses, Distortion during Post Quench Processing**.** Heat treatments of general engineering steels: Spring, bearing steels, Tool steels, HSLA steel and Maraging steels, Dual phase steels and Stainless steels, Heat treatment cast irons.		
Module -V			[*8hours*]
	Heat Treatments of Nonferrous alloys: Al-alloys, Brass, Bronze, and Ti-alloys, Superalloys		
TEXT BOOK(S):			
1.	Heat treatment –Principles & Techniques by T.V. Rajan, C.P. Sharma and A. Sharma, PHI publishers.		
2.	Singh, Heat Treatment of Metals, Standard Publishers.		
REFERENCE BOOK(S):			
1.	Steel Heat Treatment Handbook (Steel Heat Treatment Handbook, Second Edition)" by George E Totten and Maurice A H Howes		
2.	Heat Treatment of Metals" by B Zakharov		

COURSE OUTCOMESS:	
CO1	Evaluate the possible microstructure evolution for a given composition of Carbon steel
CO2	Apply suitable heat treatment technique to get desired set of properties for a given service
CO3	Analyze suitable ways to strengthen a given steel and nonferrous metal and alloys for real application
CO4	Develop skills to carry out all the essential heat treatment on a large scale
CO5	Can selects the best steel for desired application and can modify the properties according the recent demands.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	3	2	1	2	1	2	2
CO2	3	2	3	3	3	3	2	1	2	1	2	2
CO3	3	3	3	3	3	3	2	1	2	1	2	2
CO4	3	2	3	3	3	3	2	1	2	1	2	2
CO5	3	3	3	3	3	3	2	1	2	1	2	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	2	3	3	3	3	2	1	2	1	2	2

Subject Code: BMM05003	Subject Name: Deformation Behavior of Materials

Pre-Requisite:		Co-requisite:	

Module -I	[*8hours*]
Introduction: Scope of the subject, elastic, plastic and visco-elastic deformation. Deformation behavior: Tensile and compression testing, effect of temperature and strain rate Continuum mechanics: Concepts of stress and strain in 3D stress and strain tensor.	

Module -II	[*8hours*]
Principal stresses and strains and principal axes, mean stress, stress deviator, maximum shear, equilibrium of stresses, equations of compatibility. Elastic behavior of materials: Constitutive equations in elasticity for isotropic and anisotropic materials, strain energy, elastic stiffness and compliance tensor.	

Module -III	[*8hours*]
Effect of crystal structure on elastic constants. Plastic response of materials-a continuum approach: classification of stress-strain curves, yield criteria. Microscopic basis of plastic deformation: Elements of dislocation theory, movement of dislocation, elastic properties of dislocation.	

Module -IV	[*8hours*]
Intersection of dislocation, dislocation reactions in different crystal structures, origin and multiplication of dislocations. Plastic deformation of single crystals: Critical resolved shear stress, deformation by twinning, deformation band and kink band, strain hardening of single crystal; stress-strain curves of fcc, bcc and hcp materials.	

Module -V	[*8hours*]
Plastic deformation of polycrystalline materials: Role of grain boundaries in deformation, strengthening by grain boundaries, yield point phenomenon, strain ageing, strengthening by solutes, precipitates, dispersoids and fibres. Deformation in non-metallic materials: structure and deformation of polymers, concept Super lattice dislocations in inter metallics, and concept of charge associated with dislocations in ceramics.	

TEXT BOOK(S):

1.	Mechanical Metallurgy, 3rd Ed., McGraw Hill Book Company, New Delhi, 1986 - G.E Dieter
2.	Mechanical Behavior of Materials, McGraw Hill Book Company, New Delhi, 1990 - T.H. Courtney

REFERENCE BOOK(S):

1.	Mechanical Behaviour of Materials by Norman E. Dowling
2.	Mechanical Behaviour and Testing of Materials" by a K Bhargava and C P Sharma

COURSE OUTCOMESS:	
CO1	Calculate and develop the concepts of stress and strain relationships for homogenous, isotropic materials.
CO2	Calculate and predict the yielding phenomena occurs in metals and alloys using yield criteria.
CO3	Calculate and describe the internal stresses and deformations that result in combined loading conditions
CO4	Evaluation of different strengthening mechanism occurs in metals and alloys.
CO5	Basic knowledge of deformation mechanism in polymers and intermetallics.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	1	2	3	2	1	3	2	1	3
CO2	2	3	1	3	1	2	2	3	2	2	3	1
CO3	3	2	2	2	3	1	3	2	2	3	2	3
CO4	2	2	3	2	2	2	1	3	2	2	3	2
CO5	3	2	2	2	3	2	3	2	2	2	3	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	2	2	2	2	2	2	2	2	2

Subject Code: BMMPE501	Subject name: Powder Metallurgy and Composite Materials

Pre-Requisite:		Co-requisite:	

Module -I	[8hrs]
Introduction to powder metallurgy: metal and alloy powder production, chemical, physical and mechanical methods of production. Metal powder characterization: introduction, chemical composition, particle size, surface area, density, compressibility and strength.	

Module -II	[8hrs]
Powder compaction, Sintering introduction, Introduction to Composites: Matrices, Reinforcements: galss fibre, carbon fibre, whiskers, Fundamental concept of reinforcement, review of current developments; Basic mechanics of reinforcement, stiffness of parallel arrays of fibers in a matrix.	

Module -III	[8hrs]
Polymer Matrix Composites (PMCs): processing of thermoplastic and thermoset matrix composite, structural defect and mechanical properties, application. Metal Matrix Composites (MMCs): Aluminum alloy, copper alloy, titanium alloys, solid state processing, in situ processing, high temperature properties and strength, applications.	

Module -IV	[8hrs]
Ceramic Matrix Composites (CMCs): cold pressing and sintering, hot pressing, self-propagating high temperature synthesis, thermal shock resistance properties, crack deflection and toughness.	

Module -V	[8hrs]
Nano composites: polymer clay nano composite, bio composite, hybrid composite.	

TEXT BOOK(S):

1.	Powder metallurgy technology by G. S. Upadhyaya
2.	Composite materials science and engineering by K. Chawla

REFERENCE BOOK(S):

1.	Powder Metallurgy: An advanced technique of processing engineering materials by B.K.Datta.
2.	An Introduction to Composite Materials by T.W.Clyne and D.Hull.

COURSE OUTCOMESS(COs)

CO1	Develop the basic knowledge of the powder metallurgy processing; and the theory and technology of powder production, consolidation and sintering.
CO2	Acquire the basic knowledge of composite materials, matrices, reinforcements and interfaces used in the different composite materials.

CO3	Evaluate the different processing methods used for Polymer, Metallic and ceramic matrix composite
CO4	Analyze the difference between polymer clay nano-composites over bio-composite
CO5	Develop an idea about hybrid composite

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	---	---	---	---	---	---
CO2	3	3	3	3	3	3	---	---	---	---	---	---
CO3	3	3	3	3	3	3	---	---	---	---	---	---
CO4	3	3	3	3	3	3	---	---	---	---	---	---
CO5	3	3	3	3	3	3	---	---	---	---	---	---

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	2	3	1	1	2	2	---	1	---

Subject Code: BMMPE502	Subject name: Fuel, Furnace and Refractories
Module -I	[8hrs]
Introduction of fossil fuels and their worldwide reserves; Primary and secondary fuels, Coking and non-coking coals, Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analyses, etc.); Coal carbonization and effects of different parameters; Properties of coke, Selection of coal for sponge iron making, Ferro coke and Formed coke.	
Module -II	[8hrs]
Furnacees and its Accessories: commonly used furnaces, basic principle of furnace design, furnace instruments, and furnace accessories.	
Module -III	[8hrs]
Refractory mortars and cements, Refractory castable, selection of refractories for coke oven, iron blast furnace, copper convertor, soaking reheating furnaces and heat treatment furnaces and electric arc furnaces, Classification of furnaces: basis and uses.	
Module -IV	[8hrs]
Mechanism of combustion and combustion calculations, Ignition temperature, Flames: Flame propagation, flame speed and inflammability limits, types of flames; premixed and diffusion flames and their characteristics.	
Module -V	[8hrs]
Flame temperature and type, Heat losses in furnaces: Heat balance and furnace efficiency. Burners for liquid and gaseous fuel combustion.	
TEXT BOOK(S):	
1	Fuel, Furnace, and Refractories by O.P.Gupta.
2	Fuels, Furnaces and Refractories by J.D. Gilchrist.
REFERENCE BOOK(S):	
1	Fuel, Furnace, and Refractories by R.C.Gupta.
2	Fuels, Furnaces and Refractories, 1st Edition, International Series on Materials Science and Technology by J. D. Gilchrist and Editor: R. W. Douglas

COURSE OUTCOMESS:	
CO1	Develop a basic knowledge of different types of fossil fuels, concept of carbonization and physico-chemical properties of coke.
CO2	Analyze the different types of refractories and their properties used in various metallurgical furnaces.
CO3	Express the concept of different types of furnaces and their applications.
CO4	Evaluate the mechanism of combustion and combustion calculation
CO5	Demonstrate the different types of burners used for liquid and gaseous fuel combustion.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	2	2	3	2	1
CO2	3	2	2	3	3	2	3	2	2	3	2	1
CO3	3	2	2	3	3	2	3	2	2	3	2	1
CO4	3	2	2	3	3	2	3	2	2	3	2	1
CO5	3	2	2	3	3	2	3	2	2	3	2	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	1	3	3	1	2	2	2	1

Subject Code: BMMPE503		Subject name: Alternative Routes of Iron Making	
Pre-Requisite:	Metallurgical Thermodynamics & Kinetics	Co-requisite:	Iron Making

Module -I	[8 hours]
Introduction: Present and future of sponge iron industries in India; Characteristics of raw materials and their preparation. Thermodynamics and Kinetics aspects.	

Module -II	[8 hours]
Direct Reduction Processes: Reduction of Iron bearing materials in shaft furnace, rotary kiln. Classification of DR processes; Salient features of coal- based (rotary kilns) DR processes; Salient features of gas-based DR processes.	

Module -III	[8 hours]
Retort and fluidized bed with special reference to reductant, energy consumption and operational problems. Commercially available processes like SL/RN, ACCAR, Krup-CODIR, Kinglon Meter, MIDREX, HyL, Purofer, Iron Carbide, etc.	

Module -IV	[8 hours]
Uses of DRI in steel making, iron making and foundries; effect on DRI on EAF performance and product characteristics. Smelting Reduction Processes: COREX, ROMELT, Fluidized bed reactors, Hismelt etc.	

Module -V	[8 hours]
Strengths and weaknesses of different DR processes particularly in context to India; Properties and usage of DRI; Pollution issues in the Indian DR industries. Present status of alternative methods of iron making in India.	

TEXT BOOK(S):

1. Alternative Routes of Iron Making by Amit Chatterjee, PHI
2. Beyond the Blast Furnace by Amit Chatterjee. .

REFERENCE BOOK(S):

1. Modern Iron Making - Dr. R.H. Tupkary
2. Rate Processes In Metallurgy by Mohanty, A. K.; PHI Learning**.**

COURSE OUTCOMES:

CO1	Aware of different alternative routes of iron making processes and their present status in India and throughout the world.
CO2	Provide fundamental knowledge and demonstrate the differences between different alternative routes of iron making.
CO3	Define and solve the major issues in the iron and steel industries.

CO4	Analyze and incorporate the ideas of increasing productivity of iron by means of various alternative iron making processes.
CO5	Evaluate and implement the suitable analysis to produce high grade iron steel for best use in engineering applications.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	3	3	2	2	3	3	3	3	3
CO2	1	1	2	1	3	2	1	2	2	3	2	2
CO3	3	2	3	2	3	2	2	3	3	3	3	2
CO4	2	2	3	3	3	3	3	2	3	3	3	3
CO5	3	3	3	3	3	3	3	2	3	3	3	3

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	3	2	3	2	2	2	3	3	3	3

Subject Code: BMMOE501	Subject Name: Nonequilibrium Processing of Materials

Pre-Requisite:		Co-requisite:	

Module -I	[8 hours]
Introduction to non-equilibrium processing. Thermodynamics of meta-stable phase formation: Free energy of elements and alloy phases-determination of free energy of metastable phases, lattice parameter of the super-saturated phase; Kinetics of meta-stable phase formation – Nucleation of metastable and alloy phases. Grain growth rate of metastable phases.	

Module -II	[8 hours]
Rapid solidification: Methods, constitution and microstructure formation, properties performance and applications. Mechanical Alloying: process, mechanism of alloying, consolidation, synthesis of non-equilibrium phases, industrial applications.	

Module -III	[8 hours]
Laser processing: principles, classification, laser quenching, laser surface-alloying and cladding, laser annealing, laser beam joining, micro joining. Thermal plasma processing: advantages, principles of plasma generation, plasma processing systems, processing of materials by plasma spraying.	

Module -IV	[8 hours]
Spray forming: Principles, applicability, non-equilibrium phenomena in spray forming, effects of non-equilibrium features on mechanical/physical properties.	

Module -V	[8 hours]
Physical Vapor Deposition and Chemical Vapor Deposition: basic principles, processing and application. Bulk amorphous alloys.	

TEXT BOOK(S):

1.	Non-equilibrium processing by C Suryanarayana.
2.	Elements of Rapid Solidification: Fundamentals and Applications, Editor Monde A. Otooni, Springer series in Materials Science.

REFERENCE BOOK(S):

1.	ASM HandBook Volume 5 - Surface Engineering.
2.	Physical Metallurgy and Advanced Materials, Seventh Edition, R E Smallman, A. H. W., Butterworth-Heinemann, 2007, ISBN: 0750669063

COURSE OUTCOMESS: Upon completion of the course, the students will be able to:	
CO1	apply the knowledge of materials thermodynamics and kinetics in predicting the formation and stability of metastable phases during the nonequilibrium processing of materials.
CO2	produce materials industrially via rapid solidification process and mechanical alloying for

	engineering applications.
CO3	implement the laser and plasma technology in selection and design of advanced materials via modern processing routes.
CO4	demonstrate the applicability of spray forming by nonequilibrium features.
CO5	create amorphous alloys using the vapor deposition techniques.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	3	3	3	3	--	--	--	--	--
CO2	2	3	3	3	3	3	2	--	--	--	--	--
CO3	2	2	2	3	3	3	2	--	--	--	--	--
CO4	2	3	3	3	3	3	2	--	--	--	--	--
CO5	2	3	3	3	3	3	2	--	--	--	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	3	3	3	3	3	2	--	--	--	--	--

Subject Code: BMMOE502	Subject name: Mechanical Working of Metallic Materials
Pre-Requisite: Calculus	Co-requisite:
Module -I	[8 hours]
Fundamentals of Metal Working: Classification of forming processes; Temperature in Metal–working, Hot working, Cold working and Warm working of metals, Heating of metals and alloys for hot working, Friction in Metal working, Lubrication, concept of yield criteria.	
Module -II	[8 hours]
Rolling of Metals: Classification of Rolled products, Types of rolling mills, terminology used in rolling; Forces and Geometrical relationships in rolling, rolling variables, Theories of rolling, Rolling Torque and HP calculations. Rolling practice adopted for some common products such as Slabs, Blooms, Billets, Plates, Sheets etc. Rolling defects and their control.	
Module -III	[8 hours]
Forging of Metals: Forging principles, types of forging and equipment's needed, calculation of forging load under sticking and slipping friction conditions, Forging defects and their control	
Module -IV	[8 hours]
Extrusion: Types, Principles and Equipment's. Variables in extrusion, deformations in extrusion, calculation of extrusion pressure under plane strain conditions; extrusion defects; production of tubes and seamless pipe	
Module –V	[8 hours]
Wire Drawing: Drawing of Rods, Wires and Tubes, calculation of drawing load; drawing defects. Sheet Metal Forming: Forming methods such as bending stretch forming, shearing and blanking, deep drawing, and redrawing. Defects in formed products, Special forming methods such as explosive forming (elementary ideas excluding mathematical treatment).	
TEXT BOOK(S):	
1.	G. W. Rowe, Principles of Industrial Metal Working processes, Crane Russak, 1977.
2.	Amitabh Ghosh, Asok Kumar Mallick, Manufacturing sciences, East-west press private ltd; latest reprint-1991
REFERENCE BOOK(S):	
1.	**Dieter, G. E., & Bacon, D. J. (1986).** ***Mechanical metallurgy*** **(Vol. 3). New York: McGraw-hill**

COURSE OUTCOMES:	
CO1	Differentiate various metal forming processes such as Hot and Cold Working, Rolling, Forging, Extrusion and Drawing Processes.
CO2	Select an appropriate forming process to manufacture a component.
CO3	Design different metal forming equipment
CO4	Design different sheet metal working processes
CO5	To capture the international market with latest mechanical industry needs with the knowledge and support of advanced manufacturing techniques, so student with this judgment will be absorbed in any mechanical industry

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	1	3	3	1	1	1	1	3	1
CO2	1	1	3	1	3	3	1	1	1	1	3	1
CO3	1	1	3	1	3	3	1	1	1	1	3	1
CO4	1	1	3	1	3	3	1	1	1	1	3	1
CO5	1	1	3	1	3	3	3	2	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	1	1	3	1	3	3	1	1	1	1	3	1

Subject Code: BMM05004	Subject Name: Heat Treatment Laboratory
Experiment - 1	To study the microstructure, grain size and hardness of annealed steel.
Experiment - 2	To study the microstructure, grain size and hardness of normalized steel.
Experiment - 3	To study the microstructure, grain size and hardness of hardened steel.
Experiment - 4	To study the microstructure, grain size and hardness of tempered steel.
Experiment - 5	To study the hardenability of a given material (Jominy End Quench Test)
Experiment - 6	To study/draw the TTT diagram of a material.
Experiment - 7	To study/draw the CCT diagram of a given material.
Experiment - 8	To study the heat treatment cycles for Titanium and Super alloys.

COURSE OUTCOMESS: Upon completion of the course, the students will be able to:	
CO1	assess the behavior of materials built into a device or structure from the viewpoint of the selected heat treatment.
CO2	create surface integrity yielded by different heat treatment processes and ensure the required quality for the operation of a product.
CO3	evaluate the microstructural transformations in the material after different thermal and thermochemical treatments.
CO4	analyze and interpret the experimental data for quantitative and qualitative research.
CO5	apply the concepts of heat treatment processes at industry level.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	3	3	2	--	--	--	3	--	--
CO2	2	2	1	3	3	2	--	--	--	2	--	--
CO3	2	2	2	2	2	3	--	--	--	2	--	--
CO4	2	2	2	2	2	2	--	--	--	3	--	--
CO5	2	2	2	2	3	2	--	--	--	2	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	1	2	3	2	--	--	--	2	--	--

Subject Code: BMM05005	Subject Name: Foundry Laboratory
Experiment - 1	Preparation of sand specimen's and conduction of the following tests.
Experiment - 2	Compression, Shear and Tensile tests on Universal Sand Testing Machine.
Experiment - 3	Permeability test
Experiment - 4	Core hardness & Mould hardness tests.
Experiment - 5	Sieve Analysis to find Grain Fineness number of Base Sand
Experiment - 6	Clay content determinations in Base Sand
Experiment - 7	Compression, Shear and Tensile tests on Universal Sand Testing Machine.

COURSE OUTCOMESS:	
CO1	The ability to assess the behavior of materials built into a device or structure from the viewpoint of the selected heat treatment.
CO2	Select appropriate materials for specific engineering applications considering manufacturing and working conditions
CO3	The ability to evaluate the microstructural transformations in the material after different thermal and thermochemical treatments.
CO4	Differentiate various defect types and characterize them.
CO5	Follow proper safety precautions to avoid radiation hazards

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	2	3	3	1	3	3	1
CO2	3	3	3	3	3	3		3	3	1	2	3
CO3	3		3	3	2	3	3	1	3	2	3	
CO4	3	3	3	3	3	2	2	3	1		3	3
CO5	3	3	2	3	3	3	3	3	3	1	1	

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	2	3	3	3	3	2	3	2	1	2	1

Subject Code: BMM05006	Subject Name: Powder Metallurgy & Composite Materials Laboratory
Experiment - 1	To Determination the particle size and size distribution of metal powder by using particle size analyzer.
Experiment - 2	To determine the apparent and tap density of metal powders by using density meter.
Experiment - 3	To determine the flow rate of powder sample.
Experiment - 4	To study the compaction of metal powder by uniaxial compaction machine.
Experiment - 5	To study the sintering behavior of metal powders by scanning electron microscopy.
Experiment - 6	To determine the surface area of metal powders before and after sintering.

COURSE OUTCOMESS:	
CO1	Able to determine the different size of powder particles.
CO2	Analyze the density and flow rate behavior of metallic and ceramic powder particles
CO3	Acquire the knowledge of powder compaction
CO4	Develop an idea about the sintering practice used for the powder compacts
CO5	Demonstrate the concept of production of an engineering component through powder metallurgy

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	3	1	2	--	3	2	--
CO2	3	2	2	3	1	2	3	2	--	3	2	--
CO3	3	2	2	3	1	2	3	2	--	3	2	--
CO4	3	2	2	3	1	2	3	2	--	3	2	--
CO5	3	2	2	3	1	2	3	2	--	3	2	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	2	3	3	3	2	2	2	--

SIXTH SEMESTER

Subject Code: BMM06001	**Subject name: Casting Processes and Solidification**
Pre-Requisite:	Co-requisite:
Module -I	[8hrs]
Introduction: Casting as a process of Manufacturing. Advantages, dis advantages and application, casting terms, gating system, parts of gating system Molding Processes, Equipment's and Mechanization: Different types of Molds and moulding sands, Molding Materials and Molding processes.	
Module -II	[8hrs]
Properties of moulding sand, Pattern and its type, allowances, types of Pattern allowances, steps involve in sand casting, sand testing and its type, Different types of binders and their uses in mold and core makings.	
Module -III	[8hrs]
Melting of Metals and Alloys for casting: Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as CI, steels. Solidification of Metals and Alloys: Nucleation, Growth, Role of alloy constitution.	
Module -IV	[8hrs]
Principles of Gating and Risering system: Types of Gates and Risers, gating ratio, design of rising system, criteria for riser design, method for improving riser efficiency, Chvorinov rule, concept of directionality in solidification Significance and practical control of cast structure, Caines method, modulus method.	
Module -V	[8hrs]
Special casting Methods: Investment casting, die casting, Centrifugal casting, Full mould casting, Vacuum sealed casting. Casting Defects: A detailed analysis of casting defects Their causes and prescription of remedial measures.	
TEXT BOOK(S):	
1	P. R. Beeley, Foundry Technology, Newnes -Buttterworths, 2001.
2	P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.
REFERENCE BOOK(S):	
1	Solidification and Casting: By Brian Cantor, K O'Reilly
2	Principles of Solidification by Glicksman, Martin Eden

COURSE OUTCOMESS:	
CO 1	The features of casting problem; a survey and scope of foundry industry.
CO 2	Interpret different casting process and its different terminology
CO 3	Able to understand Pattern, Core, Gating, Riser system
CO 4	Able to differentiate between different furnaces likeGas fired furnace, pit furnace, Resistance furnace, Coreless furnace, Electric arc furnace and Cupola Furnaces.
CO 5	Apply advanced casting methods like V-process, lost foam process, Gravity die casting, Pressure die casting, Centrifugal casting, Squeeze casting, slush and Continuous Metal mold castings in the industrial purpose.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	3	2	3	3	--
CO2	3	3	3	3	1	3	3	3	3	1	3	3
CO3	3	3	2	3	3	3	3	3	3	3	1	3
CO4	3	3	3	3	2	2		3	3	2		2
CO5	3	3	3	3	3	3	2	3	3	2	2	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	3	2	3	2	3	3	2	2	2

Subject Code: BMM06002	**Subject name: Steel Making**
Pre-Requisite:	Co-requisite:
Module -I	[8hrs]
Introduction: History of modern steelmaking, Principles of steel making reactions: Decarburisation, Dephosphorisation, Desulphurisation, silicon and manganese reaction. Slag Theories: Molecular and Ionic theories; Interpretation of the above reactions in terms of ionic theory of slag.	
Module -II	[8hrs]
Fundamentals of converter steelmaking technology: LD Process, Design of converter & lance, Quality of raw materials charged, Operation of the converter and control of bath and slag composition, Characteristics of L. D. blow: emulsion formation, lance height for dephosphorisation and decarbonisation. Recovery of waste heat, OBM/Q-BOP, Process, Concept and operation of the process, Mixed/Combined blowing Processes, Oxygen top blowing with inert gas purging at bottom, Oxygen top blowing with inert and oxidizing gases at bottom, Oxygen top and bottom blowing. Open Hearth Furnace: Its modification into Twin Hearth, Operational principle and advantage.	
Module -III	[8hrs]
Steelmaking in electric arc furnace; design and operation, Development in Electric Furnace steel making Electric Arc Furnace: Advantages, Charging, Melting and Refining practices for plain carbon and alloy steels, Use of DRI in arc furnace and its effect on performance. Duplex processes of stainless steel making using VOD, AOD.	
Module -IV	[8hrs]
Induction Furnace: Advantages, principle of induction melting, Deoxidation of liquid steel: Requirements of deoxidisers, deoxidation practice, Use of complex deoxidisers, Inclusions and their influence on quality of steel, Killed, Semi-killed and Rimming steel, Secondary refining of steel: Objectives, Principle of degassing, Different industrial processes such as DH, RH, VAD, SD. LF, and ESR, Limitations and specific applications.	
Module -V	[8hrs]
Continuous Casting of Steel: Advantages, types of machines, Mould lubrication and reciprocation, Developments in technology with respect to productivity, quality and energy conservation, Near-net-shape casting, Strip casting.	
TEXT BOOK(S):	
1.	Iron and steel making theory and practiced - Ahindra Ghosh, Amit Chatterjee
2.	Introduction to Modern Steel Making, Khanna Publishers, Delhi - R.H.
REFERENCE BOOK(S):	
1.	Steel Making by A.K.Chakrabarti, PHI Learning Pvt. Ltd., 19-Dec-2006 - Technology & Engineering.
2.	Design of Steel Structures: By Limit State Method as Per IS: 800-2007" by S S Bhavikatti.

COURSE OUTCOMESS(COs)	
CO1	Define the principles of steel mking reactions
CO2	Demonstrate different converter steelmaking technologies
CO3	Create an idea in different aspect of electric arc furnace steel making
CO4	Analyze the advantages of secondary refining of steel
CO5	Apply the knowledge of continuous casting process to enhance the quality and productivity of steel

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	---	---	---	---	---	---
CO2	3	3	3	3	3	3	---	---	---	---	---	---
CO3	3	3	3	3	3	3	---	---	---	---	---	---
CO4	3	3	3	3	3	3	---	---	---	---	---	---
CO5	3	3	3	3	3	3	---	---	---	---	---	---

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	2	3	3	1	1	---	2	---	---

Subject Code: BMMPE601	**Subject Name: Material Testing**
Pre-Requisite:	Co-requisite:

Module -I	[*8 Hours*]
Engineering materials and their applications, testing of materials: Types of testing systems, significance of measurement of properties and test conditions, interpretation of test results, Tensile Testing: significance of measured parameters, necking, stress distribution, ductility measurement.	

Module -II	[*8 Hours*]
Effect of gauge length, effect of strain rate and temperature on flow properties, Machine stiffness in tensile testing system, measuring instrument computerization, Torsion Test: Mechanical properties in torsion. torsion vs tension test.	

Module -III	[*8 Hours*]
Hardness Test: Rockwell, Brinell, Vickers and micro-hardness, elastic and plastic behavior during hardness testing, Special hardness tests: superficial, micro and shore.	

Module -IV	[*8 Hours*]
Fracture mechanics: Introduction, Strain-Energy Release Rate, Stress Intensity Factor, Fracture Toughness and Design, KI_c Plane-Strain Toughness Testing Ductile, brittle fracture, Griffith theory, Ductile to brittle transition, Notch effect in fracture.	

Module –V	[*8 Hours*]
Fatigue Tests: Stress cycles, SN curve, effect of stress concentration, size and surface conditions on fatigue, Creep, Stress rupture tests, Creep curve and its analysis, Non-destructive Testing: Visual, magnetic, radiographic, ultrasonic, electromagnetic, penetrant tests, their applications in quality control and inspection.	

TEXT BOOK(S):

1.	Mechanical Metallurgy George E. Dieter.
2.	Materials Testing by S. Bhargava

REFERENCE BOOK(S):

1.	Mechanical Behavior of Materials, Cambridge University Press, UK, 2005 - William F. Hosford.
2.	Welding Metallurgy 2nd Edition by Sindo Kou, Wiley-Interscience
3.	Tensile Testing, ASM International, United States of America, 2004 - J.R. Davis Davis & Associates.

COURSE OUTCOMESS:	
CO1	Demonstration of different testing techniques and their relationships for homogenous, isotropic materials.
CO2	Calculate and predict the necking phenomena and distribution of stresses occurs in metals and alloys.
CO3	Evaluation of effect of gauge length, effect of strain rate and temperature on flow properties, machine stiffness in tensile testing system in tensile testing of a materials.
CO4	Basic knowledge of fracture mechanics, fracture toughness and KIc plane-strain toughness for design and application aspect.
CO5	Basic knowledge of fatigue test, creep test and non-destructive testing.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	3	1	2	3	2	2	3	2	1	3
CO2	2	3	1	3	2	2	2	3	2	2	3	1
CO3	3	2	2	2	3	1	3	2	2	3	2	3
CO4	2	2	3	2	2	2	1	3	2	2	3	2
CO5	2	2	2	2	3	2	3	2	2	2	3	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	2	2	2	2	2	2	2	2	2

Subject Code: BMMPE602		**Subject name: Sintering Theory and Practice**	
Pre-Requisite:		Co-requisite:	
Module -I			[8hrs]
	Introduction to sintering over view, brief history, the sintering process, overview of sintering technique, goals in sintering, related problems.		
Module -II			[8hrs]
	Fundamental of solid-state sintering coarsening and densification, sintering stress, mass transfer, stages of sintering rearrangement mechanism, coarsening and densification, sintering diagrams. Microstructure and processing.		
Module -III			[8hrs]
	Liquid phase sintering over view, rearrangement mechanism, grain growth mechanism.		
Module -IV			[8hrs]
	Mixed power sintering novel sintering, sintering atmosphere, sintering practices, post sintering process overview.		
Module -V			[8hrs]
	Sintering Measurement Techniques, Sintering behavior of a wide variety of engineered materials--metals, alloys, oxide ceramics, composites, carbides, intermetallics, glasses, and polymers.		
TEXT BOOK(S):			
1	Sintering Theory and Practice by Randall M. German		
2	Powder metallurgy technology by G. S. Upadhyaya		
REFERENCE BOOK(S):			
1	Sintering Theory and Practice by Carl Burt.		
2	Sintering : Densification, Grain Growth and Microstructure by Suk-Joong L. Kang		

COURSE OUTCOMESS(COs)	
CO1	Develop an idea about the principle of sintering.
CO2	Evaluate the concept of solid and liquid state sintering.
CO3	Express the various mechanism of mass transfer during sintering process.
CO4	Analyze the growth mechanism as well as rearrangement mechanism during solid and liquid phase sintering
CO5	Demonstrate the effect of sintering process on different engineering materiials.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	2	2	3	2	1
CO2	3	2	2	3	3	2	3	2	2	3	2	1
CO3	3	2	2	3	3	2	3	2	2	3	2	1
CO4	3	2	2	3	3	2	3	2	2	3	2	1
CO5	3	2	2	3	3	2	3	2	2	3	2	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	1	3	3	1	2	2	2	1

Subject Code: BMMPE603		Subject Name: Theory of Alloys	
Pre-Requisite:	Introduction to Physical Metallurgy	Co-requisite:	
Module -I			[8 hours]
	Structure and physical properties of elements: Alloys formation: primary solid solution, intermetallic compounds, concept of atomic size factor, normal valance compounds, electron compounds in noble metals and transition metal systems, size compounds, borides, carbides and silicide of metals.		
Module -II			[8 hours]
	Experimental methods for the study of alloying behavior of metals Aluminium alloys. Phase diagrams. Alloys and tempers. Alloy characteristics. Review of precipitation hardening, oxidation, corrosion resistance and fatigue.		
Module -III			[8 hours]
	Titanium alloys: Pure Ti. Alloying Ti. Specific alloys: α, α + β, and β. Superplasticity. Magnesium alloys: Heat treatment of Mg alloys. Nickel alloys: overview and superalloys: Ni-base, Fe-base and Co-base superalloys and their properties.		
Module -IV			[8 hours]
	Steels. Review of plain C, alloy steels and cast irons. Commercial steels: high-strength, low-alloy (HSLA), Stainless steels.		
Module -V			[8 hours]
	Bainitic steels, Martensitic steels, Dual-phase steels, transformation induced plasticity (TRIP), TWIP Steels, IF steels.		
TEXT BOOK(S):			
1.	The structure of metal and alloys - William Hume Rothery.		
2.	Physical Metallurgy Principles - Reza Abbaschian and Robert E.Reed Hill.		
REFERENCE BOOK(S):			
1.	Physical Metallurgy and Advanced Materials, Seventh Edition, R E Smallman, A. H. W., Butterworth-Heinemann, 2007, ISBN: 0750669063		
2.	ASM Handbook Volume 3 – Alloy Phase Diagrams, 1992		

COURSE OUTCOMESS: Upon completion of the course, the students will be able to:	
CO1	evaluate a comparative analysis of principles of alloy formation.
CO2	organize the different types of ferrous and nonferrous alloys based on structure and properties.
CO3	apply different experimental methods to study the alloy behavior.
CO4	analyze the material properties according to their specific application.
CO5	develop the engineering materials by observing structure-property relation.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	3	3	2	--	--	--	--	--
CO2	1	1	1	2	2	2	1	--	--	--	--	--
CO3	2	2	2	3	2	2	1	--	--	--	--	--
CO4	2	2	3	3	2	2	2	--	--	--	--	--
CO5	3	3	3	3	3	3	3	--	--	--	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	3	2	2	2	--	--	--	--	--

Subject Code: BMMPE604	**Subject Name: Material Processing**

Pre-Requisite:		Co-requisite:	

Module -I	[*8 Hours*]
Foundry: Sand casting, Introduction to patterns and foundry process, Sand binders and different additives, Sand testing.	

Module -II	[*8 Hours*]
Principles of Gating and Risering: Types of Gates and Risers, Solidification of castings, gating system design.	

Module -III	[*8 Hours*]
Continuous casting process: Precision investment casting, centrifugal casting, die casting, Casting defects.	

Module -IV	[*8 Hours*]
Welding and cutting: Introduction to gas welding, cutting, Arc welding and equipment's. TIG (GTAW) and MIG (GMAW) welding, resistance welding and thermit welding. Weldability, Newer Welding methods like plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding. Brazing and soldering, welding defects.	

Module –V	[*8 Hours*]
Plastic deformation of metals. Hot and cold working of metals, brief idea about different metal forming process.	

TEXT BOOK(S):

1.	P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.
2.	Kalpakjian, S., & Schmid, S. R. 2008. Manufacturing processes for engineering materials: Pearson Education

REFERENCE BOOK(S):

1.	Principles of Modern Manufacturing, by Mikell P. Groover,5th Edition SI Version
2.	Welding Metallurgy 2nd Edition by Sindo Kou, Wiley-Interscience
3.	Manufacturing processes and materials for engineers. Lawrence E.Doyle, Prentice-Hall

COURSE OUTCOMESS:	
CO1	Select appropriate Manufacturing Processing to manufacture any component.
CO2	Interpret foundry practices like pattern making, mold making, Core making and Inspection of defects.
CO3	Select appropriate Joining Processes to join the Workpiece,Design different sheet metal working processes.
CO4	Classify different plastic molding processes, Extrusion of Plastic and Thermoforming.
CO5	Implement the Knowledge of Gained Subject in Industry.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	1	3	3	1	1	1	1	3	1
CO2	1	1	3	1	3	3	1	1	1	1	3	1
CO3	1	1	3	1	3	3	1	1	1	1	3	1
CO4	1	1	3	1	3	3	1	1	1	1	3	1
CO5	1	1	3	1	3	3	3	2	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	1	1	3	1	3	3	1	1	1	1	3	1

Subject Code: BMMPE605	**Welding Technology**
Pre-Requisite:	Co-requisite:
Module -I	[*8 hours*]
Introduction: Principle, Theory and Classification of welding and other joining processes. Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes.	
Module -II	[*8 hours*]
Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage. The influence of these power sources on welding, metal transfer. Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process.	
Module -III	[*8 hours*]
Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges. TIG welding: Process details, power sources requirements, electrode sizes and materials, current carrying capacities of different electrodes, shielding gases, application of process.	
Module -IV	[*8 hours*]
Resistance welding: General principle of heat generation in resistance welding, application of resistance welding processes. Process details and working principle of spot, seam, and. projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages.	
Module –V	[*8 hours*]
Welding metallurgy of carbon and alloy steels, Cast irons, Stainless steels, Al- and Cu-based alloys. Weldability and Heat affected zones (HAZ). Welding defects and detection techniques. Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, their purposes and flux residue treatment.	
TEXT BOOK(S):	
1.	J F Lancaster, Allen and Unwin, Metallurgy of Welding.
2.	R L Little, Welding and Welding Technology, TMH
REFERENCE BOOK(S)	
1.	Sindo Kou “Welding Metallurgy,2nd Edition, John wiley and sons.
2.	R.S. Parmar, Welding Engineering and Technology, Khanna Publishers.

COURSE OUTCOMESS:	
CO1	Classify welding processes based on different industrial and commercial requirements.
CO2	Differentiate gas and electric arc welding processes and their use in the field of engineering.
CO3	Evaluate weld joints and its failure conditions and provide suitable solutions.
CO4	Explain the importance of welding metallurgy in developing best weld structures for practical purposeand usage.
CO5	Know the importance of alternative joining processes required in materials processing.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	3	1	1	---	---	1	---	3
CO2	2	1	2	1	1	1	1	---	---	1	---	3
CO3	2	1	2	1	1	1	1	---	---	1	---	3
CO4	2	1	2	1	2	1	1	---	---	1	---	3
CO5	3	1	3	1	1	1	1	---	---	1	---	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	1	2	1	1	1	1	---	---	1	---	3

Subject Code: BMMPE606		**Subject name: Failure Analysis**	
Pre-Requisite:	Material Testing	Co-requisite:	
Module -I			[8 hours]
	Causes & Sources of Failures, Methodology, Art of Questioning, Fractography: ductile versus brittle, Fractography: Fatigue, Creep, Stress Calculations, Fatigue Design Fractography: overload Calculations. Case studies related this topic.		
Module -II			[8 hours]
	Fracture Toughness, Creep, Wear, Rolling Contact Fatigue, Advanced Fractography, Case studies related this topic.		
Module -III			[8 hours]
	Non-Destructive Evaluation (NDE) Metallography, Introduction to Corrosion, Forms of Corrosion, Galvanic, Pitting, crevice corrosion etc.		
Module -IV			[8 hours]
	Failures in Polymers, Ceramics and Glass, Liquid Metal Embrittlement, Case studies related this topic.		
Module -V			[8 hours]
	Failures related to Casting, Welding, Metal working, Fasteners (screws bolts, rivets), Shafts and Gears, Sequencing, Case studies related this topic.		

TEXT BOOK(S):

1.	Handbook of Materials Modeling, Springer, 2005 - S. Yip (Ed)
2.	Numerical Methods for Engineers, New Age International (P) Limited, New Delhi, 1998 - Santosh K. Gupta

REFERENCE BOOK(S):

1.	K. M. Hangos and I. T. Cameron, "Process Modeling and Model Analysis", Academic Press:London, 2001.
2.	Rate Processes In Metallurgy by Mohanty, A. K.; PHI Learning.

COURSE OUTCOMESS:

CO1	Have information about the various factors that needs to be considered in material selection, design and the service environment.
CO2	Be able to recognize some of the basic features and characteristics of different failure mechanisms.
CO3	Be knowledgeable in the laboratory testing methods and procedures that can help determine the cause of the failures.
CO4	Be able to provide precisive solutions to the failure of engineering structures.

CO5	Have the basic ideas and necessities of doing case studies of failed components

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	1	2	3	2	2	3	2	1	3
CO2	2	3	2	3	2	2	2	3	2	2	2	2
CO3	3	2	2	2	3	2	3	2	2	3	2	3
CO4	1	2	2	2	2	2	1	3	2	2	3	2
CO5	2	2	2	2	3	2	3	2	2	2	3	2

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	2	2	2	2	2	2	2	2	2

Subject Code: BMMOE601		**Subject Name: Engineering Materials**	
Pre-Requisite:	Introduction to Physical Metallurgy	Co-requisite:	
Module -I			[8 hours]
	Introduction, Metals: the generic metals and alloys; iron-based, copper-based, nickel-based, aluminum-based and titanium-based alloys. Metal structures the range of metal structures that can be altered to get different properties: crystal and glass structure, structures of solutions and compounds, grain and phase boundaries, equilibrium shapes of grains and phases;		
Module -II			[8 hours]
	The light alloys where they score over steels, solution, age and work hardening; thermal stability; Alloy steel, solution strengthening, precipitation strengthening, corrosion resistance, and austenitic (f.c.c.) steels.		
Module -III			[8 hours]
	Introduction: Ceramics and glasses: the generic ceramics and glasses: glasses, vitreous ceramics, high technology ceramics. Cements and concretes, natural ceramics (rocks and ice), ceramic composites; Structure of ceramics, crystalline ceramics; glassy ceramics; ceramic alloys; ceramic micro-structures: pure, vitreous and composite; mechanical properties of ceramics high stiffness and hardness; poor toughness and thermal shock resistance; the excellent creep resistance of refractory ceramics.		
Module -IV			[8 hours]
	Introduction: Polymers and composites Polymers the generic polymers: thermoplastics, thermosets, elastomers, natural polymers; The structure of polymers giant molecules and their architecture; molecular packing: amorphous or crystalline.		
Module -V			[8 hours]
	Mechanical behavior of polymers how the modulus and strength depend on temperature and time, making giant molecules by polymerization; polymer “alloys”; Composites: fibrous, particulate and foamed how adding fibres or particles to polymers can improve their stiffness, strength and toughness; why foams are good for absorbing energy.		
TEXT BOOK(S):			
1.	Engineering Materials 1 by Michael F Ashby & David R H Jones		
2.	Engineering Materials 2 by Michael F Ashby & David R H Jones		
REFERENCE BOOK(S):			
1.	Physical Metallurgy; principles & practice, by V. Raghavan, PHI		
2.	Introduction to Physical Metallurgy by Sydney Avner, McGraw Hill.		

COURSE OUTCOMESS: Upon completion of the course, the students will be able to:	
CO1	Define the resulting configuration and potential applications of light alloys.
CO2	Analyze the crystallinity of a polymer and predict its effect on mechanical properties.
CO3	Write the effect of Tg on the mechanical properties of a polymer as a function of temperature.
CO4	Design a suitable sintering schedule for heat-treating ceramics and understand the effects of existing microstructural features.
CO5	Apply prior knowledge of materials science and engineering to composition-processing structure-properties-performance relationships for polymer composites and ceramic composites.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	3	3	3	3	--	--	--	--	--
CO2	2	3	3	3	3	3	2	--	--	--	--	--
CO3	2	2	2	3	3	3	2	--	--	--	--	--
CO4	2	3	3	3	3	3	2	--	--	--	--	--
CO5	2	3	3	3	3	3	2	--	--	--	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	3	3	3	3	3	2	--	--	--	--	--

Subject Code: BMMOE602	**Subject name: Modeling of Materials Processes**

Pre-Requisite:	Mathematics-I, Mathematics-II,	Co-requisite:	Iron Making

Module -I	[8 hours]
Solution of linear, non-linear algebraic equations, ordinary differential equations and related metallurgical problems, transport phenomena-based Modeling.	

Module -II	[8 hours]
Model formulation based on heat, mass and momentum transfer, governing equations and boundary conditions.	

Module -III	[8 hours]
Numerical solution of differential equations, process related numerical problems, Stress Analysis. Mesoscopic Modeling: CA based modeling.	

Module -IV	[8 hours]
Monte Carlo Simulation, application to metallurgical processes, Classical Molecular Dynamics Modeling and its applications in materials	

Module -V	[8 hours]
Optimization and control, Elements of modern artificial intelligence (AI) related techniques, Introduction to Genetic Algorithm and Artificial Neural Networks	

TEXT BOOK(S):

1.	Handbook of Materials Modeling, Springer, 2005 - S. Yip (Ed)
2.	Numerical Methods for Engineers, New Age International (P) Limited, New Delhi, 1998 - Santosh K. Gupta

REFERENCE BOOK(S):

1.	K. M. Hangos and I. T. Cameron, "Process Modeling and Model Analysis", Academic Press:London, 2001.
2.	Rate Processes In Metallurgy by Mohanty, A. K.; PHI Learning.

COURSE OUTCOMESS:

CO1	To analyze and demonstrate the fundamentals and basic concepts of mathematical modeling.
CO2	To fit in the linear, non-linear and differential mathematical knowledge in solving metallurgical problem.
CO3	To analyze different numerical problems to apply modelling technique and define CA based modeling
CO4	To apply Monte Carlo simulation in different metallurgical process.
CO5	To get knowledge about classical molecular dynamics modeling and its application.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	2	2	3	3	3	2	3
CO2	3	3	2	3	3	2	2	3	3	3	2	3
CO3	3	3	1	3	3	2	1	2	3	3	2	3
CO4	3	3	1	3	3	2	1	2	3	3	2	3
CO5	3	3	2	3	3	2	2	3	3	3	2	3

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	3	2	2	3	3	3	2	3

Subject Code: BMM06003	**Subject Name: Computational Laboratory**
Experiment-1	Basics of numerical mathematics Concept of physical domain and computational domain numerical, Integration, Initial value problems.
Experiment-2	Assumptions and limitations in numerical, Initial value problems, assumptions and limitations in numerical solutions, simulation, instrumentation and data acquisition systems.
Experiment-3	To draw a circle using MATLAB
Experiment-4	To solve a system of linear equations using MATLAB
Experiment-5	To solve an ODE using MATLAB
Experiment-6	To find out the standard deviation of a given set of values using MATLAB
Experiment-7	Curve fitting techniques using regression and interpolation
Experiment-8	Using MATLAB fit a linear curve for given set of data
Experiment-9	To draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structures
Experiment-10	To find out the lattice parameter from the XRD data of an element belonging to the cubic system using MATLAB
Experiment-11	To create your own design using MATLAB codes

COURSE OUTCOMES:	
CO1	Classify the different numerical solving methods with their inherent merits and limitations.
CO2	Analyze the obtained different data acquisition systems and their solutions and limitations
CO3	Develop the knowledge of the standard deviation of a given set of values using MATLAB.
CO4	Analyze & draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structures
CO5	Create your own design using MATLAB codes

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	3	3	2	3	3	2	3
CO2	3	3	1	3	3	2	2	2	3	3	2	3
CO3	3	3	2	3	3	3	2	2	3	3	2	3
CO4	3	3	2	3	3	2	2	2	3	3	2	3
CO5	3	3	2	3	3	2	2	3	3	3	2	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	3	2	2	2	3	3	2	3

Subject Code: BMM06004	**Subject Name: Material Processing Laboratory**
Experiment-1	To Study the Gas tungsten arc welding process
Experiment-2	To Study the Gas Metal arc welding process
Experiment-3	To Study the different zone in a welded joint.
Experiment-4	To Study the microstructure of a cast sample.
Experiment-5	To Study the microstructure of a forging sample.
Experiment-6	To Study the microstructure of a Rolled sample.
Experiment-7	To study the friction stir welding process
Experiment-8	To study the microstructure of a friction stir welded joint.
Experiment-9	To study the resistance spot welding process.
Experiment-10	To study the dilution and microstructure of weld cladding.

COURSE OUTCOMESS:	
CO1	Select appropriate Manufacturing Processing to manufacture any component.
CO2	Correlate the mechanical properties from microstructure.
CO3	Can operate a welding machine.
CO4	Select a proper process parameter to improve quality as well as strength.
CO5	Implement the Knowledge of Gained Subject in Industry.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	1	3	3	1	1	1	1	3	1
CO2	1	1	3	1	3	3	1	1	1	1	3	1
CO3	1	1	3	1	3	3	1	1	1	1	3	1
CO4	1	1	3	1	3	3	1	1	1	1	3	1
CO5	1	1	3	1	3	3	3	2	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	1	1	3	1	3	3	1	1	1	1	3	1

Subject Code: BMM06005	Subject name: Material Testing Laboratory
Experiment-1	Hardness Measurement: definition, various methods of measurements –
Experiment-2	Rockwell, Vickers, Brinell, – testing procedure, derivation of various expressions.
Experiment-3	Tension Testing: theory of testing, standard specimens, calculation of various engineering and true properties – yield strength, tensile strength, fracture strength, % elongation, % area reduction, resilience, toughness.
Experiment-4	Impact Testing: determination of Impact strength of metallic materials using Charpy test methods.
Experiment-5	Wear Testing: Conduct the Friction and Wear test of a given material
Experiment-6	Conduct the Ericson Cupping Test of a given material.
Experiment-7	Fatigue Testing: Study the principle of fatigue testing and construction of an S-N curve (stress level - number of cycles to failure) of the test samples provided.
Experiment-8	Creep Testing: Study of the principle of creep testing and determination of creep strength of the given sample.
Experiment-9	Compression testing of metallic material.
Experiment-10	Study the principle of Strain Ageing and Yield Point Phenomenon in metallic materials.
Laboratory Outcomes:	
CO1	Classify the different mechanical testing methods with their inherent merits and limitations.
CO2	Analyze the obtained mechanical properties in relevant to the nature of each material and use
CO3	This information as a tool for selecting suitable materials for engineering applications.
CO4	Ability to analyze the industrial problems along with appropriate boundary conditions.
CO5	Ability to develop steady and time dependent fracture mechanics calculations

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	3	3	2	3	3	2	3
CO2	3	3	1	3	3	2	2	2	3	3	2	3
CO3	3	3	2	3	3	3	2	2	3	3	2	3
CO4	3	3	2	3	3	2	2	2	3	3	2	3
CO5	3	3	2	3	3	2	2	3	3	3	2	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	3	2	2	2	3	3	2	3

SEVENTH SEMESTER

Subject Code: BMM07001		Subject name: Introduction to Surface Engineering	
Pre-Requisite:		Co-requisite:	
Module -I			[8hrs]
	Introduction, Surface dependent engineering properties, viz., Friction and wear, corrosion, fatigue, etc.; common surface-initiated engineering failures; mechanism of surface degradation; importance and necessity of surface engineering; classification and scope of surface engineering in metals, ceramics, polymers and composites, tailoring of surfaces of advanced materials.		
Module -II			[8hrs]
	Surface protection (Physical); surface modification (Chemical) techniques: classification, principles, methods, and technology.		
Module -III			[8hrs]
	Conventional surface engineering methods: carburising, nitriding, cyaniding, diffusion coating, hot dipping, galvanizing etc. Electrochemistry and electro-deposition; scope and application of conventional surface engineering techniques in engineering materials; advantages and limitations of conventional processes.		
Module -IV			[8hrs]
	Recent trend in surface engineering: physical/chemical vapor deposition; plasma spray coating; plasma assisted ion implantation.		
Module -V			[8hrs]
	Surface modification by directed energy beams like ion, electron and laser beams; energy transfer, novelty of the directed energy beams assisted surface modification techniques.		
TEXT BOOK(S):			
1	K. G. Budinski: Surface Engineering for Wear Resistance, Prentice Hall, New Jersey 1988.		
2	J. R. Davis: Surface Engineering for Corrosion and Wear Resistance, ASM International, Materials Park, Ohio, 2001.		
REFERENCE BOOK(S):			
1	Surface Engineering Processes and Applications by K.N.Strafford.		
2	Introduction to Surface Engineering by P.A.Dearnley.		

COURSE OUTCOMESS:	
CO1	Able to express the fundamental concept of surface engineering
CO2	Implement the principle of surface engineering on the different engineering materials
CO3	Evaluate the concept of conventional surface engineering methods to enhance material property
CO4	Analyze the recent surface engineering methods applied on different engineering materials
CO5	Demonstrate the advanced surface modifications through electron, ions and laser beams

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	1	2	3	3	2	1
CO2	3	2	2	3	3	2	3	2	3	3	2	1
CO3	3	2	2	3	3	2	3	2	3	3	2	1
CO4	3	2	2	3	3	2	3	2	3	3	2	1
CO5	3	2	2	3	3	2	3	2	3	3	2	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	3	3	3	3	3	2	2	2	1

Subject Code: BMM07002	Subject name: Materials Characterization
Pre-Requisite:	Basic idea about atomic structure, bonding, introduction to crystal structures, optics, Interference, diffraction
Module -I	[8 hours]
	Introduction to materials characterization & its importance, Fundamentals of Crystallography, levels of characterization (macro, meso and micro), Resolution, depth of field/focus, aberrations (spherical, chromatic and astigmatism) and its remedial measures
Module -II	[8 hours]
	Optical microscopy (OM) – Microscope construction and working, reflected/transmitted light microscope, theoretical and practical resolution of optical microscope, numerical aperture, principle of image formation, effective/empty magnification, Types of illumination - bright field, dark field, polarized light and phase contrast, applications of each type of illumination. Sample preparation for optical microscopy, features of an image.
Module -III	[8 hours]
	Introduction to scanning electron microscope (SEM), working and construction, advantages/disadvantages as compared to OM, types of electron gun and comparison between them. Electron - specimen interaction, imaging modes (secondary and backscattered), effect of spot size, apertures, accelerating voltage on SEM image, Everhart-Thornley detector, Robinson detector, solid state segmented detector, atomic number and topological contrast. Chemical analysis using SEM, EDS/WDS working principle, construction, resolution of EDS/WDS detector, advantages/disadvantages.
Module -IV	[8 hours]
	X-ray diffraction: Generation of X-rays, characteristic X-ray spectrum, Bragg's Law, Diffraction methods: Laue method, rotating crystal method, powder method, structural factor, applications of X-ray diffraction in materials characterization: determination of crystal structure, lattice parameter.
Module -V	[8 hours]
	Thermal analysis techniques & its Importance, principles and applications of differential thermal analysis (DSC), differential scanning calorimetry (DSC) and thermo gravimetric analysis (TGA). Brief idea of TEM: principle of operation, application. Introduction to advanced microscopic techniques.
TEXT BOOK(S):	
1.	Materials Characterization by Yang Leng, - 2nd Edition, Wiley-VCH Verlag GmbH & Co.
2.	Microstructural Characterization of Materials- D. Brandon and W.D. Kaplan, John Wiley and Sons, 2008.
REFERENCE BOOK(S):	
1.	P.J. Goodhew, F.J. Humphreys, and R. Beanland, Electron Microscopy and Analysis: 3rd Edition, Taylor and Francis, NY, 2001.

COURSE OUTCOMESS:	
CO1	Characterize the structures and chemistries of materials using traditional analytical experimental techniques.
CO2	Select the proper characterization techniques to solve problems in research and/or industry
CO3	Students will be able to understand the basic microscopy images of materials
CO4	Students will be able to read the basic spectra of materials characterizations and can characterize the chemical composition of materials.
CO5	Students will be able to understand correlation between Processing, microstructure, properties and performance analysis.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	1	3	2	1	3	3	1	3	3
CO2	3	1	3	1	3	2	1	3	3	1	3	3
CO3	3	1	3	1	3	2	1	---	---	1	3	3
CO4	3	1	3	1	3	2	1	---	---	1	3	3
CO5	3	1	3	1	3	2	1	---	---	---	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO11	PO11	PO12
Course	3	1	3	1	3	2	1	1	1	1	3	3

Subject Code: BMMPE701		**Subject name: Non-Ferrous Extractive Metallurgy**	
Pre-Requisite:		Co-requisite:	
Module -I			[8hrs]
	General principles of extraction of metals from oxides and sulphides; Mineral resources of non – ferrous metals in India; their production, consumption and demand; Future of non – ferrous metal industries in India, extraction of metals from Sulphide ores , pyrometallurgy extraction of Cu, Matte smelting; Converting; Refining; by-products recovery; recent developments; Continues copper production processes, hydrometallurgy of copper, extraction of Zn, Imperial Smelting Process, slag fuming process.		
Module -II			[8hrs]
	Extraction of Ni- pyro metallurgy and hydrometallurgy route, Extraction of Pb from base bullion, refining of base bullion Aluminimum: Bayer's process and factors affecting its operation; Hall – Heroult process: principle & practices, use of electrodes, anode effect.		
Module -III			[8hrs]
	Refining of Aluminimum; Alternative methods of Alumina and Aluminimum production-ALCOA process, ALCAN process, TOOTH process, Extraction of metals from oxide ores, extraction of Sn.		
Module -IV			[8hrs]
	Extraction of Mg, pidgeon process, magnotherm process, extraction of magnesium from sea water, extraction of Ti, kroll process, hunter process		
Module -V			[8hrs]
	Electro winning and Electro refining of metals: From aqueous salts (Cu, Ni, Au, and Ag); From fused salts (Al and Mg); Extraction of metal halides route, extraction of zirconium from Environmental pollution and its address related to various metal extraction processes in general.		
TEXT BOOK(S):			
1	Extraction of Non - Ferrous Metals by H.S. Ray, R. Sridhar& K.P. Abraham, Affiliated East West Press, New Delhi.		
2	Principles of Extractive Metallurgy, by T. Rosenquist, McGraw hill, 1974.		
3	Non-Ferrous Extractive Metallurgy – G B Gill John Wiley & Sons 1980.		
REFERENCE BOOK(S):			
1	Extractive Metallurgy of Copper - WGL Davln Port, U King, M Schelesinger and A.K. Biswas, Elsevier Science 2002.		
2	Metallurgy of Non-Ferrous Metals - WH Dennis.		
3	Nuclear Chemical Engineering - Manstion Bendict and Thomas H. Pigfort		

COURSE OUTCOMESS:	
CO1	Describe and explain processes and reactors for extraction and refining of metals and alloys
CO2	Explain processes based on a thermodynamic perspective and Awareness about modern extraction and refining techniques in production of different non-ferrous metal like Copper, Zinc, Aluminium, Titanium, Uranium, Thorium and Zirconium.
CO3	Describe and explain material and energy flows related to extraction of metals and alloys
CO4	Describe and explain ore treatment techniques and Different route for the extraction of metal
CO5	Environmental pollution and its address related to various metal extraction processes

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	2	1
CO3	3	2	1	3	1	3	2	3	2	3	3	-
CO4	3	3	3	3	3	3	2	3	3	3	3	3
CO5	3	1	3	3	1	3	3	3	2	3	3	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	2	2	3	2	3	3	3	3	3	3	2

Subject Code: BMMPE702	**Subject name: Thermo-mechanical Processing of Materials**

Pre-Requisite:		Co-requisite:	

Module -I	[---hrs]
General introduction, Microstructure and Properties: Solidification, Interfaces, Properties: Physical Properties, Chemical Properties, Mechanical Properties, Electrical Properties, Magnetic Properties, Thermal Properties, Plasticity: Introduction, Fundamentals, Flow Stresses and Strains, Generalized Stresses and Strains, Yield Criteria, Stress–Strain Relations, Plastic Anisotropy, Fracture, Failure Mechanisms	

Module -II	[ ]
Work hardening Mechanisms and theories: Introduction, Basic Microscopic Mechanisms, Low Temperature, Influence of Alloying Elements, Microscopic Hardening Laws, Hot Deformation, Flow Stresses, Hot Deformation Microstructures, Softening mechanisms: Introduction, Recovery, Recovery Mechanisms, Recovery Kinetics, Structural Changes During Recovery, Extended Recovery	

Module -III	[ ]
Continuous Recrystallization, Sources of Recrystallized Grains, Recrystallization Mechanisms, Recrystallization Kinetics, Role of Second Phase, Dynamic Recrystallization, Grain Coarsening, Theories of Grain Coarsening, Factors Affecting Grain Growth, Alternative deformation mechanisms: Introduction, Deformation Mechanism Maps,	

Module -IV	[ ]
Creep, The Creep Curve, Creep Mechanisms, Influence of the Microstructure, Grain Boundary Sliding, GBS and Superplasticity, Conditions for Superplasticity, Twinning, Introduction, Twinning Mechanism, Influence of Some Parameters on Twinning, Twinning and Deformation, Phase transformations during thermo-mechanical processing	

Module -V	[ ]
Textural developments during thermo-mechanical processing, Residual stress modeling of texture and microstructural evolution, Forming Techniques, Defects in TMP, Physical Simulation of Properties, Case studies: Thermo mechanical processing of steel, aluminum, magnesium, titanium and other advanced alloy systems, recent trends in thermo mechanical processing, new Technologies	

TEXT BOOK(S):

1.	Recrystallization and related phenomena - F.J. Humpherys and M. Hatherly
2.	Thermo-mechanical Processing of Metallic Materials - Bert Verlinden, Julian Driver, Indradev Samajdar, Roger D. Doherty

REFERENCE BOOK(S):

1.	Mechanical Behavior of Materials, Cambridge University Press, UK, 2005 - William F. Hosford

2.	Introduction to Dislocations, Printed and bound in Great Britain, UK, 2011 - D. Hull and D. J. Bacon

COURSE OUTCOMESS:	
CO1	Demonstration of different testing techniques and their relationships for homogenous, isotropic materials.
CO2	Calculate and predict the necking phenomena and distribution of stresses occurs in metals and alloys.
CO3	Evaluation of effect of gauge length, effect of strain rate and temperature on flow properties, machine stiffness in tensile testing system in tensile testing of a materials.
CO4	Basic knowledge of fracture mechanics, fracture toughness and KIc plane-strain toughness for design and application aspect.
CO5	Basic knowledge of fatigue test, creep test and non-destructive testing.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	1	2	3	2	2	3	2	1	3
CO2	2	3	2	3	2	2	2	3	2	2	2	2
CO3	3	2	2	2	3	2	3	2	2	3	2	3
CO4	2	2	3	2	2	2	1	3	2	2	3	2
CO5	2	2	2	2	3	2	3	2	2	2	3	2

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	2	2	2	2	2	2	2	2	2

Subject Code: BMMPE703	**Subject Name: X-ray Diffraction**
Pre-Requisite:	
Module -I	[8 hours]
Basics of X-rays, Production and detection of X-rays, Properties of X-Rays; continuous and Characteristic- X-Rays, absorption, filter.	
Module -II	[8 hours]
Geometry of crystals, Reciprocal lattice, stereographic projection, point groups and space groups, Bragg's law derivation, Diffraction Methods: Laue Method, Powder method, Diffraction relationship with reciprocal space.	
Module -III	[8 hours]
X-ray scattering, Intensities of the diffracted beam, Factors affecting intensities of X-ray peaks-continuation Diffractometer measurements, Intensity of diffracted beam.	
Module -IV	[8 hours]
Determination of crystal structure, Precise lattice parameter determination, Phase diagram determination, Order-disorder transformation, Qualitative phase analysis	
Module -V	[8 hours]
Chemical analysis by X-ray fluorescence, Chemical analysis by X-ray absorption, Particle size determination by X-rays, Texture determination by X-rays, Stress analysis by X-rays, Determination of single crystal orientation by X-rays	
TEXT BOOK(S):	
1.	B.D.Cullity, "Elements of.Ray Diffraction", Third Edition, Addison Wesley Publishing C ompany, Inc., Reading, 2004
2.	Structures of Metals by Charles Barrett & T. B. Massalski by McGraw Hills Publishers
REFERENCE BOOK(S):	
1.	Physical Metallurgy by R.W .Cahn & Peter Hassan Vol I to Vol IV
2.	Modern Physical Metallurgy by R. E. Smallman

COURSE OUTCOMESS:	
CO1	Demonstrate the principles of X-ray Diffractrometer (XRD)
CO2	Determine crystal structure, lattice parameter, phase identification, solvus line estimation and residual stress analysis using XRD
CO3	Apply the principles and knowledge of the capabilities and limitations of different types of analysis covered in the course.
CO4	Select appropriate methods for particular problems and have a good understanding of

	the data obtained in XRD.
CO5	Able to apprehend the behavior and use of X-ray in material characterization

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	3	3	3	1	---	1	---	1	2
CO2	3	3	1	3	3	3	1	---	1	---	1	2
CO3	3	3	1	3	3	3	1	---	1	---	1	2
CO4	3	3	1	3	3	3	1	---	1	---	1	2
CO5	3	3	1	3	3	3	1	---	1	---	1	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	1	3	3	3	1	---	1	---	1	2

Subject Code: BMMPE704	FABRICATION OF MATERIALS

Pre-Requisite:		Co-requisite:	

Module -I	[*8 hours*]
Foundry: Introduction to patterns and foundry process, Sand binders and different additives, Sand testing and melting furnaces for ferrous and non-ferrous metals such as cupola, Induction furnace, Arc furnace & Resistance furnace	

Module -II	[*8 hours*]
Principles of Gating and Risering: Feeding characteristics of alloys, Types of Gates and Risers, Solidification of castings.	

Module -III	[*8 hours*]
Continuous casting process: Precision investment casting, centrifugal casting, die casting, Casting defects.	

Module -IV	[*8 hours*]
Welding and cutting: Introduction to gas welding, cutting, Arc welding and equipment's. TIG (GTAW) and MIG (GMAW) welding, resistance welding and thermit welding. Weldability, Newer Welding methods like plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding. Brazing and soldering, welding defects.	

Module –V	[*8 hours*]
Plastic deformation of metals. Hot and cold working of metals, brief idea about different metal forming process	

TEXT BOOK(S):

1.	P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill, 1980.
2.	Kalpakjian, S., & Schmid, S. R. 2008. Manufacturing processes for engineering materials: Pearson Education

REFERENCE BOOK(S):

1.	Principles of Modern Manufacturing, by Mikell P. Groover,5th Edition SI Version
2.	Manufacturing processes and materials for engineers. Lawrence E.Doyle,, Prentice-Hall

COURSE OUTCOMESS:	
CO1	Select appropriate Manufacturing Processing to manufacture any component
CO2	Interpret foundry practices like pattern making, mold making, Core making and Inspection of defects
CO3	Select appropriate Joining Processes to join the Workpiece,Design different sheet metal working processes.
CO4	Classify different plastic molding processes, Extrusion of Plastic and Thermoforming.
CO5	Implement the Knowledge of Gained Subject in Industry

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	3	1	3	3	1	1	1	1	2	1
CO2	1	1	3	1	3	3	1	1	1	1	2	1
CO3	1	1	3	1	3	3	1	1	1	1	2	1
CO4	1	1	3	1	3	3	1	1	1	1	2	1
CO5	1	1	3	1	3	3	3	2	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	1	1	3	1	3	3	1	1	1	1	2	1

Subject Code: BMMOE701	**Subject Name: Crystallography**
Pre-Requisite:	Basic idea about crystal structure
Module -I	[9 hrs]
Introduction: The Lattice, Bravais lattice, Directions, Planes, Crystal Structure, crystal system, point group, symmetry operation: translation, rotation, symmetry plane, degree of symmetry, crystal basis, unit cell, face-centered cubic, simple cubic, body-centered cubic, hexagonal close-packed, Weiss Zone Law, Point Group Symmetry.	
Module -II	[7 hrs]
Stereographic projections: Introduction, Utility of stereographic projections, construction and characteristics, Stereographic representation of point groups.	
Module -III	[8 hours]
Low symmetry system: Stereograms for Low Symmetry Systems, Hexagonal System, Space Groups: Screw axes and glide planes Pyrite, Cementite, Shape of Precipitates.	
Module -IV	[7 hrs]
The Reciprocal Lattice and Diffraction: The Reciprocal Basis, Crystallography of diffraction, Intensities, Diffraction from Thin Crystals.	
Module -V	[9 hrs]
Deformation and Texture, Slip in a Single-Crystal, Orientation Distribution Functions Interfaces and orientation relationship, Symmetrical Tilt Boundary, Coincidence Site Lattices Crystallography of Martensitic Transformations, The Shape Deformation, Bain Strain Martensitic transformations.	
TEXT BOOK(S):	
1.	Geometry of crystals, polycrystals and phase transformations, 2017, H. K. D. H. Bhadeshia.
2.	Crystallography and crystal defects, 3rd edition 2020, A. Kelly and K. M. Knowles
REFERENCE BOOK(S):	
1.	M. Buerger, Elementary Crystallography, MIT Press.
2.	B.D. Cullity and S.R. Stock, Elements of X-Ray Diffraction (3rd Edition), Prentice Hall

COURSE OUTCOMESS:	
CO1	Students will be able to identify the particular type of crystal structure and know their application
CO2	Students will be able to describe complicated structures.
CO3	Students will be able to sketch Miller indices of crystallographic planes
CO4	Students will be able to formulate Bragg's diffraction formula which is useful in determination of crystal structure using X-ray diffraction technique.
CO5	Students will be able to envisage the importance of crystallography in metallurgical field.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	3	1	3	3	1	3	3	1	3	3
CO2	3	1	3	1	3	3	1	---	3	1	3	3
CO3	3	1	3	1	3	3	1	---	3	---	3	3
CO4	3	1	3	1	3	3	1	---	3	---	3	3
CO5	3	1	3	1	3	3	1	3	3	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO11	PO11	PO12
Course	3	3	3	3	3	3	3	1	3	1	6	3

Subject Code: BMMPE702	**Introduction to Nano Science & Nano Technology**
Pre-Requisite:	Co-requisite:
Module -I	[*8 Hours*]
Introduction to Nano science and nanotechnology, Definition, Background and Development of nanotechnology, Basic ideas about Atoms, Molecules and structure. Length scale and properties of matter. Techniques for Synthesis and preparation of Nanostructured materials, Concept of Bottom Up and top down approach of nanotechnologies	
Module -II	[*8 hours*]
Nanolithography, mask and resist technology, electron beam lithography, dip pen lithography, mechanical milling, Self- assembly, Sol – Gel method, Chemical Vapor deposition (CVD)/PECVD etc.	
Module -III	[*8 hours*]
Measurement and Characterization of Nanocrystal line Materials: Structure (Atomic structure, Particles size determination, surface structure), Microscopy scanning probe microscopy, principle of working of STM and AFM, Electron microscopy, resolution vs. magnification issue, SEM, Field Ion, high resolution TEM.	
Module -IV	[*8 hours*]
Carbon nanostructure: Introduction to Carbon Molecules, Carbon Clusters (C60, Bucky ball), Carbon Nanotube –Type of Carbon Nanotube, Formation of Carbon Nanotube and properties and Application of Carbon Nanotube.	
Module -V	[*8 Hours*]
Cutting age areas of application of Nanotechnology; state of art of the nano technology, current areas of research, scope and opportunity of the technology, some special topics on application of nanomaterials.	
TEXT BOOK(S):	
3.	Introduction to Nanotechnology. Charles P Pool. Frank J Owens, JhonWiely and Son Publication, New Jersey, 2003
4.	Introduction to Nanoscience and Nanotechnology, K K Chattopadhyay and A. N Banerajee, PHI, Learning Privet Limited, New Dehli, 2010
REFERENCE BOOK(S):	
3.	Introductory Nanoscience: Physical and Chemical Concepts by Masaru Kuno
4.	A Textbook of Nanoscience and Nanotechnology by Pradeep T.

COURSE OUTCOMESS:	
CO1	Students can incorporate the knowledge in synthesizing and developing a new Nano

	materials
CO2	Students can analyze the advantages and disadvantages between bottom up and top down approach for synthesis Nano material's
CO3	Student can able to characterize different Nano materials using various advanced techniques such as TEM
CO4	Students can able to analyze the various properties of material at different length scale
CO5	Student can define the different types of Nano materials and their suitable application

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	3	3	3	2	-	-	-	2	1
CO2	2	2	1	3	3	3	2	-	-	-	1	1
CO3	2	2	2	2	2	2	2	-	-	-	1	2
CO4	2	2	2	2	2	2	2	-	-	-	1	1
CO5	1	1	3	3	3	2	2	-	-	-	1	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	5	3	3	2	2	-	-	-	1	1

Subject Code- BMM07003	**Laboratory Name: Materials Characterization Laboratory**
Pre-Requisite:	Basic idea about atomic structure, bonding, introduction to crystal structures, optics, Interference, diffraction
Experiment 1	Micro structural analysis of a given (Ferrous & Nonferrous) sample using Optical Microscope
Experiment 2	Study of electron microscope (SEM &TEM)
Experiment 3	Determination of interlamellar spacing of pearlite using SEM
Experiment 4	Study of precipitation hardening of Al-Cu alloy using SEM
Experiment 5	Compositional Analysis of an unknown sample using EDX Study of electron microscope (SEM &TEM)
Experiment 6	Determination of phase transformation temperature of given sample using DSC
Experiment 7	Determination of melting temperature of a unknown metal using DTA
Experiment 8	Indexing of XRD Pattern of a given sample
Experiment 9	Determination of lattice parameter of a given sample
Experiment 10	Determination of crystallite size of a powdered sample using XRD
Experiment 11	Determination of lattice strain of a deformed sample using XRD
COURSE OUTCOMESS:	
CO1	Understand the principles and knowledge of the capabilities and limitations of different types of analysis covered in the course.
CO2	Select appropriate methods for particular problems and have a good understanding of the data obtained.
CO3	Describe the principles of operation and uses of optical microscopy and Interpret metallographic images.
CO4	Able to realize the importance of DSC and DTA characterization in phase transformation
CO5	Able to apprehend the behavior and use of X-ray in material characterization

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	1	2	2	2	1	3	3	2	3
CO2	3	3	3	3	3	3	3	2	3	3	2	3
CO3	3	2	3	3	2	2	2	1	3	3	2	3
CO4	3	2	3	2	2	2	2	1	3	3	2	3
CO5	3	2	3	2	2	2	2	1	3	3	2	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO11	PO11	PO12
Course	3	2	3	2	2	2	2	1	3	3	2	3

EIGHTH SEMESTER

Subject Code: BMMPE801	**Subject Name- Advanced Materials**
Pre-Requisite:	Basic idea about different types of materials and their properties
Module -I	[8 hours]
Electronic Polymers, Organic electronics, Organic semiconductor, Printed electronics, Organic LED.	
Module -II	[8 hours]
Nanostructures, Nanomaterials, Nanocomposites. Biomaterials: Metallic biomaterials like 316L stainless steel, Co-Cr Alloys, Titanium Ti6Al4V.	
Module -III	[8 hours]
Ceramic biomaterials like Alumina, Zirconia, Carbon Hydroxy-apatite, Polymeric biomaterials like Ultra high molecular weight polyethylene, Polyurethane Smart Materials: Piezoelectric materials, Shape memory alloys and shape memory polymers.	
Module -IV	[8 hours]
High Performance Alloys: Nickel super alloys, Ti alloys, Al-Li alloys, Hastelloy, Inconel, Monel, Nitronic, Cobalt based alloys and commercially available pure nickel alloys. Functional and Engineering Ceramics: diverse applications as cutting tools, mobile phone microwave devices, polycrystalline diamond and fuel cells.	
Module -V	[8 hours]
Hybrid Materials: Design, Synthesis and Properties of hybrid materials created by blending disparate materials such as plastics with metals. Processing of Advanced Materials: Superplastic, spray forming, rapid solidification. Materials selection and design.	
TEXT BOOK(S):	
1.	Mark J. Hampden-Smith Wiley-VCH, Chemistry of Advanced Materials: An Overview Leonard V. Interrante, 1st edition (1997) ISBN-10: 0471185906 ISBN-13: 978-0471185901
2.	R E Smallman, A. H. W., Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN: 0750669063.
REFERENCE BOOK(S):	
1.	Nanostructures And Nanomaterials: Synthesis, Properties And Applications by Guozhong Cao

COURSE OUTCOMESS:	
CO1	Visualize the recent the world of miniaturization.
CO2	Understand the recent nanotechnology applications and its advantages.
CO3	Integrate different synthesis process which may lead to develop new nanostructures with improved properties.
CO4	Different alloy system for diverse application.
CO5	Describe processing of advanced materials.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	1	3	3	3	1	---	---	1	3
CO2	2	2	3	1	3	3	3	1	---	---	1	3
CO3	3	3	3	3	3	3	3	1	---	---	1	3
CO4	2	2	3	1	3	3	3	1	---	---	1	3
CO5	2	2	3	1	3	3	3	1	---	---	1	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO11	PO11	PO12
Course	2	2	3	1	3	3	3	1	---	---	1	3

Subject Code: BMMPE802		**Subject Name: Finite Element Method**	
Pre-Requisite:		Co-requisite:	
Module -I			[8]
	Objective of the Course, Basic Steps in FEM Formulation, General Applicability of the Method; Variational Functional, Ritz Method, Variational FEM: Derivation of Elemental Equations, Assembly, Imposition of Boundary Conditions, Solution of the Equations, 1 -D Elements, Basis Functions and Shape Functions, Convergence Criteria, h and p Approximations		
Module -II			[8]
	Natural Coordinates, Numerical Integration, Gauss Elimination based Solvers, Computer implementation: Pre-processor, Processor, Post-processor, Alternate Formulation: Weighted Residual Method, Galerkin Method; Problems with C1 Continuity: Beam Bending, Connectivity and Assembly of C1 Continuity Elements		
Module -III			[8]
	Variational Functional; 2-D Elements (Triangles and Quadrilaterals) and Shape Functions, Natural Coordinates, Numerical Integration, Elemental Equations, Connectivity and Assembly, Imposition of Boundary Conditions, Axisymmetric (Heat Conduction) Problem,		
Module -IV			[8]
	Plane Strain and Plane Stress Solid Mechanics Problems, Sub-parametric, Iso-parametric and Super-Parametric Elements; Elements with C1 Continuity, Free Vibration Problems, Formulation of Eigen Value Problem, FEM Formulation,		
Module -V			[8]
	Time-dependent Problems, Combination of Galerkin FEM and FDM (Finite Difference Method), Convergence and Stability of FD Scheme, Problems with Material Non-linearity, Direct Solution Technique		
TEXT BOOK(S):			
1.	Concepts and applications of Finite element analysis: Cook, Malkus and Plesha, John Wiley and Sons, 2003.		
2.	T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, Second Edition, Prentice-Hall, 1997		
REFERENCE BOOK(S):			
1.	W. L. Luyben, Process Modelling, Simulation and Control for Chemical Engineers, McGraw Hill, 1990.		
2.	Hussain and K. Gangaiah, Optimisation Techniques for Chemical Engineers, Macmillan, 2001		

COURSE OUTCOMESS:	
CO1	Solve problems related to engineering applications by modeling.
CO2	Formulate model related to heat, mass and momentum transfer.
CO3	Use artificial neural network to predict the chemical and physical behavior of different alloys produced by different synthesis process.
CO4	Solve the real time problems in hand
CO5	Got the knowledge of approximation used in real time problems

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	1	2	3	2	2	3	2	1	3
CO2	2	3	2	3	2	2	2	3	2	2	2	2
CO3	3	2	2	2	3	2	3	2	2	3	2	3
CO4	2	2	3	2	2	2	1	3	2	2	3	2
CO5	2	2	2	2	3	2	3	2	2	2	3	2

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	2	2	2	2	2	2	2	2	2

Subject Code: BMMPE803		**Subject Name: Modelling and Simulation**	
Pre-Requisite:	Material Science, Deformation Behavior of Materials, Transport Phenomena	Co-requisite:	Mathematical Modelling & Simulation,

Module -I	[8 hours]
Introduction to the computational approach to Materials Science and Engineering: Model classification. Basic modeling procedure. Classification of materials science processes and physical phenomena. Length scales and the corresponding modeling techniques.	

Module -II	[8 hours]
Diffusion based phenomena: Mass and Heat transfer by diffusion. Various systems where these are important. Basic heat and mass transfer differential equations. Their formulation into discretized algebraic equations and solution using Finite Difference Method. Analyzing the effect of various kinds of boundary conditions.	

Module -III	[8 hours]
Microstructure modeling - Macro-scale (Spinodal decomposition): Quasi-chemical model of solutions, nucleation versus spinodal mechanisms of phase separation, Cahn-Hilliard equation as a modification of classical diffusion equation with the inclusion of gradient energies, spectral implementation for numerical solutions of Cahn-Hilliard equation.	

Module -IV	[8 hours]
Microstructure modeling - Molecular-scale - Calculating diffusivities/mobilities: Mechanisms of diffusion, vacancy diffusion in substitutional solid solutions, Molecular dynamics (MD) simulations, constant temperature MD simulations, vacancy diffusion in forced Lennard-Jones system using constant temperature MD	

Module -V	[8 hours]
Mechanical behavior - Dislocation dynamics: Looking at plastic deformation as a result of collective behaviour of dislocation motion and interactions. Simulating dislocation dynamics as a function of orientation.	

TEXT BOOK(S):

1.	K. M. Hangos and I. T. Cameron, "Process Modeling and Model Analysis", Academic Press:London, 2001.
2.	R. Aris, "Mathematical Modelling Techniques", Dover:New York, 1994.

REFERENCE BOOK(S):

1.	Mechanical Metallurgy by G.E. Dieter, McGraw Hill Book Company.
2.	Rate Processes In Metallurgy by Mohanty, A. K.; PHI Learning.

COURSE OUTCOMESS:	
CO1	Analyze different modelling techniques and incorporate the suitable one in material science.
CO2	Analyze and apply the suitable modelling technique in heat and mass transfer process.
CO3	Analyze and incorporate the microstructural modelling in a macroscale.
CO4	Analyze and incorporate the microstructural modelling in a microscale.
CO5	Analyze and incorporate the suitable simulation technique to simulate the dislocation activities.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	2	2	3	3	3	2	3
CO2	3	3	2	3	3	2	2	3	3	3	2	3
CO3	3	3	1	3	3	2	1	2	3	3	2	3
CO4	3	3	1	3	3	2	1	2	3	3	2	3
CO5	3	3	2	3	3	2	2	3	3	3	2	3

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	3	2	2	3	3	3	2	3

Subject Code: BMMPE804	**Numerical Methods in Engineering**

Pre-Requisite:		Co-requisite:	

Module -I	[*8 hours*]

Sources of errors, Approximation and Errors in computing: Introduction, Significant digits, Inherent error, Rounding error, Truncation error, Absolute and relative error, Error propagation.

Module -II	[*8 hours*]

Roots of non-linear Equations and solution of system of Linear Equations: Bisection method, False position Method, Newton-Raphson Method, fixed – point iteration, Muller's method for complex and multiple roots, convergence of Bisection, Newton- Raphson's and False position methods, Gauss Elimination method by pivoting, Gauss – Jordan method, Iterative methods: Gauss-Jacobi and Gausss - Seidel methods, Relaxation method.

Module -III	[*8 hours*]

Difference Operators & Interpolation: Forward and Backward difference operators and table, Interpolation with equidistant point, Lagrange Interpolation Polynomial, Newton Interpolating Polynomial using divided Difference Table.

Module -IV	[*8 hours*]

Numerical Differentiation and Integration: Differentiating continuous functions, differentiating tabulated functions, Higher order derivatives, Richardson's Extrapolation, Newton – cotes integration formula, Trapezoidal rule, Simpson's rule.

Module –V	[*8 hours*]

Numerical Solution of Ordinary and Partial Differential Equations: Taylor series method, Euler and modified Euler method, Runge Kutta methods, Finite differences approximations of partial derivatives

TEXT BOOK(S):

1.	B.S. Grewal, "Numerical Methods in Engineering & Science", Khanna Publication, Ed. 9th..
2.	Santosh K. Gupta: Numerical Methods for Engineers, New Age International (P) Limited, New Delhi, 1998.

REFERENCE BOOK(S):

1.	Numerical Methods That Work by Forman S. Acton.
2.	Computational Partial Differential Equations by Hans P. Langtangen.

COURSE OUTCOMESS:

CO1	Students will be aware of the use of numerical methods in scientific computing.
CO2	Students will become familiar with calculation and interpretation of errors in numerical methods

CO3	Students will become familiar with numerical interpolation and approximation of functions.
CO4	Students will become familiar with familiar with numerical solution of ordinary differential equations.
CO5	Students will become familiar with use of optimization techniques in solving engineering problems.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	1	3	1	1	1	1	3	1
CO2	3	3	3	1	1	3	1	1	1	1	3	2
CO3	3	3	3	3	2	3	1	1	1	1	3	2
CO4	3	3	3	3	2	3	2	1	1	1	3	2
CO5	3	3	3	3	3	3	3	2	1	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	2	2	3	2	1	1	1	3	2

Subject Code: BMMPE805	Subject Name: Corrosion and Degradation of Materials
Pre-Requisite:	Basic idea about different types of materials and their properties
Module -I	[8 hours]
Introduction, importance of corrosion study, factor affecting corrosion, Difference between dry and wet corrosion, corrosion rate expressions, Different forms of corrosion-uniform attack, galvanic corrosion and its characteristic, E.M.F Series and Galvanic Series, crevice corrosion and its mechanism, Selective leaching, dezincification.	
Module -II	[8 hours]
Pitting corrosion and its mechanism, Intergranular corrosion, sensitization, weld decay corrosion cracking, stress corrosion cracking -their characteristic features, causes and remedial measures.	
Module -III	[8 hours]
Corrosion fatigue, Hydrogen Damage-Sources, Types of damage, Liquid metal attack -liquid metal embrittlement, preventive measures Principles of corrosion prevention-material selection control of environment, changing composition, microstructure, design.	
Module -IV	[8 hours]
Use Inhibitors and its type, Cathodic protection, impressed current cathodic protection, Sacrificial anode, anodic protection, coatings and its type. Corrosion testing methods.	
Module -V	[8 hours]
Introduction to high temperature corrosion, Pilling- Bedworth ratio, electrochemical principles of corrosion-cell analogy concept of single electrode potential, reference electrodes polarization, passivity.	
TEXT BOOK(S):	
1.	M. G. Fontana: Corrosion Engineering, third edition, Mc Graw Hill International, 1987.
2.	U. K. Chatterjee, S. K. Bose and S. K. Roy: Environmental Degradation of Metals, Marcel Dekker, 2001.
REFERENCE BOOK(S):	
1.	Corrosion and Environmental Degradation by Michael Schütze , Robert W. Cahn Peter Haasen , E. J. Kramer
2.	Corrosion handbook by Gerhard Kreysa and Michael Schütze

COURSE OUTCOMESS:	
CO1	apply fundamental knowledge and concepts in corrosion and List various atmospheres responsible for corrosion.
CO2	Classify various corrosion forms and the mechanisms involved.
CO3	solve numerical and problems on corrosion
CO4	Calculate corrosion rate using Tafel extrapolation and linear polarization techniques and select, test materials and apply corrosion prevention methods
CO5	Compare high temperature metal-gas reactions and corrosion of metals at high temperature in atmospheres such as sulphur dioxide, chlorine etc

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	3	3	3		3
CO2	3	3	3	3	2	3	2	1	3		3	1
CO3	3	3	3	3	3	3	3	3		2	3	2
CO4	3	3	3	3	3	2	2	1	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	1	3	3

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	3	3	3	3	2	2	2	2	2

Subject Code: BMMPE806	**Subject Name: Bio Materials**
Pre-Requisite:	Co-requisite:
Module -I	[8 hours]
Introduction, importance Properties requirement of Biomaterials and its applications, Properties requirement of Biomaterials and its applications, Bioactive, Bioinert and Bioresorable Biomaterials, Biocompatibility and its types	
Module -II	[8 hours]
Difference between Biomaterials and biologicals materials, Science of Biomaterials, selections of Biomaterials, Processing of Biomaterials, Methods for testing of biocompatibility, Evaluation of biocompatibility	
Module -III	[8 hours]
In Vitro Testing, In Vivo Testing, Tissue response Biomaterials, Assessment of biocompatibility, Biomaterials used in different metals, Stainless steel as Biomaterial application and its advantages, Properties and synthesis of Co-Cr alloy, Advantage and application of Co-Cr alloy	
Module -IV	[8 hours]
Titanium as Biomaterials application and its Advantage, Heat treatment to change the microstructure of titanium, Properties and phases of Shape memory alloys, Ceramics, applications Ceramics materials and its application	
Module -V	[8 hours]
Types of Bio-ceramics – Tissue Attachment, Processing of Porous Ceramics, Bioactive Glasses and Glass-Ceramics, Resorbable Ceramics and its applications, Polymer as Biomaterial, Surface modification of implant materials Electrostatic spraying technique, Plasma spraying technique, hard tissue replacement.	
TEXT BOOK(S):	
1.	J.B. ParkandJ. D. Boonzino, Biomaterials, Principles and application, CRC Press, 2002
2.	RE Smallman, A.H. W. Butterworth-Heinemann, Physical Metallurgy and Advanced Materials, Seventh Edition, 2007, ISBN:0750669063
REFERENCE BOOK(S):	
1.	Biomaterials by Park, Joon, Lakes, R. S.
2.	Biomaterials Edited By Joon B. Park and Joseph D. Bronzino

COURSE OUTCOMESS:	
CO 1	Analyse the common use biomaterials as metals, ceramics and polymers and its chemical structure, properties and morphology

CO 2	describe general structure and function of cells, extracellular matrix and tissue.
CO 3	explain methods to modify surfaces of biomaterials and choose material for desired biological response.
CO 4	Devlop interactions between biomaterials, proteins and cells and also able to express the interaction between biomaterial and tissue for short term and long-term implantations, distinguish between reactions in blood and in tissue.
CO 5	apply and account for methods to characterise interactions between materials and tissue.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	3	3	3	2	3	1	3
CO2	3	3		3	1	3	3		3	2	3	
CO3	3	3	2	1	3	3	3	3	3	1	3	2
CO4	3	3	3	3	3	3	3	1	1		1	
CO5	3	3	3	3	3	3		2	3	3	2	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	2	3	3	3	2	2	2	2	2	1

Subject Code: BMMPE807	**Subject Name: Non-Metallic Materials**
Pre-Requisite:	Co-requisite:
Module -I	[8 hours]
Classification of non-metallic materials. Rubber: Properties, processing and applications.	
Module -II	[8 hours]
Plastics: Thermosetting and Thermoplastics, Applications and properties. mechanical behavior of polymer: Stress–Strain Behavior, Macroscopic Deformation, Viscoelastic Deformation, Fracture of Polymers.	
Module -III	[8 hours]
Ceramics: types and applications of ceramics, properties, Glasses, Glass-Ceramics, Clay Products, Refractories, Abrasives, Cements, Advanced Ceramics and applications. Fabrication and processing of ceramics Fabrication and Processing of Glasses and Glass-Ceramics, Fabrication and Processing of Clay Products, Powder Pressing, Tape Casting.	
Module -IV	[8 hours]
Adhesives: Properties and applications. Optical fibers: Properties and applications.	
Module -V	[8 hours]
Composites, Particle-reinforced composites, Influence of Fiber Length, Influence of Fiber Orientation and Concentration, The Fiber Phase, The Matrix Phase, Polymer-Matrix Composites, Metal-Matrix Composites, Ceramic-Matrix Composites, Carbon–Carbon Composites, Hybrid Composites, Processing of Fiber-Reinforced Composites.	
TEXT BOOK(S):	
1.	Materials Science and Engineering by William D. Callister.
2.	Handbook of Materials Science :Nonmetallic Materials & Applications By Charles T. Lynch
REFERENCE BOOK(S):	
1.	Introduction to Non-metallic materials: Easy course for everything worth-knowing for non-metallic materials (Materials and elements) Kindle Edition by Ben T Atban
2.	Nonmetallic Materials and Composites at Low Temperatures by Hartwig, Günther, Evans, David

COURSE OUTCOMES:	
CO1	classify of non-metallic materials in terms of application.
CO2	able to classify properties and application of plastic material with other.

CO3	Introduce various traditional and advanced ceramic products and industries that manufacture them
CO4	Familiarize the ceramic products which the students come across in their day to day life.
CO5	Able to classify composite material in term of their application and industrial uses.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	3	3	3	3	1	3	---	3
CO2	3	3	1	3	2	1	2	---	3	3	3	---
CO3	3	2	2	3	3	2	3	1	---	---	1	3
CO4	1	1	3	2	1	3	---	3	2	1	3	1
CO5	3	3	2	---	3	3	1	2	2	3	3	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	2	2	2	2	3	2	2	2	2	2	2

Subject Code: BMMPE808	**Subject Name: Hydro and Electro Metallurgy**
Pre-Requisite:	Co-requisite:
Module -I	[*8 Hours*]
Introduction: Justification of Hydrometallurgical selection of solvent processing, Eh- Pt Diagrams Principles underlying hydrometallurgical processes, various commercial hydrometallurgical processes	
Module -II	[*8 hours*]
Criteria for selection of solvents, Types of Solvents, Thermodynamics & kinetics of hydrometallurgical processes, Unit operations in hydrometallurgical processing, Thickness & filters	
Module -III	[8 hours]
Counter current decantation, Applications of hydrometallurgy to Copper, Zinc, Precious metals etc, Solvent Extraction & Ion Exchange, Purification methods of leach solutions.	
Module -IV	[*8 Hours*]
Recovery of metal values from solution, Precipitation methods Thermodynamics & Kinetics of concentration. Mass balance calculations.	
Module -V	[*8 hours*]
Electrolytic Recovery: Electro wining of methods from Aq. Solutions Electro Refining, Fused Salt Electrolysis –Extraction of Aluminium& Magnesium from their ores.	
TEXT BOOK(S):	
1.	H. S. Ray, K. P. Abraham and R. Sridhar, Extraction of Non- Ferrous Metals, Affiliated East- West Press.
2.	E. Jackson, Hydrometallurgical Processing & Reclamation, John Wicky & Sons.
REFERENCE BOOK(S):	
1.	Hydrometallurgy Principle and application by T. Havlik
2.	Rosequist, T., Principles of Extractive Metallurgy.

COURSE OUTCOMESS:	
CO1	Students can evaluate the production cost and can solve critical issues such as anode effects while working in an electrometallurgical plant.
CO2	Students can recover metals using hydrometallurgy route in laboratory scale
CO3	Students can produce metals using electrometallurgy route in laboratory scale
CO4	Students can Analyze the loss of current efficiency while working in an smelter
CO5	Analyze the best solvent selection and techniques for metal recovery and refining economically n profitably

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	2	-	-	-	-	1
CO2	2	2	2	2	2	2	2	-	-	-	-	1
CO3	2	2	2	2	2	2	2	-	-	-	-	1
CO4	3	3	1	2	2	2	1	-	-	-	-	-
CO5	2	2	2	2	2	2	1	-	-	-	-	1

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	2	2	2	2	2	2	-	-	-	-	1

Subject Code: BMMOE801	**Subject Name: Alloy Design & Selection of Materials**

Pre-Requisite:	Introduction to Physical Metallurgy, Phase Transformation, Heat Treatment	Co-requisite:	

Module -I	[8 hours]
Basic concepts of materials science: processing-structure-property-performance correlation; overview of conventional and advanced materials, Brief introduction to the manufacturing processes for metals, polymers, ceramics, glasses and composite materials.	

Module -II	[8 hours]
Overview of the design process: concepts and stages of engineering design and design alternatives to develop materials with tailored properties; Performance indices of materials; function, objective and constraints in design, specific stiffness-limited and strength-limited design for maximum performance, Performance indices for thermal, mechanical, thermomechanical applications, damage tolerant designs for structural applications. Design for manufacturability, Ashby's material property charts. Application of statistics in materials and materials selection.	

Module -III	[8 hours]
Specification of steels, Composition, heat treatment, microstructure and properties of ferrous and non-ferrous alloys, ceramics and polymers for light and heavy structural, Corrosion resistant, high temperature, low-temperature and cryogenic, wear resistant.	

Module -IV	[8 hours]
Materials selection – case studies: magnetic, electrical and electronic applications, pressure vessels and boilers, springs, bearings, tools, medical implants and prostheses application, Composites, shape memory alloys, metallic glasses.	

Module -V	[8 hours]
Decision matrices and decision matrix techniques in materials selection, relationship between materials selection and processing; Case studies: designing of Metals and alloys, ceramics and glasses, composite materials (MMC, CMC and PMC/ FRC) for specific applications. Materials and the Environment.	

TEXT BOOK(S):

1.	Engineering Materials, 4th Edition by M.F. Ashby.
2.	Materials Selection in Mechanical Design by M.F. Ashby.

REFERENCE BOOK(S):

1.	Materials Selection and Design, ASM Publication, Vol.20.
2.	The Principles of Materials Selection and Design by Pat L. Mangonon

COURSE OUTCOMESS: Upon completion of the course, the students will be able to:	
CO1	plan the need of material science tetrahedron for stimulating innovation in all branches of engineering.
CO2	apply the concepts and stages of engineering design and design alternatives to develop materials with tailored properties.
CO3	compile the data required for material selection in high performance applications.
CO4	implement the decision matrix techniques in material selection to carryout material failure case studies.
CO5	apply prior knowledge of materials science and engineering to composition-processing structure-properties-performance relationships for all types of materials.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	3	3	--	--	--	--	--
CO2	3	3	3	3	3	3	2	--	--	--	--	--
CO3	3	2	2	3	3	3	3	--	--	--	--	--
CO4	3	3	3	3	3	3	3	--	--	--	--	--
CO5	2	3	3	3	3	3	2	--	--	--	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	3	3	3	3	3	3	3	--	--	--	--	--

Subject Code: BMMPE802	**Subject Name: Manufacturing & Design of Composites**

Pre-Requisite:		Co-requisite:	

Module -I	[8 hours]
Introduction - Definition & classification of composites; Reinforcing Fibers-Types, Characteristics & Selection; Natural fibers, Boron; Carbon; Ceramic; Glass; Aramid; Particulate fillers; Matrices-Polymer; Graphite; Ceramic & Metal matrices, Short & continuous fiber reinforced composites.	

Module -II	[8 hours]
Processing - Pultrusion; Filament winding; Pre-page technology; Injection & compression molding; Bag molding; Resin transfer molding. Other manufacturing processes; Processing of MMC- Diffusion bonding; Stir casting; Squeeze casting.	

Module -III	[8 hours]
Mechanics - Rule of mixture; Volume & mass fractions; Density & void content; Stress-strain relations for anisotropic materials; Generalized Hook's law; Stiffness, Compliances & engineering constants for orthotropic materials.	

Module -IV	[8 hours]
Stress-strain relations for plane stress in orthotropic materials; Stress-strain relations for a lamina; Characteristics of fiber reinforced lamina. Analysis - Classical lamination theory; Stress analysis of composite laminates.	

Module -V	[8 hours]
Failure predictions -Maximum stress theory; Maximum strain theory; Tsai-Hill theory; Modes of failure of composites; First ply failure; Partial ply failure; Total ply failure.	

TEXT BOOK(S):

1.	Mechanics of composite materials, R. M. Jones, Mc Graw Hill Book Co.
2.	Mechanics of composite materials & structures, M Mukhopadhay, Universities Press

REFERENCE BOOK(S):

1.	Composite Materials – science and engineering by KK Chawla, MRE, Springer-Science & Business Media, B.V.
2.	ASM HandBook Volume 21 - Composites

COURSE OUTCOMESS: Upon completion of the course, the students will be able to:	
CO1	compile and explain the types of composite materials and their characteristics features.
CO2	express the difference in the strengthening mechanism of composite and its corresponding effect on performance and application.
CO3	demonstrate and implement the methods employed in composite fabrication.
CO4	organize the theoretical basis of the experimental techniques utilized for failure mode of composites.
CO5	develop expertise on the applicable engineering design of composite.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	3	1	2	2	2	--	--	--	--	--
CO2	2	2	2	2	2	2	1	--	--	--	--	--
CO3	1	1	1	1	2	2	2	--	--	--	--	--
CO4	2	2	2	2	2	2	2	--	--	--	--	--
CO5	2	2	2	2	2	2	2	--	--	--	--	--

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); "---": No Correlation

Program Articulation Matrix row for this Course

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Course	2	2	2	2	2	2	2	--	--	--	--	--