DEPARTMENT OF METALLURGICAL ENGIEERING
INDUS INSTITUTE OF TECHNOLOGY & ENGINEERING
INDUS UNIVERSITY

B-TECH METALLURGICAL ENGINEERING, SEMESTER –III TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017

SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME					
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	SH0301	Differential Equations and Integral Transforms	03	02	00	04	05	30	10	60	00	00	100
2	MT0301	Mineral Processing	03	00	02	04	05	30	10	60	40	60	200
3	MT0302	Structural Metallurgy & Physics of Materials	03	02	00	04	05	30	10	60	00	00	100
4	MT0303	Fuels, Furnaces & Refractories	03	02	00	04	05	30	10	60	00	00	100
5	MT0304	Physical Metallurgy of Ferrous Alloys	03	02	02	05	07	30	10	60	40	60	200
6	MT0305	Environmental Pollution and Control in Metallurgical Industries	03	00	00	03	03	30	10	60	00	00	100
7	SH0307	Human Values and Professional Ethics	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**19**	**08**	**04**	**24**	**31**	**180**	**60**	**360**	**80**	**120**	**800**

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

DEPARTMENT OF METALLURGICAL ENGIEERING
INDUS INSTITUTE OF TECHNOLOGY & ENGINEERING
INDUS UNIVERSITY

B-TECH METALLURGICAL ENGINEERING, SEMESTER –IV TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017

SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME					
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	SH0401	Complex Analysis and Numerical Methods	03	02	00	04	05	30	10	60	00	00	100
2	MT0401	Physical Metallurgy of Non-Ferrous Alloys	03	00	02	04	05	30	10	60	40	60	200
3	MT0402	Introduction to Process Metallurgy	03	02	00	04	05	30	10	60	00	00	100
4	MT0403	Transport Phenomena	03	02	02	05	07	30	10	60	40	60	200
5	MT0404	Metallurgical Thermodynamics	03	02	00	04	05	30	10	60	00	00	100
6	MT0405	Energy Economy and Waste Management	03	00	00	03	03	30	10	60	00	00	100
7	CE0407	Cyber Security and Intellectual Property Right	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**19**	**08**	**04**	**24**	**31**	**180**	**60**	**360**	**80**	**120**	**800**

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DEPARTMENT OF METALLURGICAL ENGIEERING
INDUS INSTITUTE OF TECHNOLOGY & ENGINEERING
INDUS UNIVERSITY

B-TECH METALLURGICAL ENGINEERING, SEMESTER –V TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017

SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME					
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	MT0501	Heat Treatment Principles and Practices	03	00	02	04	05	30	10	60	40	60	200
2	MT0502	Iron Making	04	00	02	05	06	30	10	60	40	60	200
3	MT0503	Foundry Technology	04	00	02	05	06	30	10	60	40	60	200
4	MT0504	Non Ferrous Extractive Metallurgy	03	02	00	04	05	30	10	60	00	00	100
5	MT0505	Plastic Deformation of Metals	03	02	00	04	05	30	10	60	00	00	100
6	MT0506	Surface Engineering	04	00	00	04	04	30	10	60	00	00	100
7	SH0507	Technical Communication and Soft Skills	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**22**	**04**	**06**	**26**	**32**	**180**	**60**	**360**	**120**	**180**	**900**

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

DEPARTMENT OF METALLURGICAL ENGIEERING
INDUS INSTITUTE OF TECHNOLOGY & ENGINEERING
INDUS UNIVERSITY

B-TECH METALLURGICAL ENGINEERING, SEMESTER –VI TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017

SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME					
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	MT0601	Steel Making	04	02	00	05	06	30	10	60	00	00	100
2	MT0602	Electrometallurgy and Corrosion	04	00	02	05	06	30	10	60	40	60	200
3	MT0603	Powder Metallurgy	04	00	02	05	06	30	10	60	40	60	200
4	MT0604	Metal Forming	03	02	00	04	05	30	10	60	00	00	100
5	MT0605	Material Characterization (EL – 1)	03	02	00	04	05	30	10	60	00	00	100
	MT0611	Computational Materials Science (EL – 1)											
	MT0612	MOOC Course – 1 (EL – 1)											
6	MT0606	Industrial Ceramics & Polymers (EL – 2)	04	00	00	04	04	30	10	60	00	00	100
	MT0607	Nano Technology (EL – 2)											
	MT0608	Composite Materials (EL – 2)											
	MT0609	Nuclear Metallurgy (EL – 2)											
	MT0610	Modelling of Metallurgical (EL – 2)											
7	SH0607	Advanced Technical Communication and Soft Skills	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**23**	**06**	**04**	**27**	**33**	**180**	**60**	**360**	**80**	**120**	**800**

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

DEPARTMENT OF METALLURGICAL ENGIEERING
INDUS INSTITUTE OF TECHNOLOGY & ENGINEERING
INDUS UNIVERSITY

B-TECH METALLURGICAL ENGINEERING, SEMESTER –VII TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017

SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME					
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	MT0701	Metal Joining Processes	03	00	02	04	05	30	10	60	40	60	200
2	MT0702	Non-Destructive Testing	04	00	00	04	04	30	10	60	00	00	100
3	MT0703	Alloy Design	03	02	00	04	05	30	10	60	00	00	100
4	MT0704	Material Testing and Standards	03	00	02	04	05	30	10	60	40	60	200
5	MT0705	Selection of Materials and Failure Analysis	03	02	00	04	05	30	10	60	00	00	100
6	MT0706	Advanced Ferrous Metallurgy (EL – 3)	04	00	00	04	04	30	10	60	00	00	100
	MT0707	Advanced Materials and Applications (EL – 3)											
	MT0708	Advanced Foundry Technology (EL – 3)											
	MT0709	Phase Transformations (EL – 3)											
	MT0710	Advances in Thin Film Technology (EL – 3)											
	MT0711	Industrial Welding Codes and Standards (EL – 3)											
	MT0712	MOOC Course – 2 (EL – 3)											
7	CV0712	Disaster Management	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**21**	**04**	**04**	**24**	**29**	**180**	**60**	**360**	**80**	**120**	**800**

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DEPARTMENT OF METALLURGICAL ENGIEERING
INDUS INSTITUTE OF TECHNOLOGY & ENGINEERING
INDUS UNIVERSITY

B-TECH METALLURGICAL ENGINEERING, SEMESTER –VIII TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017														
SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME						
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	MT0801	Project	00	00	40	20	40	00	00	00	120	180	300
TOTAL			**00**	**00**	**40**	**20**	**40**	**00**	**00**	**00**	**120**	**180**	**300**

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3RD SEMESTER

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B-TECH METALLURGICAL ENGINEERING, SEMESTER –III TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017													
SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME					
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	SH0301	Differential Equations and Integral Transforms	03	02	00	04	05	30	10	60	00	00	100
2	MT0301	Mineral Processing	03	00	02	04	05	30	10	60	40	60	200
3	MT0302	Structural Metallurgy & Physics of Materials	03	02	00	04	05	30	10	60	00	00	100
4	MT0303	Fuels, Furnaces & Refractories	03	02	00	04	05	30	10	60	00	00	100
5	MT0304	Physical Metallurgy of Ferrous Alloys	03	02	02	05	07	30	10	60	40	60	200
6	MT0305	Environmental Pollution and Control in Metallurgical Industries	03	00	00	03	03	30	10	60	00	00	100
7	SH0307	Human Values and Professional Ethics	01	00	00	00	01	00	0	00	00	00	00
TOTAL			**19**	**08**	**04**	**24**	**31**	**180**	**60**	**360**	**80**	**120**	**800**

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

Subject: **Differential Equations and Integral Transforms**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: SH0301				Semester**: III**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	24/60	0	16/40	0	100

1. **Course Outcomes :**

- To provide an ability to see differential equations as a rigorous way of modeling physical phenomena.
- To provide an ability to derive major differential equations from physical principles.
- To provide an ability to understand the role of initial and boundary conditions in determining the solutions of equations.
- To provide an ability to choose and apply appropriate methods for solving differential equations.
- To provide an ability to undertake problem identification, formulation and solution.
- To provide an ability to calculate Laplace transforms and inverse Laplace transforms and uses them to solve differential equations (Initial value problems, Boundary value problems).
- To provide an ability to understand various concepts of Control System -Theory using Laplace Transform.
- To provide an ability to obtain Fourier series for simple periodic functions
- To provide an ability to understand Oscillation and Vibration related problems using Fourier Series and transform
- To provide an ability to obtain solution of the differential equations in form of the series using power series method.
- To provide an ability to communicate effectively with professionals within applied and engineering mathematics as well as with persons working with different scientific-technological applications in an interdisciplinary context.
- To provide an ability to develop abstract, logical and critical thinking and the ability to reflect critically upon their work and work of others.
- To provide an ability to insight their strengths and weakness as learners and to appreciate the value of errors or mistakes as powerful motivators to enhance learning and understanding.
- To provide an ability to interlink various engineering fields with Mathematics.
- To provide mathematical knowledge and skills needed to support their concurrent and subsequent engineering studies.

2. Contents:

		Time Allotted
Unit 1	**Ordinary Differential Equations with applications:** Revision of ordinary differential equation: Introduction of Mathematical Modeling, Basic Definitions, First Order First Degree Differential Equations, Variable Separable equation, Homogeneous Equation, Exact Differential Equations, Reduction of Non-exact Differential Equations to exact form using Integrating Factors, First Order Linear Differential Equation, Bernoulli Equation, Applications: Orthogonal Trajectories, Simple Electric Circuits, Solution of Linear differential equations of higher order with constant coefficients, complimentary function and particular integral	**10 hours**
Unit 2	**Ordinary and Partial Differential Equations with applications:** Method of variation of parameters, Method of Undetermined coefficients, Linear differential equations with variable coefficients (Cauchy's and Legendre forms), Simultaneous linear differential equations, Bessel and Legendre functions, Application of Linear differential equation - Application ofDeflection of Beams, Electric circuits, Series Solution of Ordinary Differential Equations – Power series method, Formation of Partial differential equations, Directly Integrable equations, Method of separation of variables, solution of one dimensional wave equation, heat equation and Laplace equation.	**10 hours**
Unit 3	**Laplace transforms:** Relation between Laplace and Fourier Transform, Definition, Linearity property, Laplace transforms of elementary functions, Shifting theorem, Inverse Laplace transforms, Laplace transforms of derivatives and integrals, Convolution theorem, Application of Laplace transform in solving ordinary differential equations, Laplace transforms of periodic, Unit step and impulse functions	**10 hours**
Unit 4	**Fourier series, Fourier Integrals, Fourier Transforms and Z-Transforms:** Fourier series, Drichlet's conditions, Euler's formula, Fourier expansion of periodic functions, Fourier series of even and odd functions, Half range Fourier series, Fourier integral theorem (only statement), Fourier sine and cosine integrals, Complex form of Fourier integral, Fourier transforms, Fourier sine and cosine transforms, Introduction to Z-transforms: Definition and Standard Z-transforms, Linearity Property, dumping Rule and some standard results, Some useful Z-transforms	**12 hours**

3. Text books:

1) Erwin Kreyszig: Advanced Engineering Mathematics (8th Ed.) , Wiley Eastern Ltd., New Delhi.

4. Reference Books:

1) B. V. Ramana: Higher Engineering Mathematics, Mc Graw Hill, New Delhi.
2) Dr. B.S. Growl: Higher Engineering Mathematics, Khanna Publishers, New Delhi.
3) R K Jain, S R K Iyengar: Advanced Engineering Mathematics. Third Edition, Narosa Publishing House
4) Merel C Potter, J L Goldberg: Advanced Engineering Mathematics (3rd Ed.), Oxford India Publication.
5) Murray Spiegel: Advanced Mathematics for Engineering & Science: (Schaum's Outline Series),Tata – McGraw Hill Publication

5. Digital Resources

http://freevideolectures.com/blog/2010/11/130-nptel-iit-online-courses/
http://nptel.ac.in/video.php?subjectId=122107036
http://ocw.mit.edu/index.htm
https://www.khanacademy.org/

6. Activity Based Learning

Branch specific projects will be given to students as under:

1) Electrical Circuit
2) Signal system
3) Deflection problems
4) Starching problems
5) Oscillations Problems
6) Forced vibration of an elastic string
7) Vibration of Beam
8) Electrostatic potential
9) Model of Mass, spring system, Circuits, Network
10) Vibrating cable or chain

Subject: **Mineral Processing**								
Program: **B. Tech** Metallurgical Engineering			Subject Code: MT0301			Semester: **III**		
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	24/60	60	16/40	40	200

1. Course Outcomes

- To make the students aware about basics of mining technology.
- To impart the knowledge about the basic steps followed in mineral dressing and its importance before extraction of pure metal from their respective ores.
- To develop the knowledge regarding the auxiliary operation and the advancement in mining technology.

2. Contents

		Allotted hours
Unit 1	Introduction and scope of mineral processing in extractive metallurgy, mineral resources in India, physical characteristics exploited in mineral processing, terminology in mineral processing. Physical and chemical characteristics of industrial minerals i.e. hematite, magnetite, galena, chalcopyrite, azurite, monazite, cassiterite, chromite, bauxite, and ilmenite, economics of ore processing.	8 hours
Unit 2	Liberation and its significance, Comminution and sizing, Laws of comminution, Crushing and Grinding- types, equipment, washing, sorting and hand-picking ; Laboratory and industrial screening- equipment, screen efficiency.	10 hours
Unit 3	Classifier- mechanical and hydraulic, sizing and sorting, classifiers, Mill calculation and Selectivity index. Gravity concentration methods, Tabling, Jigging, Heavy media separation, Separation in vertical and streaming currents, Sedimentation, Dewatering, techniques, Thickener, Filtration and Drying.	10 hours
Unit 4	Froth flotation: principles, reagents, collectors, modifiers and frothers, process variables in floatation, Tailings disposal, Process integration and, Study of flow sheet for important minerals. Magnetic and Electrostatic separation: principles, wet and dry separators, High tension separation, Motion of solid in fluid, Strokes and Newton's law, Free and hindered settling, Thickening, Batch and continuous settling, chambers. Application of computer in mineral processing.	10 hours

3. Mineral Processing Lab (List of Experiments)

Experiment No.	Title
1	To study the crushers (primary and secondary) like jaw crusher and roll crusher and to measure their reduction ratios and capacities
2	To determine the reduction ratio of Coal.
3	To determine the reduction ratio of Coke.
4	To determine the reduction ratio of Iron ore.
5	To determine the reduction ratio of Ceramic material.
6	To study the sieve analysis of weighed powder sample
7	To study the ball mill and measure the grind ability of Ball mill
8	To determine the grindability of Coal.
9	To determine the grindability of coke.
10	To determine the grindability of Iron ore.
11	To determine the grindability of ceramic material.
12	To study the principle , operation and efficiency of laboratory classifier
13	To determine the efficiency of magnetic separation by varying strength of magnetic field
14	To study the coal and gravel separation using jig
15	To study the froth flotation of given sample of coal

4. Text Book(s)

1) Principles of mineral dressing, by S.K.Jain. (2013)

5. Reference Books

1) Principles of Mineral Dressing, A. M. Gaudin, Tata McGraw Hill.(1980)
2) Mineral Processing Technology, B. A. Wills, Pergamon Press.(1992)
3) Introduction to Mineral Processing, E. G. Kelly and D. J.Spottiswood, John Wiley & Sons. (1982)
4) Extraction Metallurgy, J. D. Gilchrist, Pergamon Press.(2006)

5) Extractive Metallurgy, Joseph Newton, Wiley Eastern.(1966)
6) Mineral Processing, E. J. Pryor, Pergamon Press.(1965)
7) Extraction of Non-ferrous Metals, H. S. Ray and K. P. Abraham, Affiliated East West Press. (2006)
8) Experiments in Mineral Processing, S. Venkatachalam. (2011)

6. Digital Learning Resources :

www.youtube.com/watch?v=YO23kmDdLf8
www.youtube.com/watch?v=ZrJtzCfoqxI

7. Question Paper Pattern for End Sem Exam :

As per Appendix A

Subject: **Structural Metallurgy & Physics of Materials**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0302			Semester: **III**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	24/60	0	16/40	0	100

1. Course Outcomes

- To provide knowledge about the basic structure of metals and alloys, which are the building block for developing macro and micro structure of metallic materials
- To provide knowledge about metallic and non-metallic type of bonding and their differentiation.
- To teach them about concept of polymorphism and others.
- To solve different numerical pertaining to crystal structure determination & phase diagram determination
- To give them knowledge about diffusion in solids.
- To teach them basics on nucleation and growth and its applications.
- To teach them about crystal defects in metallic materials their origin, causes and remedial measure.
- To provide basic knowledge about properties of materials such as electrical and thermal Conductivity, magnetism, dielectric properties.

2. Contents

		Allotted hours
Unit 1	Atomic Structure, types of bonds; ionic bonds, covalent bonds, Van der Waals bonds, metallic bonds, metallic properties; crystalline vs. non-crystalline solids. Inter-atomic Bonding. Interatomic distances. Equilibrium & Kinetics: Macro and micro structure in metallic materials, levels of structure, structure property relationships in materials, Equilibrium & kinetics: stability & met stability, Basic thermodynamic functions, The statistical nature of entropy, The kinetics of thermally activated processes.	12 hours
Unit 2	The Structure of Crystalline Solids: Crystalline & non crystalline states, covalent solids, Metals & alloys. Ionic solid, unit cell, space lattice, Crystal geometry, crystal systems & Miller- Bravais lattices, Polymorphism or allotropy**,** direction & planes, slip planes, atom sizes and coordination. Co-ordination Number, atomic packing factor. Single crystal, Polycrystalline & Non crystals.	10 hours

Unit 3	Isotropy & Anisotropy, Homogenous & Heterogeneous. Types of deformation elastic & anelastic deformation, viscoelastic behavior, work hardening & strain hardening, dislocation & strain aging, The Bragg's Law. Diffraction methods, structure factor and its determination, Crystal structure determination, Crystallite size determination	10 hours
Unit 4	Glass transition, Conductors and Resistors: The resistivity range, Free electron theory, conduction by free electrons, conductor, Semi-conductor, insulators and resistor materials. Ferromagnetism, diamagnetism, paramagnetism, superconductivity, dielectric behavior, thermal conductivity principles.	8 hours

3. Text Book(s)

1) Structure of Metals – Crystallographic Methods, Principles & Data- Charles S. Barret & T.B.Massalski, Eurasia publishing house(Pvt.)Ltd., New Delhi(2004)
2) Theoretical Structural Metallurgy – A.H.Cottrell, The English Language Book Society & Edward Arnold (Publishers) Ltd., U.K.(1959)
3) Elements of X-ray diffraction – B.D. Cullity, Addison – Wesley Publishing Company Inc., U.S.A(1956)
4) Physical Metallurgy Principles – Robert E-Reed-Hill, Affiliated East-West Press Private Ltd., New Delhi.(1991)

4. Reference Books :

1) Materials Science & Engineering by V.Raghavan 4th edition, PHI Pvt. Ltd. New Delhi

5. Digital Learning Resources

MIT Open Courseware: http://ocw.mit.edu/OcwWeb/Materials-Science-and-Engineering/

Defects in Crystals: http://www.tf.uni-kiel.de/matwis/amat/def_en/

Hyper Physics: http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

6. Question Paper Pattern for End Sem Exam :

As per Appendix A

Subject: **Fuel Furnace & Refractories**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0303			Semester**: III**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	24/60	0	16/40	0	100

1. Course Outcomes:

- Students will understand use of fuels and refractories in the different levels of the operational systems.
- Students will gain the knowledge of various types of high temperature changes and also the mode of fabrication for such changes used in the research areas and how to design those operations.
- Students can develop creativity for Pyro- Research.
- Co-relating the basic of the mechanical and high temperature properties and individual response and related over all logical changes and uses of the respective materials.
- Students can predict effectively and accurately the reasons of faults related to temperature and then correlate how to rectify.
- Students will know various considerations like laws of physics, chemistry and also factors of safety etc.
- Students will know of basic principles, working principles laws, related details, graphical details, applications and also a comparison study with each other.

2. Contents

		Allotted hours
Unit 1	**Fuels:** Classification of fuels, solid, liquid and gaseous fuel-their advantages and limitations, Comparative study of solid, liquid and gaseous fuels, Combustion of fuels, Combustion characteristics of fuel, Analysis and testing of fuels, Carbonization of coal-coke making and by products, producer gas, water gas, natural gas, LPG, Blast Furnace gas, Coke oven gas, LD gas, storage of Fuels in transport, nuclear fuel, other energy resources such as Solar, Wind, Geothermal, Bio-mass, Hydrogen, Nuclear Energy.	8 hours
Unit 2	**Furnaces and Furnace Design:** Classification based on heating methods, application wise and temperature ranges, Batch furnaces, continuous furnaces, Construction and working of furnaces like Cupola, Induction Furnace, Electric Arc Furnace, Resistance Furnace, Pit	10 hours

	furnace, Rotary Furnace, Muffle Furnace, Modern furnaces: plasma heating Furnace accessories (Burners, blowers, pumps, chimneys, drafts), thermal interactions in furnace, furnace atmosphere, heat economics, Furnace capacity and efficiency along with factors affecting it. Related numerical.	
Unit 3	**Refractories:** Introduction, concept of Refractoriness, requirements of good refractory material, classifications, types of the refractories and their individual manufacturing processes, Refractory properties, Testing and related machineries and how to control those machineries, a comparative study of the ternary phase diagram of different types of refractories, Details of Blast furnace refractory and LD Converters of Ladles, Castable refractory – preparation, fabrication and uses, Supper Refractories and their uses. Refractories numerical.	10 hours
Unit 4	**Pyrometry:** Basic concept of temperature measurement and control, Stefan's Boltzmann's theory and related ideas in temperature measurement, Thermometry, resistance thermometer - principle, constructional details, applications, Principle of thermocouple, construction and calibration of thermocouple, Different types of thermocouple for measurement of various temperature ranges, Optical Pyrometer and Radiation Pyrometer – Principle, construction, working principle, advantages, comparative study of Optical Pyrometer and Radiation Pyrometer	8 hours

3. Text Book(s)

1) O. P. Gupta, Elements of Fuels, Furnaces and Refractories, Khanna Publishers, 1998.

4. Reference Books

1) J. D. Gilchrist, Fuels, Furnaces and Refractories, Pergamon, 1977
2) W. Trinks, M. H. Mawhinney, Industrial Furnaces, John Wiley and Sons, 6th Edition, 2003.

5. Digital Learning Resources

http://nptel.ac.in/courses/113104008/
http://www.steeluniversity.org/content/html/eng/default.asp?catid=25
http://www.youtube.com/watch?v=yVZJP3u9Kek
http://nptel.ac.in/courses/113104059/lecture_pdf/Lecture%209.pdf

6. Question Paper Pattern for End Sem Exam :

As per Appendix A

Subject**: Physical Metallurgy of Ferrous Alloys**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0304			Semester**: III**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	2	5	60	60	40	40	200

1. Course outcomes

After completion of this course students will be able to gain knowledge about following

Physical metallurgy is the study of the structure of metals and its influence on material properties and performance. It is an essential component of many areas of mechanical, manufacturing, civil, and materials engineering in the aerospace, automobile, transportation, energy, environmental, biomedical, and electronics industries as well as in engineering research and design for military and government applications. The courses in the minor provide the student with a broad introduction to the engineering science principles and applications associated with physical metallurgy.

2. Contents

		Allotted hours
Unit1	Introduction, solid Solution, Types of solid solution, Hume-Rothery Rules for Primary Substitutional Solid Solubility, Types of Interstitial Voids, Chemical compounds versus solid solution, Intermediate Phases, Polycrystalline Materials, Grain Size, Measurement of Grain Size, Multiple –Phase Alloys. Intermetallic compounds. Solidification of Metals & Alloys: Structure of Liquid Metals, Energetic of Solidification, Nucleation and growth phenomena, Homogenous & Heterogeneous Nucleation, Growth of Solid, Smooth or Stable interface growth, Temperature Inversion in pure Metals, Segregation, Porosity. Numericals.	10 hours
Unit2	Concepts of alloy system and explanation of terms like system, component, phase, micro constituent and degree of freedom, structural constituent of an alloy, phase rule and phase equilibria, equilibrium diagrams and their classification based on solubility of components in liquid and solid states, cooling curves, morphology and distribution of phases, effect of non-equilibrium cooling on morphology. Constitutional super cooling Unary	8 hours

	Diagram, Binary Phase Diagram, Use of Phase Diagram, Determination of Phase Diagrams, Limitation of Equilibrium Diagram, Zone Melting, Ternary Diagram, Numerical, Interpretation of Phase Diagram, Interpretation of Phase Diagram by using Lever Rule	
Unit3	**Fe-Cementite Diagram** Introduction, Allotropy of Iron, Cooling & Heating curves of Pure Iron, Effect of pressure on allotropy of Iron, Iron- carbon equilibrium diagram, phase Fe- Cementite diagram. Effect of Alloying element on Fe- Cementite diagram, effect of carbon on Fe- Cementite. Critical temperature in Fe-Cementite diagram. Physical significance of grain size: Grain size effects, Grain size designation, Grain size measurement. Interpretation of Phase Diagram.	10 hours
Unit4	**Steels** Classification and application of carbon steels, Plain carbon steels, Advantages and limitations of Plain carbon steels, Effect of impurity elements on the properties of steels, Purpose of alloying of steel, Functions of alloying elements in steel, Effects of alloying elements on the properties of steels, Steel Specifications-according to AISI, Indian grades, and UNS. **Cast Iron** Introduction, Cast Irons, Various Types, Properties & Applications, ADI – Austempered Ductile Cast Iron. Cast Iron Specifications – according to AISI and Indian Grades. **Metallography** Microscopic examination, Polishing techniques for different metals and alloys, Etching and Mounting techniques, Difference between Macro & Micro Etching, electrolytic polishing Metallurgical microscope, Macroscopic & Microscopic examination methods, Nonmetallic inclusions.	10 ours

3. Physical Metallurgy I Lab (List of Experiments)

Experiment No	Title
1	Study of optical microscope.
2	Specimen preparation for metallography.
3	Study and preparation of etching agents
4	Mounting of specimen.

5	Plotting of Thermal Equilibrium Phase Diagram of Binary alloys and pure metal by Cooling Curve Method.
6	Application of Gibb's Phase Rule for confirming the accuracy of Unary and Binary Phase Diagrams
7	Microstructure observation of Pure metals
8	Application of Lever Rule for Phase, Phase Composition & Phase Fraction (Binary Alloys)
9	Microstructural observation of Steels.
10	Microstructural observation of Cast Irons.
11	Study of phase diagrams for structure-properties correlation.
12	Eutectic, Hypo- And Hyper-Eutectic Alloys: Al-Si (Unmodified), Al-Si (Modified), Pb-6wt%Sb, Pb- 11.1 Wt%Sb And Pb- 20 Wt%Sb
13	Peritectic And Monotectic Alloys: 60:40 (+) Brass, 70:30 ( ) Brass, Cu- 10wt%Sn, Cu- 36wt% Pb, Cu- 50 Wt% Pb*
14	Grain size measurement
15	Understanding SAE, AISI, UNS and Indian Standards for Steels.

4. Text books

1) Physical Metallurgy – Vijendra Singh (2012)

5. Reference books

1) Physical Metallurgy Principles - Robert E Reed-Hill and Reza Abbaschian(2008)
2) Phase Transformation in Metals & Alloys - D A Porter & K Easterling(1992)
3) Physical metallurgy by Avner-(1997)
4) Physical Metallurgy - Peter Haasen(1996)
5) Structure and Properties of Alloys - R M Brick, R B Gordon, A. Phillips(2002)
6) Physical Foundations of Materials Science - G. Gottstein (2004)
7) Physical Metallurgy and Advanced Materials Engineering - R.E. Smallman and A.H.W. Ngan (2007)

6. Digital learning resources

http://nptel.ac.in/courses/113105024/

7. Question paper pattern for end sem exam

As per Appendix A

Subject: **Environmental Pollution and Control in Metallurgical Industries**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0305			Semester**: III**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	60	0	40	0	100

1. Course Outcomes:

- To understand the sources of Air pollution.
- To understand the various effects of pollution on human health, vegetables etc.
- From application point of view students can learn how to measure the air pollution
- It will help students to understand how to reduce or control the pollutants.

2. Contents

		Allotted hours
Unit 1	**Introduction:** Definition, air pollution episodes, general nature of air pollution problems **Air Pollutants, Sources & their inventory:** Particulate matter, carbon dioxide, carbon Monoxide, sulphur oxide, effects of hydrocarbon, oxide of nitrogen, photochemical oxidants, asbestos and metals on materials and health.	8 hours
Unit 2	**Effects of Air Pollution:** Effects of air pollution on human, vegetation, animals and Materials. **Meteorology:** Introduction, solar radiation, wind circulation, lapse rate, stability conditions, wind velocity profile maximum mixing depth, wind rose turbulence, and general characteristics of plumes, heat island effect, and global circulation of pollutants.	10 hours

Unit 3	**Pollution in Metal Industries:** Pollution in Iron and Steel industries and Non-ferrous Metals (Cu, Al, Zn, and Pb) industries and its control, Pollution Control in Ferrous & Non-ferrous Foundries.	10 hours
Unit 4	Air pollution and control due to toxic and non-toxic gases, fumes, dust etc. during combustion, heating and roasting processes and industrial production, control methods, cleaning of gaseous effluents, recovery of economic value from gases. Noise pollution Sources, effects and control Odor problem Causes and control.	10 hours

3. Text Book(s)

1) Environmental Pollution Control Engineering by C S Rao, 2006.
2) Air Pollution Rao & Rao. - Tata McGraw-Hill Publishing Ltd, 2007.

4. Reference Books

1) Environmental Pollution Studies by Gerald Arthur Best, 1999.
2) Understanding Environmental Pollution by Marquita K. Hill, 2010.
3) Air Pollution Henry C. Perkins. - Tata McGraw-Hill Publishing Ltd, 1947.
4) Air Pollution, its origin and control Wark & Warner, 1998.
5) Environmental Pollution and Control by J. Jeffrey Peirce, P Aarne Vesilind, Ruth Weiner, 1998**.**

5. Digital Learning Resources

http://nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Environmental%20Air%20Pollution/

http://nptel.ac.in/video.php?subjectId=105104099

http://www.youtube.com/watch?v=4AuwG2G_ERU

http://www.youtube.com/watch?v=5hKjurPjzwI

http://textofvideo.nptel.iitm.ac.in/105104099/lec38.pdf

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Human values & professional Ethics**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: SH0307			Semester: **III**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
1	0	0	0	60	00	40	00	100

Course Objectives:

1. To create an awareness on Engineering Ethics and Human Values.
2. To understand social responsibility of an engineer.
3. To appreciate ethical dilemma while discharging duties in professional life.

Contents:

Unit 1: Values and Self Development **04 hours**

Social Values and individual Attitudes, Work ethics, Indian vision of Humanism, Moral and non moral valuation, Standards and principles, Value judgments. Importance of cultivation of values, Sense of duty, Devotion, Self reliance, Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National unity, Patriotism, Love for nature, Discipline.

Unit 2: Personality and Behavior Development **04 hours**

Soul and scientific attitude. Goad and scientific attitude, positive thinking, integrity and discipline, punctuality, love and kindness. Avoiding fault, finding. Free from anger, Dignity of labor, Universal brotherhood and religious tolerance, True friendship, Happiness vs. suffering love for truth. Aware of self destructive habits, Association and cooperation, doing best, saving nature.

Unit 3: Character and Competence **04 hours**

Science vs. God, Holy books vs. Blind faith, Self management and good health, Science of reincarnation, Equality, Nonviolence, Humility, Role of women, All religions and same message, Mind your mind, Self control, Honesty, Studying effectively.

Unit 4: Engineering Ethics **04 hours**

Senses of 'Engineering Ethics', variety of moral issues, types of inquiry, moral dilemmas, moral autonomy, Kohlberg's theory, Gilligan's theory, consensus and controversy, models of professional roles, theories about right action, self interest, customs and religions, uses of ethical

theories, Valuing time, Co-operation and commitment, Code of ethics, Sample codes – IEEE, ASCE, ASME and CSI.

Text Books:

1. Chakraborty, S. K., Values and Ethics for Organization Theory and Practice, Oxford University Press, New Delhi, 2001

2. Gaur R. R., Sangal R., Bagaria G. P., *A foundation course in Value Education*, 2009.

3. Gaur R. R., Sangal R., Bagaria G. P*., Teacher's Manual*, 2009.

4. Mike Martin and RolandSchinzinger, *Ethics in Engineering*, Mc Graw Hill. New York, 1996.

Reference Books:

1. Govindrajan M., Natrajan S. and Senthil Kumar V. S., Engineering Ethics (including Human Values), Prentice hall of India Ltd., New Delhi, 2004.
2. Frankena, W. K., *Ethics*, Prentice Hall of India, New Delhi, 1990.
3. Dhar P. L., Gaur R. R., *Science and Humanism*, Commonwealth Publishers, 1990.
4. TripathyA. N., *Human Values*, New Age International Publishers, 2003.
5. Seebauer E. G. and Robert L. Berry, *Fundamentals of Ethics for Scientists andEngineers*, Oxford University Press, 2000.
6. Banerjee B. P., *Foundations of Ethics and Management*, Excel Books, 2005.
7. Bajpai B. L., *Indian Ethos and Modern Management*, New Royal Book Company, 2004.

4TH SEMESTER

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

B-TECH METALLURGICAL ENGINEERING, SEMESTER –IV TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017														
SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME						
								THEORY			PRACT		TOTAL
			L	T	P			CIE		ESE	CIE	ESE	
								MID	IE				
1	SH0401	Complex Analysis and Numerical Methods	03	02	00	04	05	30	10	60	00	00	100
2	MT0401	Physical Metallurgy of Non-Ferrous Alloys	03	00	02	04	05	30	10	60	40	60	200
3	MT0402	Introduction to Process Metallurgy	03	02	00	04	05	30	10	60	00	00	100
4	MT0403	Transport Phenomena	03	02	02	05	07	30	10	60	40	60	200
5	MT0404	Metallurgical Thermodynamics	03	02	00	04	05	30	10	60	00	00	100
6	MT0405	Energy Economy and Waste Management	03	00	00	03	03	30	10	60	00	00	100
7	CE0407	Cyber Security and Intellectual Property Right	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**19**	**08**	**04**	**24**	**31**	180	60	360	80	120	800

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

Subject: **Complex Analysis and Numerical Methods**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: SH0401			Semester**: IV**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

2. Course outcome

After completion of this course students will be able to gain knowledge about following

- To provide an ability to understand, interpret and use the basic concepts: complex number, analytic function, harmonic function, Taylor and Laurent series, singularity, residue, conformal mapping, meromorphic function.
- To provide an ability to prove certain fundamental theorems about analytic functions, e.g. Cauchy's integral formula
- To provide an ability to determine the images of curves under simple complex mappings.
- To provide an ability to determine the stability of certain dynamical systems using complex functions.
- To provide an ability to use conformal mapping to solve certain applied problems regarding heat conduction, electrical engineering and fluid mechanics.
- To provide an ability to use Taylor and Laurent expansions to derive properties of analytic and meromorphic functions.
- To provide an ability to compute integrals by means of residues.
- To examine common numerical methods such as finite element and finite difference techniques, including the strengths and weaknesses of particular applications.
- To discuss the concept of approximation in geometric and engineering applications.
- To provide an ability to utilize a systems approach to design and operational performance.
- To provide an ability to formulate mathematical models, choose suitable methods to investigate these models including the efficient use of computer tools.
- To provide an ability to analyze zeros and poles of meromorphic functions, classify singularities
- To provide an ability to identify various mathematical problems and reformulate these in a way suitable for numerical treatment.
- To provide an ability to select a suitable numerical method for the treatment of the given problem.

- To provide an ability to solve various engineering problems including tabular data.
- To provide an estimate of the accuracy of the results.
- To provide an ability to communicate effectively with professionals within applied and engineering mathematics as well as with persons working with different scientific-technological applications in an interdisciplinary context.
- To provide an ability to develop abstract, logical and critical thinking and the ability to reflect critically upon their work and work of others.
- To provide an ability to interlink various engineering fields with Mathematics.
- To provide mathematical knowledge and skills needed to support their concurrent and subsequent engineering studies.

3. Contents

		Allotted hours
Unit 1	**Complex Analytic Functions:** Complex Numbers, Demoivere's Theorem, Roots of Complex Numbers, Elementary complex functions, Complex planes, Curves in complex planes, Concept of neighborhood in The complex plane, Analytic function, Cauchy- Riemann equations (Cartesian and polar forms – without proof), Harmonic functions, conformal mappings, some standard conformal transformations.	8 hours
Unit 2	**Interpolation** **Finite differences and Interpolation:** Finite differences Forward, Backward & Central difference operators and difference tables. Interpolation, Interpolation Formulae with equal intervals: Newton's forward, Newton's backward, Central difference interpolation by Stirling's formulae **Interpolation Formulae with unequal intervals**: Lagrange's & Newton's divided difference interpolation **Numerical Integration:** Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule. **Numerical differentiation**: Using Newton's forward and backward interpolation formula	10 hours
Unit 3	**Numerical Methods:** Basic Errors. **Solution of Algebraic and Transcendental Equations:** Bisection method, Regula-Falsi method, Newton-Raphson method, Convergence condition for these methods.	10 hours

	Numerical methods in Linear Algebra: Gauss-Jacobi, Gauss-seidel method **Largest Eigen values and corresponding Eigen vectors**: By power method **Numerical Solutions of ordinary differential equations:** Taylor's Method, Euler's Method, Improved Euler Method (Heun's Method), Runge-Kutta method of order four	
Unit 4	**Complex Integration:** Complex integration, Cauchy's integral theorem and Cauchy's integral formula (without proof), Singularities, Taylor's and Laurent's series, Cauchy-Residue theorem, Residues & Contour integration, Applications of residue to evaluate real integrals.	10 hours

4.Text books

1) Erwin Kreyszig: Advanced Engineering Mathematics (8^{th} Edition) Wiley Eastern Ltd., New Delhi (1999).

5.Reference Books

1) R. V. Churchill and J. W. Brown: Complex variables and applications (7^{th} Edition), McGraw-Hill (2003)
2) B. V. Ramana: Higher Engineering Mathematics, McGraw Hill, New Delhi (2008).
3) Merel C Potter, J L Goldberg: Advanced Engineering Mathematics (3rd Edition) Oxford India Publication (2005).
4) Dr. B.S. Growl: Higher Engineering Mathematics, Khanna Publishers, New Delhi (2000).
5) R K Jain, S R K Iyengar: Advanced Engineering Mathematics. Third Edition, Narosa Publishing House (Reprint2014).
6) Murray Spiegel: Advanced Mathematics for Engineering & Science: (Schaum's Outline Series), TataMcGraw Hill Publication (2009).

6.Digital learning resources

http://freevideolectures.com/blog/2010/11/130-nptel-iit-online-courses/
http://nptel.ac.in/video.php?subjectId=122107036
http://ocw.mit.edu/index.htm
https://www.khanacademy.org/

7.**Question paper pattern for end sem exam**

As per Appendix A

Subject: **Physical Metallurgy of Non–Ferrous Alloys**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0401			Semester: **IV**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	60	60	40	40	200

1. Course outcomes

After completion of this course students will be able to gain knowledge about following

Due to specialized requirements, nonferrous alloys application are increasing due to low weight, higher conductivity, non-magnetic property and resistance to corrosion so it is required for student to understand physical metallurgy of nonferrous metals and alloys for specific application. This course emphasize on different nonferrous metals and alloy phase diagram, their heat treatment to modify their properties and applications and to choose or design heat treatment for given metal and alloy.

2. Contents

		Allotted hours
Unit1	**Introduction** Introduction to non-ferrous metals & their alloys: Aluminum Alloys, Copper Alloys, Nickel Alloys, Magnesium Alloys, Titanium Alloys, Lead Alloys, Zinc Alloys, Tin alloys, Babbitts (Antifriction Alloys).	8 hours
Unit2	**Aluminum and its alloys:** Classification of Aluminum Alloys, Grades of Aluminum alloys, Non-heat treatable Wrought Aluminum Alloys, Heat treatable Wrought Aluminum Alloys, Cast Aluminum Alloys with their Phase Diagrams, Compositions, heat treatments, properties and applications. Heat treatment of Aluminum alloys, titanium alloys and copper alloys, Concept of age-hardening. **Copper and its alloys:** Copper, Brass and Bronze Phase Diagrams, Compositions, heat treatments, properties and applications, Grades of Copper alloys.	10 hours

Unit3	**Nickel and its alloys:** Ni-Cr alloys, Ni-Al alloys, Ni-Cr-Al alloys, Ni-Cr-Al-Ti alloys, Complex Nickel- base alloys Phase diagram with compositions, Heat treatments, properties and applications, Grades of Ni alloys. **Magnesium and its alloys:** Classification of Magnesium Alloys, Wrought Magnesium Alloys, Cast Magnesium Alloys with their Phase Diagrams, Compositions, heat treatments, properties and applications. **Titanium and its alloys:** Compositions, heat treatments, properties and applications.	10 hours
Unit4	**Lead , Zinc and Tin and their alloys:** Lead and Its alloys Phase Diagrams, Compositions, heat treatments, properties and applications., Zinc and its alloys Phase Diagrams, Compositions, heat treatments, properties and applications., tin and its alloys Phase Diagrams, Compositions, heat treatments, properties and applications. **Babbitts (Antifriction alloys):** Phase Diagrams, Compositions, heat treatments, properties and applications.	10 hours

3. Physical Metallurgy of Non-Ferrous Alloys Lab (List of Experiments)

Experiment No	Title
1	Specimen preparation for non-ferrous metallography
2	Study and preparation of etching agents for non-ferrous alloys
3	Microstructure observation of Pure non-ferrous metals
4	Application of Lever Rule for Phase, Phase Composition & Phase Fraction (Binary Alloys)
5	Microstructural observation of Aluminum Alloys
6	Microstructural observation of Copper Alloys
7	Microstructural observation of Brass
8	Microstructural observation of Bronze
9	Microstructural observation of Lead Alloys

10	Microstructural observation of Zinc Alloys
11	Aging Treatment of Al-Cu Alloy
12	Eutectic, Hypo- And Hyper-Eutectic Alloys: Al-Si (Unmodified), Al-Si (Modified), Pb-6wt%Sb, Pb- 11.1 Wt%Sb And Pb- 20 Wt%Sb
13	Peritectic And Monotectic Alloys: 60:40 (+) Brass, 70:30 ( ) Brass, Cu-10wt%Sn, Cu- 36wt% Pb, Cu- 50 Wt% Pb*
14	Grain size measurement
15	Understanding SAE, AISI, UNS and Indian Standards for non-ferrous alloys.

4. Text books

1) Engineering Physical Metallurgy by Lakhtin, CBS Publisher
2) Physical Metallurgy for Engineers – Donald S. Clark, & Wilbur R. Varney, CBS Publishers & Distributors, New Delhi
3) Heat Treatment, Structure and Properties of Non-ferrous Alloys – Charlie R. Books, 1982, ASM.
4) Introduction to Physical Metallurgy – Sidney H. Avner, McGraw-Hill Book Company, New Delhi
5) Heat Treatment Principle and techniques – T V Rajan, C P Sharma, Ashok Sharma , Second Edition, PHI Publications.

5. Reference books

1) Phase Transformation in Metals & Alloys - D A Porter & K Easterling(1992)
2) Metals Handbook Ninth Edition – Vol.2, Properties and Selection: Non-ferrous alloys and Pure Metals, American Society for Metals, Metals Park, Ohio.
3) Physical Foundations of Materials Science - G. Gottstein (2004)
4) Physical Metallurgy and Advanced Materials Engineering - R.E. Smallman and A.H.W. Ngan (2007)

6. Digital learning resources

www.nptel.ac.in
http://engineershandbook.com/Materials/nonferrous.htm
https://manufacturability.wordpress.com
http://www.steelforge.com/literature/ferrousnon-ferrous-materials-textbook

7. Question paper pattern for end sem exam

As per Appendix A

Subject: **Introduction to Process Metallurgy**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0402				Semester: **IV**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

1.Course Outcomes

After completion of this course students will be able to gain knowledge about following

- Students will able to gain knowledge about the basic mechanism affecting the different extraction techniques such as Pyrometallurgical, Hydrometallurgical & Electro metallurgical extraction processes.
- The students will aware about the requirement of various devices required for carrying out different extraction processes.
- They will able to analyze various factors affecting these extraction processes.
- Students will gain knowledge about the concept of reaction kinetics & its role in understanding the extraction processes.

2. Contents

		Allotted hours
Unit 1	Basics of Pyrometallurgical Processes, Drying, Calcination, Agglomeration, Sintering, Roasting, Smelting. Converting, Refining processes with examples for metals like Aluminum, Copper, Zinc, and Lead.	8 hours
Unit 2	Basics of Hydrometallurgical processes, Fundamentals of Unit processes and Unit operations, Principles and types of Leaching, Kinetics of leaching, and Refining of leached solution, Solvent extraction and ion-exchange processes, Cementation, Gaseous reduction of metals.	10 hours
Unit 3	Basics of Electrometallurgical processes: Electrowinning and Electrorefining, Aqueous/Fused salt electrolysis. Flow-sheets of	10 hours

	Extraction of Important Metals, Simplified Flowsheets for the production of Iron, Steel, Aluminum, Copper, Zinc and Lead.	
Unit 4	Reaction kinetics, kinetics of metallurgical processes and material, velocity/rate of reaction, factors affecting rate of reaction, Order of Reaction and molecularity, zero, first, second order and order of reaction, Pseudo-unimolecular reaction, half life period, determination of order of reaction, integration method, half period method, graphical method, Ostwald's isolation method, rate constants, Arrhenius equation, collision theory, Activation Energy, activation energy profile of an exothermic reaction, activation energy barrier, theory of absolute reaction rate.	10 hours

3. Text Book

1) Principles of extractive metallurgy, H.S. Ray, A. Ghosh (2007).
2) Extraction of nonferrous metals, H.S. Ray, R. Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007).
3) Metallurgical Thermodynamics Kinetics & Numericals by Dr. S.K.Dutta, (2011), S. Chand Publication.

4. References:

1) W.H. Dennis, Extractive Metallurgy, Philosophical Library, New York (1965)
2) F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York (1969).
3) T. Rosenqvist, Principles of Extractive Metallurgy, McGraw Hill, New York (1983)
4) J.L. Bray, Nonferrous production metallurgy, Wiley, New York(1954)
5) R.D. Pehlke, Unit processed in extractive metallurgy, Elsevier, Amsterdam (1082)
6) H.S. Ray and A. Ghosh, Principles of extractive metallurgy, Wiley Eastern Ltd., New Delhi (1991)
7) Introduction to melts - molten, salts and slags, Allied Pub. Pvt. Ltd., New Delhi (2006)
8) H.S. Ray, B.P Singh and Sarama Bhattacharjee, Energy in minerals and metallurgical processes, Allied Publishers Ltd, New Delhi (2005)

5. Digital Learning Resources

http://nptel.ac.in/courses/113105021/
www.youtube.com/watch?v=xa9wR4sknh0
http://encyclopedia2.thefreedictionary.com/Pyrometallurgy

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Transport Phenomena**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0403			Semester**: IV**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	2	5	60	60	40	40	200

Course Outcomes

After completion of this course students will be able to gain knowledge about following

- To provide knowledge about the basic concept of heat transfer and its different modes.
- To analyze different modes of heat transfer with examples in day to day life.
- To demonstrate the application of various factors & mathematical equations governing the heat transfer in the system.
- To solve different numerical pertaining to all three modes of heat transfer for different systems.
- To demonstrate the phenomena of conduction, convection & Radiation by conducting laboratory scale experiments.
- To make the students understand the concept of fluid behavior & its relevance for different modes of mass transfer.
- To analyze the mass & momentum balance equations to understand the diffusion phenomenon in metallurgical systems.

2. Contents

		Allotted hours
Unit1	Fluid flow and its relevance to mass transfer. General mass transport equation. Modes of mass transfer. Film and boundary layer theories. Diffusion, Generalized diffusion equation. Diffusivity in gases, liquids and solids. Steady, diffusion. Pseudo-steady diffusion. Diffusion through porous solids. Convective mass transfer- Mass transfer in fluid at solid-fluid interface. Mass transfer between two fluids. Mass transfer v/s chemical control, enhancement of process rates. Applications in metallurgical system	8 hours

Unit2	Definition and classification of fluids. Viscosity, Newtonian and non- Newtonian fluids. Viscous and non-viscous fluids. General features of fluid flow. Laminar and turbulent flow, Newton's law of viscosity, Pascal's law	8 hours
Unit3	Differential mass balance (continuity equation). Differential momentum balance (equation of motion). Navier Stokes Equation. Application of Differential Balance Equation. Overall mass balance and momentum balance. Euler's equation and its integration to obtain Bernoulli's equation. Bernoulli's Equation, Applications of Bernoulli's Equation, Flow through porous media.	12 hours
Unit4	Modes of heat transfer. Conduction of heat through solid. Steady and unsteady state. Fourier law of heat conduction. General equation of heat conduction in Cartesian co-ordinate, spherical and cylindrical systems. Convective heat transfer. Free and forced convection. Application dimensional analysis of effective boundary layer. Aspects of Radiative Heat Transfer. Reflection, absorption and transmission of radiation. Black body radiation. Planck's Law. Wein's distribution Law. Heat transfer between two bodies by radiation. Lambert's Law.	10 hours

3. Transport Phenomena Lab (List of Experiments)

Experiment No	Title
1	To study about various fluid properties and fluid flows.
2	To determine Reynold's number for fluid flow
3	Measurement of pressure difference using manometers
4	To verify Bernoulli's theorem.
5	To apply Bernoulli's equation to Venturimeter
6	To apply Bernoulli's equation to Orificemeter

7	To study the fundamentals of heat transfer
8	To determine thermal conductivity of insulating powder using sphere in sphere method.
9	To measure overall heat transfer coefficient for given composite wall with help of composite wall apparatus.
10	To determine temperature distribution and the effectiveness of fin.
11	To determine the surface heat transfer coefficient for a vertical tube losing heat by natural convection.
12	To determine convective heat transfer coefficient in force convection
13	To determine Stefan-Boltzmann constant
14	To determine emissivity for the given surface
15	Study of mass transfer

4. Text Books

1) Rate Processes in Metallurgy -A. K. Mohanty (2009)
2) Principles of Extractive Metallurgy -A. Ghosh and H. S. Ray (2006)
3) Elements of Heat and Mass Transfer -Prof. R. C. Patel (1963)
4) Fundamentals of Heat and Mass Transfer -Inpropera and Dewitt (1986)
5) Rate Phenomena in Process Metallurgy -J. H. Szekely and N. J. Themelis(1971)

5. Reference Books

1) Fundamentals of Momentum, Heat and Mass Transfer -J. R. Welty, C. E. Wicks (Pub.- Wilson Wiley) (2008)
2) Chemical Engineering -J. M. Coulson and J. F. Richardson (Pub.- Mc Hill ELBS) (1971)
3) Engineering in Process Metallurgy -RLL Guthrie (Pub.- Oxford).(1989)
4) Heat Transfer -Yunus Cengel (2003)

6. Digital Learning Resources

http://nptel.ac.in/courses/112101097/

http://nptel.ac.in/courses/112105171/

7. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Metallurgical Thermodynamics**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0404				Semester**: IV**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

1. Course Outcomes

After completion of this course students will be able to gain knowledge about following

- Student can get the knowledge about the basic concept of system, properties of system and thermodynamics
- Students can analyze and understand all the laws of thermodynamics.
- They can demonstrate the application of various factors & mathematical equations governing the thermodynamics in the system
- They will able to solve different numerical pertaining to all three laws of thermodynamics for different systems
- They can demonstrate the phenomena of Ellingham diagram and its importance pertaining to metal oxides.
- They can understand thermodynamics of solutions ideal & non ideal solution
- They can describe basis of phase rule & its application and various equilibrium using thermodynamics and correlation for binary alloy systems.

2. Contents

		Allotted hours
Unit1	Importance of thermodynamics, Definition of thermodynamic terms, Concept of system, states and equilibrium, Types of system, Extensive and intensive properties, Homogeneous and heterogeneous systems, Quasistatic process, Zeroth law of thermodynamics. First law of thermodynamics, Internal energy, Heat capacity, Specific heat and latent heat, Enthalpy, Isothermal and adiabatic processes.	8 hours

Unit2	State properties, Heat of reaction, Heat of formation, Standard heats, Heat of transition, Hess's law, Kirchoff's law equation. Second law of thermodynamics, Entropy of irreversible processes, Auxiliary functions, combined statements of 1^{st} and 2^{nd} laws, Maxwell's relations, Third law of thermodynamics, Temperature dependence of entropy, Statistical interpretation of entropy, Consequences of third law, Nernst heat theorem	10 hours
Unit3	Concept of fugacity, activity and mole fraction, Activities in concentrated solution, Activity, Gas phase Reactions (H_2O- H_2 and CO_2 –CO mixtures), Activity in industrial liquid metallic solution, Equilibrium constant, Gibb's-Helmholtz equation. Van't-Hoff equation, Clausius – Clapeyron equation, Reactions involving solid and gases, Thermodynamics of solutions, Ideal solution, Raoult's law, Henry's law, Non-ideal solution Gibb's-Duhem equation, Partial molar properties of mixing,	10 hours
Unit4	Excess functions, Concept of 1 wt% standard state and Interaction coefficient, Regular solutions, Sievert's law-residual gases in steel, Phase relations and phase rule-its applications, Free energy-composition and temperature-composition diagrams for binary alloy systems and their correlation, determination of liquidus, solidus and solvus lines, Effect of pressure on phase transformation and phase equilibrium, Ellingham diagram in detail for metal oxides.	10 hours

3. Text Books

1) Introduction to Metallurgical Thermodynamics, R. H. Tupkary, T. U. Publishers, (1995).
2) Introduction to Materials and Metallurgical Thermodynamics, A. Ghosh, PHI, (2009).
3) Metallurgical Thermodynamics Kinetics & Numericals by Dr. S.K.Dutta, (2011), S. Chand Publications.

4. Reference Books

1) Problems in Metallurgical Thermodynamics and Kinetics, G. S. Upadhyaya and R. K. Dube, Pergamon Press , (1977).
2) Physical Chemistry of Metals, L. S. Darken and R. W. Gurry, McGraw Hill (1953).

5. Digital Learning Resources

https://www.khanacademy.org/science/physics/thermodynamics/v/thermodynamics--part-1
http://nptel.ac.in/courses/113106031/
http://chemwiki.ucdavis.edu/Physical_Chemistry/Thermodynamics/Thermodynamic_Cycles/Hess%27s_Law

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Energy Economy & Waste Management**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0405			Semester: **IV**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	60	0	40	0	100

1. Course outcome:

On completion of the course students will be able to:

- Understand economic and ability to apply economic and financial evaluation of energy projects.
- Learning the basics of cost calculation for electricity and heat production from CHP and power plants
- Design processes for the treatment of waste water and the sludges that arise from them;
- Discuss the operational aspects of handling hazardous wastes; and
- Describe methods for the recycling and minimization of solid wastes.

2. Contents

		Allotted hours
Unit 1	**Introduction** Energy basics; Energy defined, Alternative classifications of Energy, India and world energy consumption and trade. Energy and multidimensional interactions, Introduction to energy system, Energy balance, Analysis of energy balance information, Energy demand, Management of Energy Demand, Economy of energy supply.	8 hours
Unit 2	**Fossil Fuel Markets** Coal, oil, natural gas. Economics of Non-Renewable resource supply. **Financing Energy Development** Energy resources and economic rent (economic rent, leasing and taxation of energy resources, government revenues), Allocation of resources over time and financing energy development (discounting, "levelized" costs of renewable resources, Cost Benefit Analysis, Laffer Curve, Interrelationship between energy system and LCOE, depletion of non-renewable resources), GDP, GNP, Energy futures.	10 hours

Unit 3	**Solid Waste Management & Disposal** Introduction to solid waste management, the disposal decades, the nature of the problem, Methods of waste disposal (Treatment/disposal Technologies): dumping, sanitary landfills mechanical-biological treatment, incineration, anaerobic digestion, composting; recycling of plastics, batteries.	10 hours
Unit 4	**Liquid Waste Management** Introduction to liquid waste management, types and sources of liquid waste, Management of liquid waste: Human waste management, sullage management, Industrial waste management, Collection, storage, and treatment of liquid waste: septic tanks, anaerobic biogas reactor, and Centralized wastewater treatment systems.	10 hours

3. Text Books:

1) Energy Economics: Concepts, Issues, Markets and Governance by Subhes C. Bhattacharyya, 2011.
2) Energy Economics: A Modern Introduction by Ferdinand E. Banks, 2003.
3) Waste Management and Resource Recovery By Charles R. Rhyner, Leander J. Schwartz, Robert B. Wenger, Mary G. Kohrell, 2000.

4. Reference Books:

1) Environmental science by Eldon Enger, Bradley Smith. McGraw Hill, 2000.
2) Solid/liquid separation: waste management and productivity enhancement: by H. S. Muralidhara, 1989.
3) International Handbook on the Economics of Energy edited by Lester C. Hunt, Joanne Evans, 2009 Edition.
4) Energy Economics: Growth, Resources, and Policies by Richard John Eden, 1982.

5. Digital Learning Resources

http://www.youtube.com/watch?v=Ie8VxbIM1Kc
http://www.youtube.com/watch?v=PaBNI6Q6Sss
http://www.cyen.org/innovaeditor/assets/Solid%20waste%20management.pdf
http://www.tn.gov.in/dtp/liquid_wm.htm
https://www.escondido.org/Data/Sites/1/media/pdfs/Utilities/BMPLiquidWasteManagement.pdf

6. Question Paper for end semester Examination:

As per Appendix A

Subject: **Cyber Security and Intellectual Property Rights**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: CE0407			Semester: **IV**		
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
01	00	00	00	60	00	40	00	100

Learning Objectives

1. To facilitate understand & critical understanding about Cybercrimes, Ethical Hacking, cyber security, forensics and cyber laws
2. Exploration of the legal and policy developments in various countries for cyber space
3. To provide in-depth knowledge of Information Technology Act, 2000 including Information Technology Amendment Act, 2008
4. Understanding e-Governance, Electronic Contracts, e-Banking & Secure electronic records

UNIT-I **[3 hours]**

Introduction:

Information Security Overview, Cyber security, Cyber security objectives and policies, Differences between Information Security & Cyber security, Cyber security Principles, Introduction of Cyber crime, Classifications of Cybercrimes.

UNIT-II **[3 hours]**

Security Threats and vulnerabilities:

Overview of Security threats, Hacking Techniques, Password Cracking, Insecure Network connections, Malicious Code, Programming Bugs, Cyber crime and Cyber terrorism, Information Warfare and Surveillance. Applicationsecurity(Database,E-mailandInternet).

UNIT-III **[3 hours]**

Overview of Security Management:

Overview of Security Management , Security Policy , Security Procedures and Guidelines , Risk Management , Security Laws**, System Security** (Desktop, email,web), Intrusion Detection Systems, SecurityTechnology-FirewallandVPNs ,Backup SecurityMeasures.

UNIT-IV **[3 hours]**

Cyber law- Intellectual property right:

Introduction, Objectives of Intellectual property law, Types of IPR, Advantages of IPR, IPR in India, Offences and Penalties.

Text Books

1. "Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives", Nina Godbole, SunitBelapur, Wiley India Publications, April, 2011

Reference Books

1. CharlesP.Pfleeger,ShariLawerancePfleeger,"AnalysingComputerSecurity", PearsonEducationIndia.
2. .K.Pachghare,"CryptographyandinformationSecurity",PHI LearningPrivateLimited,DelhiIndia.
3. Dr.SuryaPrakashTripathi,RitendraGoyal,PraveenkumarShukla,"Introductionto InformationSecurityand CyberLaw"WilleyDreamtechPress.
4. Schou,Shoemaker,"InformationAssurancefortheEnterprise",TataMcGrawHill.
5. CHANDER,HARISH**,"**CyberLawsAndIt Protection**"**,PHILearningPrivateLimited,Delhi,India

Online courses:

- https://www.youtube.com/watch?v=yjmQurhbVas
- https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-858-computer-systems-security-fall-2014/video-lectures/
- https://www.youtube.com/watch?v=mut5Z9Ajva4
- https://www.youtube.com/watch?v=MI5KxHookDs
- https://www.youtube.com/playlist?list=PLRkCJvWSrxbt-xBX5cjzTr4pE0SZ-pIOf

5TH SEMESTER

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

B-TECH METALLURGICAL ENGINEERING, SEMESTER –V TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017														
SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME						
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	MT0501	Heat Treatment Principles and Practices	03	00	02	04	05	30	10	60	40	60	200
2	MT0502	Iron Making	04	00	02	05	06	30	10	60	40	60	200
3	MT0503	Foundry Technology	04	00	02	05	06	30	10	60	40	60	200
4	MT0504	Non Ferrous Extractive Metallurgy	03	02	00	04	05	30	10	60	00	00	100
5	MT0505	Plastic Deformation of Metals	03	02	00	04	05	30	10	60	00	00	100
6	MT0506	Surface Engineering	04	00	00	04	04	30	10	60	00	00	100
7	SH0507	Technical Communication and Soft Skills	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**22**	**04**	**06**	**26**	**32**	180	60	360	120	180	900

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

Subject: **Heat Treatment Principles and Practices**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0501				Semester: **V**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	2	5	60	60	40	40	200

1. COURSE OUTCOMES :

- To make the students aware about the basic information processes.
- To impart the knowledge about the Different heat treatment processes and different
- The central point of this course is to provide a physical basis that links the structure of materials with their properties, focusing primarily on metals. With this understanding in hand, the concepts of alloy design and microstructural engineering are also discussed.

2. Course Content:

		Allotted hours
Unit 1	**Principles of heat treatment of steels:** Phase Transformation on heating, Forming of austenite, Kinetics of formation of austenite, Nucleation sites in eutectoid steels, Austenitic grain size, Grain growth, Determination of austenitic grain size, Importance of austenitic grain size **TTT (Time Temperature Transformation) and CCT (Continuous Cooling Transformation) diagrams:** Method of plotting, Types of TTT diagram, Critical cooling rate, Effect of alloying elements on TTT diagram, Applications, Continuous cooling transformation diagram, Limitations of Iron-Iron Carbide Diagram, Effect of Alloying elements on CCT diagram.	8 hours
Unit 2	**Pearlitic transformation:** Mechanism of transformation, Kinetics of transformation, Hull-Mehl model of pearlitic transformation, Effect of alloying elements on transformation, Interlameller spacing, **Bainitic transformation:** Characteristics, Mechanism of transformation, Bainitic structure. **Martensitic transformation:**	10 hours

	Diffusionless transformation, Mechanism of transformation, Kinetics of transformation, M_s - M_f temperatures, Athermal and isothermal martensites, Effect of applied stress on transformation, Habit planes, Bain distortion model / crystallographic theory of martensitic transformation, Tempered Martensite, Retained austenite, Martensitic transformation in non-ferrous systems such as Fe-Ni and Cu-Al systems.	
Unit 3	**Heat treatment processes:** Stress relieving, Annealing – full annealing, partial annealing, bright annealing, diffusion annealing, recrystallization annealing, Spheroidizing, Normalizing, Hardening and Tempering, Hardening of typical steels, cast irons and non-ferrous alloys. **Surface hardening of metals:** Principles involved in induction and flame hardening methods and application of selective hardening, Laser hardening, Case carburizing (solid, liquid and gaseous), Cyaniding, Carbonitriding, Nitriding, Plasma nitriding etc., Depth of penetration - its measurement and relation with time and temperature, Hardening & Hardenability of steels.	10 hours
Unit 4	**Special methods of heat treatment:** Austempering, Martempering, Ausforming, Patenting, Sub-zero treatment etc., Thermo Mechanical treatments. Heat treatment of carbon steels, alloy steels, tools and dies steels, stainless steels (with reference to carbide precipitation and sigma phase formation) and cast irons – specific examples, Heat treatment of Aluminum alloys, titanium alloys and copper alloys, Concept of age-hardening. Design for heat treatment, Heat treatment furnaces- their temperature and atmosphere control, Defects in heat treated parts, Causes for the defects in heat-treated parts and remedies.	10 hours

3. Heat Treatment of Alloys Lab (List of Experiments)

Experiment No	Title
1	Annealing of Medium / High carbon steels
2	Characterization of annealed steel
3	Normalizing of Medium / High carbon steels
4	Characterization of normalized steel
5	Spheroidizing of High carbon steel
6	Characterization of spheroidized steel
7	Hardening of medium/ high carbon steels
8	Characterization of hardened steel
9	Tempering of medium/ high carbon steels
10	Characterization of tempered steel
11	To examine the effect of quenching media on hardening of steel
12	To measure the hardenability of steel using Jominy End-Quench test
13	To study the case hardening processes
14	Carburizing of low carbon steels
15	Case depth measurement and characterization of carburized steels

3. Text Book:

1) Heat Treatment (Principles and Techniques) by T. V. Rajan, C. P. Sharma and A. Sharma, PHI
2) Physical Metallurgy for Engineers by D. S. Clark and W. R. Varney, East-West

4. Reference Books

1) Introduction to Physical Metallurgy by S. H. Avner, Tata Mc-Graw Hill
2) Engineering Physical Metallurgy and Heat Treatment by Yu. M. Lakhtin, MIR Publishers
3) Material Science and Metallurgy for Engineers by V D Kodgire and S V Kodgire, Everest Publishing House
4) Heat Treatment of Metals by Vijendra Singh
5) Physical Metallurgy (Principles and Practice) by V. Raghvan, PHI
6) Heat Treatment of Metals by Zakharov
7) ASM Handbook on Heat Treating, Vol. 4
8) Handbook of Heat Treatment by K. H. Prabhudev, Tata Mc-Graw Hill

5. Digital Learning Resources

http://nptel.ac.in/courses/113105024/

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Iron Making**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0502			Semester: **V**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	2	5	60	60	40	40	200

1. Course Outcomes:

- Know the overall idea of how Irons are produced ,about the history of Iron making and availability of raw materials for iron production various techniques of raw material preparation for charging in iron making furnace, construction and operation of iron making furnace and reactions occurring in the furnace , reaction mechanism inside the blast furnace.
- The 'Metallurgist' will be able to acquire M Tech /ME / MSc(engg) & PhD degrees in order to enhance , sustain and nurture his/her professional career by : Joining any national institutes like IIT, NIT, IISc in various specialized fields of metallurgical & materials engineering such as Industrial metallurgy, Steel technology.
- For a 'Metallurgist', there are a lot of job opportunities with tremendous growth in almost all types of industrial sectors in the present scenario. These jobs include different functions such as Managerial role, Material Scientist, Techno-commercial Manager, Quality control &assurance, Marketing &Sales, Project &Planning.
- Services such as ONGC, IOCL, SAIL, GAIL, ESSAR, ISPAT,laboratories of national and inter-national repute such as NASA,BARC, BARC, CSIR, NML, DRDO, DMRL, IPR, etc.
- There is plenty of scope and feasibility for a 'Metallurgist' to go for self employment by setting up an 'Enterprise/ Industrial Unit in Setup a small foundry of ferrous and non-ferrous metals.

2. Contents

		Allotted hours
Unit1	General: History of iron making. Occurrence, distribution and evaluation of raw materials (iron ore, coal and flux) for iron making. Burden materials and burden preparation: Burden preparation, Burden qualities. Agglomeration- Sintering-process, variables and	8 hours

	machines. Pelletization process, Theory of bonding. Mechanism of ball formation, Disc and drum pelletizer, Induration of pellets, cold bonding technique and testing of pellets.	
Unit2	Blast Furnace (B.F.) Constructional features: Profile, Refractories, Accessories, Charging mechanism, Bell and bell-less charging systems. B.F. – Reactions: Physico-chemical principles of blast furnace. Blast furnace reactions. Reaction in stack, tuyere zone, bosh and hearth. Thermodynamics equilibria, Direct and indirect reduction. Kinetics of iron-oxide reduction, Slag-metal reactions, Desiliconization, Desulphurization.	10 hours
Unit3	B.F. – Operations: Operational steps, Blast furnace irregularities and remedial measures, Blast furnace gas, properties, cleaning and utilization.	10 hours
Unit4	Alternative Methods of Iron Making: Reduction smelting, Direct reduction processes, Fluidized bed process, Electro thermal process and mini blast furnace.	10 hours

3. Iron Making Lab (List of Experiments)

Experiment No	Title
1	Identification of raw material for iron making
2	Bulk density Measurement
3	Determination of Angle of Repose
4	Sintering of iron ore fines
5	Pelletization of iron ore fines
6	Induration behavior of pellets
7	Box compression test of hardened or indurated pellets
8	Tumbling/Drum test of green and indurated pellets
9	Shatter Test of agglomerated products
10	Drop Test of agglomerated products
11	Study of ISP layout
12	Charge calculations for raw materials in Blast Furnace

13	Study of different parts of Blast Furnace
14	Chemical analysis of Iron based products
15	Study of Briquetting Process

4. Text Book(s)

1) Introduction to Modern Iron Making, R. H. Tupkary, (Khanna Pub.)
2) Iron Making and Steel Making: Theory and Practice, A. Ghosh and A. Chatterjee, (Prentice Hall)
3) Principles of Blast Furnace Iron Making, A. K. Biswas, (SBA Pub.)

5. Reference Books

1) Making, Shaping and Treating of Steels, A. W. Cramb (Editor) (11th Edition, Vol. 1 & 2, AISE, Pittsburg)
2) Blast Furnace: Theory and Practice,J. G. Peacey and W. G. Davenport, (Pergamon Press, Oxford)
3) Blast Furnace Iron Making, J. J. Gupta and Amit Chatterjee, (SBA Pub.)

6. Digital Learning Resources

www.steeluniversity.org.in
http://nptel.ac.in/

7. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Foundry Technology**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0503				Semester: **V**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	2	5	60	60	40	40	200

1. **Course Outcomes** :

- Knowledge about the fundamentals of the casting, basic terminology related to casting process.
- Students will be aware about the alternative method for the manufacturing of component for engineering applications.
- Get knowledge about how to manufacture the intricate casting what should be the process parameter, design of pattern, mould, etc.
- Students will be aware about the melting practice of different cast alloy
- Get knowledge to overcome defects generated during casting

2. **Contents**

		Allotted hours
Unit 1	**General:** Introduction to metal casting and foundry industry in modern industrial scenario. Advantages and limitations of casting methods. Classification of foundries. Different sections in a foundry and their functions. Important cast metals and alloys-their composition, properties and uses. **Patternmaking:** Patterns. Types. Pattern making materials and their selection, Color code, Pattern allowances, Core-boxes and their types.	8 hours
Unit 2	**Moulding and Core-making Materials:** Ingredients of common type of moulding and core-making sands, their properties and behavior, testing of sands and clay. **Moulding Processes:** Classification, Brief description of processes such as green sand, dry sand, loam, floor, Pit and machine molding. No-bake molding process. CO2-Silicate process	10 hours

Unit 3	**Casting Processes:** Shell molding and casting process, Investment casting process, Permanent molding process. Gravity and Pressure Die-casting, Centrifugal casting process. Low Pressure Die-casting (LDPC) process. **Melting:** Melting of cast iron, Constructional features of Cupola, Principles and operation of Cupola furnace. Advances in cupola melting operation, Melting of aluminum and Copper-based alloys. Furnaces used, Melt-treatments such as degassing, Grain refining and modification.	10 hours
Unit 4	**Gating System:** Elements of gating system. Classification. Gating design considerations, Gating ratio. Gating practice for ferrous and non-ferrous alloys, Pouring equipments. **Risering System:** Risering practice, Functions of riser, Directional and progressive solidification. Centerline feeding resistance. Riser efficiency. Riser design considerations. Risering curves. Cain's, N.R.L. and Modulus methods, Feeding distance and feeding aids, Blind and atmospheric risers **Quality Control in Foundry:** Casting defects, their causes and remedies. Shop floor quality control tests such as composition control, Wedge test, fluidity, temperature measurement etc.	

3. Foundry Technology Lab (List of Experiments)

Experiment No	Title
1	Introduction to foundry laboratory.
2	To detrmine AFS fineness number and distribution coefficient of agiven sand sample
3	To demonstrate the working of sand muller
4	To determine the clay content of given sand sample
5	To prepare standard samples under identical condition for checking important physical properties of foundry sand
6	To determine compression strength of foundry sand
7	To determine permeability number of green sand,core sand and raw sand
8	To find out the green mould hardness of the sand mould
9	To determine shatter index of the sand sample.
10	To determine moisture content of the prepared sand

11	To prepare core sand
12	To findout the hardness of dried cores made out of core sands
13	To perform peelback test on core sand
14	To perform hot distortion and tensile tests on core sand
15	To study the aluminum melting and casting

1. **Text Book(s)**

    1) Principles of Metal Casting, R. W. Heine, C. R. Loper and P. C. Rosenthal, (Tata McGraw Hill)
    2) Principles of Foundry Technology, P. L. Jain, (Tata McGraw Hill).

4. Reference Books

1) Fundamentals of Metal Casting Technology, P. C. Mukherjee, (Oxford & IBH)
2) Foundry Technology, P. R. Beeley
3) Foundry Engineering, H. F. Taylor, M. C. Flemings,(Wiley Eastern)
4) Foundry Technology, D. Kumar & S. K. Jain, (CBS Pub.)

5. Digital Learning Resources

http://nptel.ac.in/

6. Question Paper Pattern for End Sem Exam :

As per Appendix A

Subject: **Non Ferrous Extractive Metallurgy**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0504			Semester: **V**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

1. Course Outcomes

- To make the students aware about basics of Non Ferrous metals and its extraction processes
- To impart the knowledge about the basic steps followed in Extraction and its importance After extraction of pure metal from their respective ores
- To develop the knowledge regarding the auxiliary operation and the advancement in various extractive process.

2. Contents

		Allotted hours
Unit 1	**General:** World resources of Non-ferrous metals and their occurrence. Present and future position of non-ferrous metallurgical industry in India-resources, production and consumption. Indian scenario of non-ferrous ores and mineral deposits. Production plants for non-ferrous metals such as copper, zinc, lead, tin, Aluminum, nickel, magnesium, titanium, etc. Basics of Pyrometallurgy, Hydrometallurgy and electrometallurgy	8 hours

Unit 2	**Aluminum:** Occurrence of Bauxite. Bayer's process for production of alumina. Alternatives to Bayer's process. Hall-Heroult process-conventional and new materials for construction of Aluminum reduction cell, nature of electrolyte. Electrolysis of alumina with emphasis on physico-chemical principles and secondary-reactions, factors affecting current efficiency. Alternatives to Hall-Heroult process. Refining of Aluminum. **Copper:** Occurrence of copper ores. Roasting. Matte-smelting, Converting and Refining process as applied to copper production and their physico-chemical aspects. Single step and multistep continuous processes. Hydrometallurgical process for production of primary copper. Recovery of copper from copper slag.	10 hours
Unit 3	**Nickel:** Occurrence of nickel ores, Pyrometallurgical and Hydrometallurgical processes for nickel production and refining. **Lead and Zinc**: Occurrence of lead and zinc ores, Pyrometallurgical and Hydrometallurgical processes for lead and zinc production and their physio-chemical aspects, Refining of lead and zinc, Recovery of byproducts. **Tin:** Occurrence of tin, various methods of extraction of tin from its ores and other sources. Uses of tin.	10 hours
Unit 4	**Gold and Silver:** Occurrence of gold and silver. Various methods for production of gold and silver from their ores and other sources. Recovery of gold, silver and platinum from secondary sources such as Copper Anode Mud, Red Mud, Zinc dross and electrolytic solutions. **Magnesium:** Occurrence of magnesium, Methods of production of magnesium oxide and magnesium chloride, Pyrometallurgical extraction of magnesium, Electrolytic extraction and refining of magnesium. **Titanium**	10 hours

	Occurrence of titanium, Extraction, Production, recovery, properties and application.	

3. Text Book(s)

1) Extraction of nonferrous metals, H.S. Ray, R. Sridhar and K.P. Abraham Affiliated East West Press Pvt Ltd., New Delhi (2007).

4. Reference Books

1) W.H. Dennis, Extractive Metallurgy, Philosophical Library, New York (1965)
2) F. Habashi, Principles of Extractive Metallurgy, Vol.1, Gordon and Breach, New York (1969).
3) T. Rosenqvist, Principles of Extractive Metallurgy, McGraw Hill, New York (1983)
4) J.L. Bray, Nonferrous production metallurgy, Wiley, New York(1954)
5) R.D. Pehlke, Unit processed in extractive metallurgy, Elsevier, Amsterdam (1082)
6) H.S. Ray and A. Ghosh, Principles of extractive metallurgy, Wiley Eastern Ltd., New Delhi (1991)
7) Introduction to melts - molten, salts and slags, Allied Pub. Pvt. Ltd., New Delhi (2006)
8) H.S. Ray, B.P Singh and Sarama Bhattacharjee, Energy in minerals and metallurgical processes, Allied Publishers Ltd, New Delhi (2005)

5. Digital Learning Resources

http://nptel.ac.in/courses/113105021/

6. QUESTION Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Plastic Deformation of Metal**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0505			Semester: **V**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

1. Course Outcomes

After completion of this course students will be able to gain knowledge about following

- To provide knowledge about the basic concept crystals their structures and their defects that is point , line, volume and surface defects
- To teach them basics about dislocations and how dislocations help in improving properties.
- To teach them various strengthening mechanism of metals.
- To solve different numerical pertaining to resolved shear stress and hall petch equation.
- To help them understand fracture mechanics like ductile and brittle fracture & give them knowledge about fracture mechanics.
- To introduce them about testing and specially creep and fatigue testing in detail.
- To solve practical example on the same testing and demonstrate them.
- To make them understand various heat treatments and their basics.

2. Contents

		Allotted hours
Unit 1	Crystal Imperfections, Point Defects, Line Defects & Surface Defects, Dislocation and its types, Slip Phenomena, Slip Systems. Theoretical strength of a perfect Crystal, Slip by dislocation movement concept of critical resolved shear stress, Climb and its types, Twinning as a mode of deformation, Burgers vector and the dislocation loop, Stress fields and energies of dislocations, Jogs and Kinks.	8 hours

Unit 2	**Dislocation:** Dislocation in F.C.C (including formation of stacking fault.) B.C.C and H.C.P., Forces. Multiplication of dislocations, Techniques to observe dislocation, Dislocation point defects interactions, Intersection of Dislocations, Dislocations pile up. Deformation of single and polycrystalline materials, Grain boundaries. Low-angle boundaries, High Angle Grain Boundaries Surface tension of the grain boundary, Strengthening from grain boundaries, Hall-petch equation, Yield point phenomenon.	10 hours
Unit 3	Strain- hardening of polycrystalline metals, Strain hardening of single crystals, Relation between single and polycrystalline stress-strain curve, Solid – Solution hardening. Strengthening due to second phase particles, Strain – ageing behavior, Annealing of cold-worked metals, Recovery, Recrystallization and grain growth. All types of tests, Modes of Failure, Theory of ductile-brittle transition temperature (DBTT).	10 hours
Unit 4	Types of fracture in metals. Theoretical cohesive strength of metals. Griffith theory of brittle fracture, Elementary concept of fracture mechanics, Fatigue test. Theory of fatigue. Effect of metallurgical variables and temperature. Creep test, Creep curve. Stress-rupture test, Creep mechanisms. High temperature alloys. Effect of some metallurgical variables. Presentation of engineering creep data.	10 hours

3. Text Books

1) Mechanical Metallurgy – G.E.Dieter, M.C. Graw- Hill (1976).
2) Physical Metallurgy Principles- R.E. Reed-Hill, Divan-Nostrand Company (1964).
3) Deformation and Fracture Mechanics of Engineering Materials – Richard W. Hortzberg, John Wiley & Sons (1996).
4) Structure and Properties of Materials, Vol.III, Mechanical Behaviour, John Wulff, H.W. Hayde, W.I.Moffatt, Wiley Eastern Private Ltd (1988).

4. Reference Books

1) Mechanical Behaviour of Materials T. H. Courtney (2005).
2) Testing of Metallic Materials –A. V. K. Suryanarayan (Pub.-PHI, New Delhi), (1976).

5. Digital Learning Resources

http://www.youtube.com/watch?v=BeZLOyqwPgQ

http://www.youtube.com/watch?v=hJPK_40NO2M

http://www.learnerstv.com/video/Free-video-Lecture-23057-engineering.htm

http://www.learnerstv.com/video/Free-video-Lecture-23058-engineering.htm

6. Question Paper Pattern for End SemExam:

As per Appendix A

Subject: **Surface Engineering**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0506			Semester: **V**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	0	40	0	100

1. Course Outcomes :

- To understand the concept and basis of surface engineering.
- To understand the various methods of surface modification techniques.
- Understanding of the various modification phenomena.
- From application point of view students can co-relate various techniques with desired properties and applications.
- It will help students to understand various advanced machineries and their working principles like plasma, laser, and ion beam, etc.

2. Contents

		Allotted hours
Unit1	Scope of surface engineering in metals, ceramics, polymers and composites, Surface Preparation methods such as Chemical, Electrochemical, Mechanical- Sand Blasting, Shot peening, Shot blasting, Hydroblasting, Vapor Phase Degreasing etc., Properties of Various Coating, Coating Methods.	8 hours
Unit2	Chromating, Phosphating, Anodizing, Thermochemical processes, industrial practice, economy and energy considerations. Electrolytic and Electroless plating of important metals and alloys	10 hours
Unit3	Surface pretreatments, Hot Dipping, galvanizing, testing/evaluation of surface properties. **Coating from Vapour Phase** PVD, CVD, Various Methods used, mechanisms, important reactions involved and applications.	10 hours
Unit4	Sputtering, Plasma Spray & Ion Implantation Methods, mechanisms & applications. Surface modification by directed energy beams like	10 hours

	ion, electron and laser beams, novelty of composition and microstructures. **Diffusion Coating:** Various Techniques For Single And Multiple Element Coating, High Temperature Coating- Carburising, Carbonitriding,Silicanizing,Chromizing, Aluminizing, Boronizing, Boronitriding.	

3. Text Book(s)

1) J. R. Davis-Surface Engineering for Corrosion and Wear Resistance.
2) George J. Rudzki -Surface Finishing Systems. metal and non-metal
3) finishing handbook-guide, Metals Park : ASM, 1983
4) James A. Murphy- Surface Preparation and Finishes for Metal, McGraw-Hill, New York 1971

4. Reference Books

1) P. G. Sheasby and R. Pinner - Surface treatment and finishing of
2) Aluminum and its alloy,Volume-2, 5th ed., ASM, Metals Park, 1987
3) K. E. Thelning -Steel and its Heat Treatment Bofors Handbook, London Butterworths, 1975
4) Surface Engineering Hand Book, edited by Keith Austin, London
5) Kogan Page, 1998
6) ASM Handbook
7) Rajiv Mishra on Friction Stir Surfacing & Friction stir Processing

5. Digital Learning Resources:

www.nptel.ac.in

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Technical Communication and Soft Skills**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: SH0507				Semester: **V**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
1	0	0	0	60	00	40	00	100

Course Objectives:

1. To enable students to interact with a degree of fluency and spontaneity that makes regular interaction with fluent English speakers quite possible without strain for either party.
2. To understand with ease virtually everything heard or read.
3. To express themselves spontaneously, very fluently and precisely, differentiating finer shades of meaning even in the most complex situations.
4. To understand sentences and frequently used expressions related to areas of most immediate relevance (e.g. very basic personal and family information, shopping, local geography, employment).
5. To communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters
6. To understand the main ideas of complex text on both concrete and abstract topics, including technical discussions in their field of specialization.

Course Content:

	Sr. No.	Content
Listening	1	Listening: Cloze test
	2	Listening to Talks (BBC, TED) 1
	3	Listening to Talks 2
Speaking	4	Phonetics: Sounds & Symbols & Accent Patterns
	5	Vocabulary Games: Intermediate Level
	6	Vocabulary Games: Intermediate Level
	7	Building Dialogues: Situational Conversation
	8	Role Play
	9	Group Discussion

Reading	10	How to Read effectively
	11	Reading to Remember : SQ3R

Writing	12	Grammar Intermediate: Sentence Transformation
	13	Common Errors in English
	14	Précis Writing
	15	Effective Paragraph Writing

6TH SEMESTER

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

B-TECH METALLURGICAL ENGINEERING, SEMESTER –VI TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017														
SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME						
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	MT0601	Steel Making	04	02	00	05	06	30	10	60	00	00	100
2	MT0602	Electrometallurgy and Corrosion	04	00	02	05	06	30	10	60	40	60	200
3	MT0603	Powder Metallurgy	04	00	02	05	06	30	10	60	40	60	200
4	MT0604	Metal Forming	03	02	00	04	05	30	10	60	00	00	100
5	MT0605	Material Characterization (EL – 1)	03	02	00	04	05	30	10	60	00	00	100
	MT0611	Computational Materials Science (EL – 1)											
	MT0612	MOOC Course – 1 (EL – 1)											
6	MT0606	Industrial Ceramics & Polymers (EL – 2)	04	00	00	04	04	30	10	60	00	00	100
	MT0607	Nano Technology (EL – 2)											
	MT0608	Composite Materials (EL – 2)											
	MT0609	Nuclear Metallurgy (EL – 2)											
	MT0610	Modelling of Metallurgical (EL – 2)											
7	SH0607	Advanced Technical Communication and Soft Skills	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**23**	**06**	**04**	**27**	**33**	**180**	**60**	**360**	**80**	**120**	**800**

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

Subject: **Steel Making**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0601			Semester: **VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	2	0	5	60	0	40	0	100

1. Course Outcomes:

- Know the overall idea of how steels are produced ,about the history of steel making and availability of raw materials for iron production various techniques of raw materials preparation for charging in steel making furnace, construction and operation of steel making furnace and reactions occurring in the furnace , reaction mechanism inside the blast furnace .
- The 'Metallurgist' will be able to acquire M Tech /ME / MSc(engg) & PhD degrees in order to enhance , sustain and nurture his/her professional career by :
- Joining any national institutes like IIT, NIT, IISc in various specialized fields of metallurgical & materials engineering such as Industrial metallurgy, Steel technology.
- For a 'Metallurgist', there are a lot of job opportunities with tremendous growth in almost all types of industrial sectors in the present scenario. These jobs include different functions such as Managerial role, Material Scientist, Techno-commercial Manager, Quality control &assurance, Marketing &Sales, Project &Planning.
- Services such as ONGC, IOCL, SAIL, GAIL, ESSAR, ISPAT, laboratories of national and inter-national repute such as NASA,BARC, BARC, CSIR, NML, DRDO, DMRL, IPR, etc.
- There is plenty of scope and feasibility for a 'Metallurgist' to go for self employment by setting up an 'Enterprise/ Industrial Unit in Setup a small foundry of ferrous and non-ferrous metals.

2. Contents

		Allotted hours
Unit1	General: Old Steel Making practices. Modern equipment and practices. Integrated Steel Plants in India. Mini steel plants their advantages and limitations – present scenario.	8 hours

	Physical Chemistry of Steel Making: Thermodynamic and Kinetics of Refining Reactions, Carbon, Phosphorus, Sulphur and Silicon Reactions. Refining Slag and its Properties. Importance and Mechanism of decarburization. Reaction at Slag Metal interface.	
Unit2	Basic Oxygen Steel Making: BOF practice, Equipment, Operation and Process, slag Metal reactions in B.O.F. Raw material and flux practices. Kaldo, OBM, LD-AC, Rotor process, Top and Bottom blowing processes. Oxygen Lance: Design, Construction and Operation. Top and Bottom Blown processes, Its advantages and disadvantages Electric Steel Making: Electric Arc Furnaces: Types and construction. Sequence of operations. Various additions at Different Stages, Slag Control. UHP Arc Furnaces. Arc Furnace practices for Carbon and Low Alloy Steels. Modern developments in ARC furnaces.	10 hours
Unit3	Quality Steel Making: Introduction, Sources of Inclusions, Sulphur, Phosphorus, and Gases in Steels. Kinetics of Deoxidation of Molten Steel, Application of Ellingham Diagrams, Thermodynamics of Reaction During Degassing of Liquid Steel, Fluid Flow and Mixing in Ladle, Kinetics and Mass Transfer, Ladle Injection Metallurgy, Desulphurization & Dephosphorization. Secondary Steel Making: Metallurgical Principles in Secondary Steel Making and Secondary Steel Making Processes. Ladle Furnaces (L.F.), Vacuum Systems and Vacuum treatment of Steel. Removal of Gases from steel. LF-VD processes and AOD, VOD, VAD techniques, R-H degassers. Ladle Stirring and its Advantages. ESR Principle And Technology. Deoxidation – Theory and practice, Floatation's of deoxidation products, Modifications of Inclusions. Injection Metallurgy	10 hours
Unit4	Inclusions in Steel: Influence of Inclusions on Mechanical Properties of Steel, Inclusion, Identification and Cleanness Assessment, Origin of Non Metallic Inclusions, Inclusion Control Continuous Casting (C.C.) and Ingot Casting: 6 Hrs Ingot Casting: Types of Moulds, Advantages and Disadvantages. Ingot Defects and Remedies. Continuous casting: C.C. machines with its various units and types. C.C. of Blooms, Slabs and Thin slabs EM S of Moulds. Reoxidation prevention methods during Steel Casting. Advantage of C.C.	10 hours

	Environmental issues related to Steel Making, Heat Transfer & Solidification Rate in Ingot Casting and Continuous Casting, Distinguishing Metallurgical Aspects of Continuous Casting of Steel.	

3. Text Book(s)

1) An Introduction to Steel Making Tupkary R.H. - Khanna Publishers, Delhi.
2) Manufacture of Iron And Steel Vol I& II Bashforth- Asia Publishing House, Mumbai.

4. Reference Books

1) Making, Shaping and Treating of Steels, A. W. Cramb (Editor) (11th Edition, Vol. 1 & 2, AISE, Pittsburg)
2) Introduction to Physical Chemistry of Steel Making: - R.G.Ward, ELBS.
3) Steel Making; Kudrin V. Mir Publisher, Moscow, 1985

5. Digital Learning Resources

www.steeluniversity.org.in

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Electrometallurgy & Corrosion**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0602			Semester**: VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	2	5	60	60	40	40	200

1. Course Outcomes:

- Understand the origin of the difference in electrical potential across an interface, in particular, a metal/electrolyte interface.
- Understand the relationship between rates of electrochemical reactions and the potential drop across interfaces.
- Understand the causes of and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, and various modes of environmentally assisted cracking.
- Be knowledgeable of the influence of a material's composition and microstructure on its corrosion performance.
- Be knowledgeable of the effect of an electrolyte's composition on the corrosion of metals.
- Be able to identify materials that will exhibit adequate corrosion resistance in a particular environment.
- Be able to propose economically viable remedial actions that will eliminate or reduce corrosion to a tolerable level.

2. Contents

		Allotted hours
Unit 1	**Basics of Electrochemistry** Faradays' laws of electrolysis, current efficiency, current density, electrode potentials, Thermodynamics and Kinetics of Electrode Processes- Polarization Curves, Concept of Over-Potential, Kinetics Of Passivity and Transpassivity, Nernst's Equation, Emf Series, Evan's Corrosion Diagram, Galvanic Series. Pourbiax Diagram for Metal Water System, Applications and Limitations.	8 hours

Unit 2	**Forms of Corrosion** The relevance of corrosion studies, forms of corrosion, Uniform Corrosion, Galvanic Corrosion, Crevice Corrosion, Pitting Corrosion, Intergranular Corrosion, Selective Leaching, Erosion Corrosion, stress cracking corrosion, Hydrogen Damage **High Temperature Corrosion** High Temperature Corrosion in Different Atmosphere, Effect of Doping, Alloying Elements, Coating Methods for High Temperature Corrosion Protection, Pilling Bedworth Ratio and its Applications.	10 hours
Unit 3	**Corrosion Protection** Principles of Protection, Selection of Suitable Design, Inhibition, Coating Methods, Anodic protection and Cathodic protection **Electro deposition** Classification and mechanism of electrodeposition processes. Electroplating of copper, Nickel and Chromium. Principles of Alloy plating and electroless plating, Anodising, Galvanizing.	10 hours
Unit 4	**Factors affecting Corrosion** Environment affecting corrosion, effects of soil, chemicals, moisture and atmospheric gases,temperature and velocity, metallurgical factors **Corrosion Testing** Physical and Electrochemical Methods such as ASTM standard methods A262 Practice A to E and their equivalents, Surface Preparation, Exposure Technique, Corrosion Rate Measurements **Material Selection to Combat Corrosion** Specific Corrosion Applications Such as Marine Industry, Petrochemical Industry, High Temperature Service, Chemical Industry, Automobile, High Temperature & High Pressure corrosion in Industries	10 hours

3. Electrometallurgy and Corrosion Lab (List of Experiments)

Experiment No	Title
1	To prepare the samples for corrosion testing.
2	To determine corrosion rate of given sample by weight loss method in Sulfuric acid solution.

3	To determine corrosion rate of given sample by weight loss method in Sodium Chloride (NaCl) solution.
4	To determine corrosion rate of given sample by weight loss method in Hydrochloric acid solution.
5	Comparative study of corrosion rate by weightless method for different acid solutions.
6	To study and perform IGC corrosion of stainless steel.
7	Determination of Inter granular corrosion susceptibility by microstructure evaluation.
8	To study and observe galvanic corrosion of two metals.
9	Observation of Effect of anodic area and type of material on galvanic corrosion of metals.
10	To perform & observe pitting corrosion in stainless steel.
11	To study & perform the effect of current density on anodic dissolution.
12	To perform the electroplating of copper on a given base metal.
13	To perform the Anodizing of Aluminum in H_2SO_4 Solution.
14	To study and perform cathodic protection of a metal by sacrificial anode method.
15	To Study corrosion rate by Tafel Extrapolation method.

4. Text Book(s)

1) M. G. Fontana, Corrosion Engineering (Third Edition) McGraw-Hill Book Company (NY) (1987).

5. Reference Books

1) Denny A Jones, Principles and Prevention of Corrosion (second edition), Prentice-Hall, N. J. (1996).
2) H. H. Uhlig and R. W. Revie, Corrosion and Corrosion Control, Wiley (NY) (1985).
3) L. L. Shreir, Corrosion. Vol I and II, Butterworths, Kent (1976).
4) M.Pourbaix, Atlas of Electrochemical Equilibria in aqueous solutions, NACE, Houston (1974).
5) J. O. M. Bockris and A. K. N Reddy, Modern Electrochemistry. Vol. I and II, Plenum Press (NY) (1970).
6) J. D. A Miller, Microbial Aspects of Metallurgy, Medical and Tech. Pub. Co. Lancaster (1971).

7) C. A. C. Sequeira, Microbial Corrosion, European Federation of Corrosion, Maney Pub. (2000).
8) B. J. Little, Microbiologically Influenced corrosion, Wiley-Intersciene (2007)
9) H. Videla, J. F. Wilkes, R. A. Silva, Manual of Biocorrosion, CRC Press (1996).
10) S.W. Borenstein, Microbiologically influenced corrosion handbook, Woodhead Pub. Ltd, Cambridge (1994).

6. Digital Learning Resources

www.nptel.ac.in

7. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Powder Metallurgy**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0603				Semester: **VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	2	5	60	60	40	40	200

1. Course Outcomes:

Student will be able to:

- Define and explain basic conditions of successful application of powder metallurgy technology for production of materials and components
- Formulate advantages and disadvantages of powder metallurgy
- Evaluate and propose optimum technology for preparation of powder materials
- Classify typical representatives of individual powder metallurgy technologies
- Evaluate and evaluate influence of individual technological parameters on basic powder metallurgy operations
- Optimize material and technological parameters of production

2. Content:

		Allotted hours
Unit1	Introduction: Historical and modern developments in P/M. Advantages limitations and applications of Powder Metallurgy. Characteristics of metal powder in terms of particle size , shape and size distribution, Characteristics of powder mass such as apparent density, tap density, flow rate, friction conditions. Properties of green compacts and sintered compacts.	8 hours
Unit2	Important methods of metal powder manufacturing like machining, milling, atomization, electrodeposition, reduction from oxide, carbonyl process, production of alloy powders, new development. Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, types of compaction presses, compaction tooling and role of lubricants. Single and double die compaction, isostatic pressing, hot pressing, effect of variables on sintering, sintering atmospheres and sintering furnaces.	10 hours

Unit3	Powder rolling, powder forging, powder extrusion and explosive forming technique Definition of sintering, stages of sintering	10 hours
Unit4	Mechanism of sintering, liquid-phase sintering, infiltration process. Study of sintered bearings, cutting tools, and metallic filters. Study of friction and antifriction parts and electrical contact materials.	10 hours

3. Powder Metallurgy Lab (List of Experiments)

Experiment No	Title of experiment
1	To study the sieve analyses of metal powders and determine the correction factor.
2	To study the particle size and shape of metal powders by Image analyzer.
3	To study the importance of blending and mixing operation for powder metallurgy.
4	To determine the apparent density and tap density of metal powders.
5	To determine the friction index and flow rate by hole flow meter.
6	To study and carry out heat treatment on metal powders.
7	Demonstrations of single action die compaction of metal powders by hydraulic press.
8	To study the sintering mechanism of metal pellets.
9	Characterization of sintered product.
10	To produce metal powder by Water Atomization Technique
11	Characterization of metal powder produced by water atomization technique
12	To produce metal powder by Gas Atomization Technique
13	Characterization of metal powder by Gas Atomization Technique
14	Copper powder production by electrolysis method.
15	Characterization of copper powder produced by electrolysis method.

4. Text Book(s):

1) Introduction to Powder Metallurgy by A.K.Sinha, 2011.

2) Principles of powder metallurgy by W.D. Jones, 1960.

5. Reference Books:

1) Handbook of powder metallurgy by Henry Herman Hausner, 1973.
2) Powder Metallurgy Technology by G. S. Upadhyaya, 2002.

6. Digital Learning Resources

http://thelibraryofmanufacturing.com/powder_processes.html
http://en.wikipedia.org/wiki/Powder_metallurgy
https://www.google.co.in/#q=powder+manufacturing+techniques
http://www.ttu.ee/public/m/Mehaanikateaduskond/Instituudid/Materjalitehnika_instituut/MTX0100/powder.pdf

7. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Metal Forming**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0604			Semester: **VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

1. Course Outcomes:

- Understand the principle of deformations and energy requirements.
- Understand different methods of deformations to produce various shapes.
- Get knowledge of special techniques of deformation.

2. Contents

		Allotted hours
Unit 1	**Fundamentals of metal working:** Yield criteria, Von-Mises equation, Classification of metal forming processes, Mechanics of metal working, Flow curve for materials, Temperature in Metal Working, Hot working, Cold working & Warm working, Strain rate effect of metallurgical structure and non-metallic inclusion on the manufacturing process, Workability, Residual stresses, Annealing of cold-worked metals.	8 hours
Unit 2	**Forging:** Classification of forgoing processes, Forging equipment and operations, Open die forging, Closed die forging, Plane strain forging analysis, Forging defects, Metallurgical variables associated with forging, Powder metallurgy forging, Residual stresses in forging. **Rolling:** Terminology of rolled products, Different kinds of rolling mills, Deformation zone in rolling, Neutral point, Angle of bite, Forward slip, Roll flattening, Rolling variables, Hot rolling, Cold rolling, Rolling of blooms billets, slabs, plates, strips, sheets, bars, rods & light section, Lay out of different mills for rolling of above products, Elementary roll pass design, Forces and geometrical relationships in rolling, Defects in rolled products.	10 hours

Unit 3	**Extrusion:** Classification of extrusion processes, Direct and indirect extrusion, Impact extrusion, Hydrostatic extrusion, Extrusion equipment, Extrusion ratio, Process variables, Lubrication & defects in extrusion, Derivation of extrusion pressure, Extrusion of tubing, Production of seamless pipe and tubing. **Drawing:** Rods, wires and tubes: Theory and practice of wire drawing, Wire drawing equipment, Variables in wire drawing, Defects in formed products.	10 hours
Unit 4	**Sheet metal working:** Shearing, Blanking, Bending, Stretch forming, Deep drawing, Spinning, Piercing, Swaging, Embossing, Coining, High energy rate forming, explosive forming, electromagnetic forming, electro hydraulic forming, formability diagrams, Super-plasticity.	10 hours

3. Text Book(s)

1) Mechanical Metallurgy by G. E. Dieter, SI Metric Editions, McGraw-Hill Book Company, 1988.

4. Reference Books

1) Manufacturing Technology (Foundry, Forming and Welding) by P. N. Rao, TMH, 2007.
2) Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddell, PTR Prentice-Hall (USA), 2011
3) Handbook of Metal Forming by K. Lange (Editor-in-Chief), Springer Verlag (Germany), 1985.

5. Digital Learning Resources

http://nptel.ac.in/courses/112106153/
http://www.doitpoms.ac.uk/tlplib/metal-forming-1/index.php
http://www.doitpoms.ac.uk/tlplib/metal-forming-2/index.php
http://freevideolectures.com/Course/2368/Manufacturing-Processes-I/4http://freevideolectures.com/Course/2368/Manufacturing-Processes-I/12

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Material Characterization (Elective – 1)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0605			Semester**: VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

1. **Course Outcomes :**
   - Theory and practice of x-ray and electron diffraction.
   - Basic elements of electron microscopy.
   - Basic aspects of optical characterization methods including Raman and infrared spectroscopy
2. **Contents**

		Allotted hours
Unit 1	Importance of Material characterization, Classification of techniques for characterization. Image formation, resolving power, numerical aperture, empty magnification, depth of focus, components of microscopes, important lens defects and their correction, principles of phase contrast, interference and polarized light microscopy, Image analyzer.	8 hours
Unit 2	Thermal Analysis techniques: Basic Principles, Working and applications of DTA, TGA, TMA and DSC.	10 hours
Unit 3	Studies by electron microscopes: Principle, Construction and Working of TEM, SEM, STEM with their merits, demerit and applications, techniques of replica preparation.	10 hours
Unit 4	X-Ray diffraction and their applications: Working principles of diffractometer. Indexing of XRD patterns, determination of crystal structure, lattice parameter, and crystallite size by diffraction techniques. Numerical based on XRD.	10 hours

	Spectroscopic and Chemical analysis Techniques: IR & Raman spectroscopy, Energy Dispersive Spectroscopy (EDS) & Wavelength Dispersive Spectroscopy (WDS), XRF.	

3. Text Book(s)

1) J.M. Walls, Editor, Methods of Surface Analysis: Techniques & Applications, Cambridge University Press, 1990.
2) John P. Sibilia, A guide to Material Characterization & Chemical Analysis, VCH Publishers, 1988.
3) An Introduction to Materials Characterization by P. R. Khangaonkar, Penram International Publishing (India) Pvt. Ltd, 2010.

4. Reference Books

1) Joseph I Goldstein, Dale E Newbury, Patrick Echlin and David C Joy, "Scanning Electron Microscopy and X-Ray Microanalysis", 3rd Edition, 2005.
2) Spencer, Michael, Fundamentals of Light Microscopy, Cambridge University Press, 1982.
3) David B. Williams, C. Barry Carter, " Transmission Electron Microscopy: A Textbook for Materials Science", Springer, pub. 2009.
4) Joseph I Goldstein, Dale E Newbury, Patrick Echlin and David C Joy, "Scanning Electron Microscopy and X-Ray Microanalysis", 3rd Edition, 2005.
5) Encyclopedia of Materials Characterization,' Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson.
6) B.D.Cullity and S.R.Stock, "Elements of X-Ray Diffraction" Third edition, Prentice Hall, NJ, 2001.
7) G.W.H. Hohne, W.F. Hemminger, H.-J. Flammersheim, "Differential Scanning Calorimetry", Springer, 2nd rev. a. enlarged ed., 2003.
8) 'Fundamentals of light microscopy and electronic imaging' Douglas B. Murphy, 2001, Wiley-Liss, Inc. USA.

5. Digital Learning Resources

www.tedpella.com/books_html/books.htm
www.net/biobooks_1_electron-microscopy.html ; www.mt.com/ta

MOOC: Fundamentals of optical and scanning electron microscopy: https://swayam.gov.in/course/1399-fundamentals-of-optical-and-scanning-electron-microscopy

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Computational Materials Science (Elective – 1)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0611			Semester: **VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	0	40	0	100

1. Course Outcomes

- This course will give students hands-on experience with popular computational materials science and engineering software through a series of projects in: electronic structure calculation, molecular simulation, phase diagram modeling, finite element modeling, and materials selection.
- The course will familiarize students with a broad survey of software tools in computational materials science, scientific computing, and prioritize the physical principles underlying the software to confer an understanding of their applicability and limitations.

2. Course Content

		Allotted hours
Unit 1	Introduction to Computational Materials Science, multiple scales in crystalline materials, materials scales for modeling, Introduction to simple numerical methods for solving coupled differential equations and for studying correlations, applications.	8 hours
Unit 2	Introduction to quantum mechanical modeling: Hartree-Fock and Density function theory (DFT), plane wave based DFT calculations, equilibrium properties and surfaces from DFT calculations, atomistic modeling of defects in materials, applications. Introduction to Monte Carlo Methods: Kinetic, Lattice, applications.	10 hours
Unit 3	**Classical equilibrium statistical mechanics:** Phase space, Hamiltonian's equation, macroscopic translation and rotation, phase space coordinates, canonical transformations, applications.	10 hours

	Molecular Dynamics: Introduction, brief MD algorithm, microcanonical ensemble (NVE), velocity-verlet algorithm, canonical ensemble (NVT), applications.	
Unit 4	**Multiscale methods:** Introduction to multiscale models, sequential multiscale models, concurrent multiscale models, Hierarchial methods, partitioned-domain methods, spanning time scales, Statistical mechanics of systems in metastable equilibrium, applications. Introduction to phase diagram modeling using CALPHAD and Thermo-Calc, applications.	10 hours

3. Text Book(s)

1) Modeling Materials: Continuum, Atomistic and Multiscale Techniques, Ellad B. Tadmor and Ronald E. Miller (2011) Cambridge University Press.

4. Reference Books

1) Guo X.Z. (Ed.), 2007, "Multiscale Materials Modelling: Fundamental and Applications", Woodhead Publishing Limited, Cambridge.
2) Raabe D., 1998, "Computational Materials Science", Wiley VCH Verlag GmbH.

5. Digital Learning Resources

http://nptel.ac.in/

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Industrial Ceramics & Polymers (Elective – 2)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0606			Semester**: VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	0	40	0	100

1. Course Outcomes:

- Students will be able to understand the various types of ceramic and different between advance and traditional ceramics.
- They can understand the developing methods of raw materials.
- They can get the understanding of sintering mechanism of ceramics and characteristics of sintered ceramics.
- They can get the knowledge of processing method of ceramics.
- They can understand the process that is used to produce glass–ceramics.
- They can get the idea about properties, applications of different clay products, refractory ceramics and abrasive ceramics.
- Comparison between traditional and advance ceramics
- Application of advance ceramics
- They can understand the polymer molecule in terms of its chain structure and, in addition, how the molecule may be generated from repeat units
- They can understand the number–average and weight–average molecular weights, and degree of polymerization

2. Contents

		Allotted hours
Unit 1	Introduction, definition and scope of ceramics. Historical perspective, classification, Structure of ceramics, Pauling's Rules, Ceramic Phase Diagrams, Silicate structures. **Traditional ceramics**: An overview, history, raw materials, Shaping, sintering, abrasives, White wares, Glazing and decoration. **Refractories:** Types of refractories, fireclay, mullite, silica refractories, magnesite refractories, carbide & nitride refractories, pure oxide refractories, chrome refractories	8 hours

Unit 2	**Glass:** Nature of glass, structure, glass forming systems, silicate systems, non-silicate systems, Types of Glasses, manufacture of glass, Viscous Deformation of Glasses, Ceramic Glass, Advance ceramics and their application. **Processing of Ceramics**: Processing of ceramic powders, shape forming operations- Dry pressing, isostatic pressing, Hot Pressing, HIP, slip casting, Extrusion method, injection molding, hot pressing and hot isostatic pressing, Sol –gel processing and monolithic ceramics. Thermal Treatment- Drying & Firing of ceramics: kiln design & sintering mechanism and densification, **Properties:** (Thermal, Mechanical & Optical properties) of sintered ceramics. Ceramics used for energy and environment technologies (fuel cell, lithium battery, gas sensor and catalytic support), ceramic coating, ceramic in bio-medical application, nanotechnology and ceramics	10 hours
Unit 3	Historical Background, Basic concepts of polymeric materials, Classification and forms of Polymers, Tacticity, Functionality, Different types of polymerization, chemistry of Polymerization: Chain polymerization, Step polymerization, Polymerization Techniques: Bulk polymerization, Solution polymerization, Suspension polymerization, and Emulsion polymerization.	10 hours
Unit 4	Molecular weight & Size, Determination of molecular weight - methods for measuring number average, weight average, viscosity average MW, Molecular weight distribution, Degree of Polymerization, Polymer Degradation, Glass transition temperature, Crystallinity, Elastomers, Fiber and plastic, Additives, Processing of polymers- Extrusion, Injection Molding, Transfer Moulding, and Blow Molding.	10 hours

3. Text Book(s)

1) Chemistry of solids – by A. K. Galwey, Chapman & Hall Publication
2) Properties of Matter – by Thomas Pollack, McGraw Hill publication
3) Fundamentals of Ceramics – Barsoum
4) Introduction to Ceramics - W.D Kingery
5) J. S. Reed: - Introduction to the principles of ceramic processing
6) Chemistry of Glasses - A. Paul

4. Reference Books

1) The Science and Engineering of Materials- by Donald R. Askeland
2) Materials Science & Engineering- by William F Smith
3) Introduction to Ceramics by F.H.Norton.
4) Materials Science and Processes, S. K. Hajra Choudhary, Indian Book Distributing Co., Ilifo book distributors Co., Kolkata, 1985
5) Materials Science and Engineering by William F Smith.

5. Digital Learning Resources

www.nptl.ac.in

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Nano Technology (Elective – 2)**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0607				Semester: **VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	0	40	0	100

1. Course Outcomes:

After a successful completion of the course, students should be able to:

- Describe and explain Nanotechnology.
- Describe Nanomaterials based on their dimensionality.
- Explain the importance of reduction in materials dimensionality, and its relationship with materials properties
- Explain top-down approaches for Nanomaterial fabrication, and give some examples
- Perform a literature survey on a chosen topic in the scientific literature
- Write a scientific report with appropriate references and citations.
- Present results of a research in the form of an oral presentation.

2. Contents

		Allotted hours
Unit 1	**Introduction** to Nanomaterials and nanotechnology, historical developments. An overview of scope & applications of nanotechnology, classifications and types of Nanomaterials. Basic understanding of various phenomena at nanoscale namely size confinement, interfacial surface phenomena.	8 hours
Unit 2	**Introduction to basic building blocks** namely atoms, molecules, self-assembly, carbon nanotubes, nanocrystals, fullerenes, quantum dots, and quantum wires. Functional properties of nanomaterials such as physical, mechanical, electrical, magnetic, chemical and optical properties. Size dependence of material at nano scale. Bulk vs. nano properties of materials.	10 hours
Unit 3	**Synthesis & fabrication techniques** 'Top down' vs. 'Bottom-up' approach of synthesis.	10 hours

	Review of synthesis methods namely sol-gel method, chemical vapour deposition, physical vapour deposition, sputtering, etc. Consolidation methods for nanopowders such as cold isostatic pressing (CIP), hot isostatic pressing (HIP), Dynamic compaction, Conventional and Microwave sintering.	
Unit 4	**Characterization of nanomaterials** by using transmission electron microscopy (TEM, atomicforce microscopy (AFM). Applications of nanomaterials namely nanograined structuralmaterials & nanocomposites, nanomagnetic materials, chemical applications etc.	10 hours

3. Text Book(s)

1) Nano Materials by A.K.Bandopadhyay New Age International Publishers
2) Introduction to Nanoscience and Nanotechnology by K.K.Chattopadhyay and A.N.Banerjee, PHI Learning Pvt. Ltd.
3) Nanostructured Materials: Professing, Properties and Applications, ed. by C.C. Koch, William Andrew Publishing, New York, 2002.

4. Reference Books

1) Nanotechnology by George Timp, Springer-Verlag, New York, 1999.
2) Nanoparticles and Nanostructured Films: Preparation, characterization & Applications, ed. By J.H. Fendler, John Willey & Sons, 1998.
3) Handbook of Nanophase and Nanostructured Materials, ed. by Z.L. Wang, Z. Zhang and Y. Lim, Kluwer Academic Publisher, 2002.
4) Handbook of Nanostructured Materials and Nanotechnology, ed. by H.S. Nalwa, Vol. 1-5, Academic Press, 2002.
5) Carbon Nanotubes: Science and Applications ed. by M. Meyyappan, CRC Press, Boca Raton Florida, 2004.
6) Processing and Properties of Structural Nanomaterials, Leon L. Shaw, C. Suryanarayana & Rajiv S. Mishra, TMS, 2003.
7) Nanomaterials: Synthesis, Properties & Applications, ed. by A.S. Edelstein and R.C. Cammarata, published by Institute of Physics, UK, 1996.

5. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Composite Materials (Elective – 2)**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0608				Semester**: VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	0	40	0	100

1. Course Outcomes:

- Name the three main divisions of composite materials, and cite the distinguishing feature of each.
- Cite the difference in strengthening mechanism for large-particle and dispersion-strengthened particle-reinforced composites.
- Distinguish the three different types of fiber reinforced composites on the basis of fiber length and orientation; comment on the distinctive mechanical characteristics for each type.
- Calculate longitudinal modulus and longitudinal strength for an aligned and continuous fiber reinforced composite.
- Compute longitudinal strengths for discontinuous and aligned fibrous composite materials.
- Note the three common fiber reinforcements used in polymer-matrix composites, and, for each, cite both desirable characteristics and limitations.
- Cite the desirable features of metal-matrix composites.
- Note the primary reason for the creation of ceramic-matrix composites.
- Name and briefly describe the two subclassifications of structural composites.

2. Contents

		Allotted hours
Unit 1	Introduction, Review of current developments, Importance of Composites over other materials. Advantages and disadvantages of composite materials, Matrix and reinforcement phases, Classification of composite materials, Types of composite materials – dispersion strengthened composites, particulate composites, concretes, Fiber-reinforced Composites, Structural composite.	8 hours

Unit 2	Types of reinforcements – Whiskers and fibers, preparation, structure and properties of different reinforcing fibers, carbon fibers, glass fibers, polymer fibers and alumina fibers. Fiber-reinforced Composites: Influence of Fiber Length, Critical Fiber Length, Short and Continuous Fibers, Influence of Fiber Orientation and Concentration, Fiber reinforced composites with different matrix systems, polymer matrix (thermoset and thermoplastic) composites, metal matrix composites and ceramic matrix composites, carbon-carbon composite, intermetallic composites.	10 hours
Unit 3	Strengthening mechanisms, Aspect Ratio, Rule of Mixture, Role of interfaces in composites, Toughening mechanisms in PMCs, MMCs, and CMCs, Wettability and bonding. Properties of composites: Mechanical Properties of composite, Effect of fiber volume content, orientation of fibers & void contents on mechanical properties of composite, fracture behaviour of composites, Applications of composites in different field, Environmental effects in composites.	10 hours
Unit 4	Fabrication of composites, Fiber Forms, Prepregs, Moulding Compounds-Processes, Lay-Ups, Filament Winding, Pultrusion, vacuum bag moulding, Pressure bag moulding, vacuum impregnation and injection moulding, transfer moulding, Green composites; Synthesis and Properties of Nanocomposites, Hybrid composites.	10 hours

3. Text Book(s)

1) K.K. Chawla, Composite Materials – Science & Engg., Springer- Veslag, New York, (1988).
2) Mel M. Schwartz, Composite Materials: Properties, Non-destructive testing and Repair, Prentice Hall, New Jersey, (1996).
3) L.J. Broutman and R.M. Krock, Modern Composite Materials, Addison-Wesley, (1967).
4) David A Colling & Thomas Vasilos, Industrial Materials: Polymers, Ceramics and Composites, vol. 2, Prentice Hall, N. Jersey, (1995).

4. Reference Books

1) The Science and Engineering of Materials by D. R. Askeland, Fifth Edition, 2006
2) Hand Book of composites – G. Lubin, 1982.

3) An introduction to composites materials – D. Hull, 1996.

5. Digital Learning Resources

http://nptel.ac.in/syllabus/syllabus.php?subjectId=113107045
http://www.netcomposites.com/guide/polymer-composites/2

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Nuclear Metallurgy (Elective – 2)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0609			Semester: **VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	0	40	0	100

1. Content:

		Allotted hours
Unit1	Atomic Structure: Fundamental Properties. Atomic Nucleus. Radio activity, half life period and isotopes Fission, fusion and other nuclear reactions. Critical mass. Neutron cross section, Multiplication factor and nuclear disintegration.	8 hours
Unit2	Essential parts of Nuclear Reactor. Reactor types, Reactor Fuel Cycle. Indian atomic power plants, Nuclear power program me in India and future trends. Difference in separation methods as compared to conventional methods.	10 hours
Unit3	Purity requirement of nuclear metal. Separation process- Ion and Solvent extraction techniques. Occurrence, extraction mechanical and physical properties and uses of Uranium and Thorium. Occurrence, extraction mechanical and physical properties and uses of Zirconium, hafnium and plutonium.	10 hours
Unit4	Methods of enrichment and production of ultrahigh purity metals and their importance in nuclear metallurgy. Influence of neutron damage on mechanical properties. Effects of radiation damage on steel and Zircalloys, Scope of beryllium in nuclear plants. Extraction, occurrence, physical and mechanical properties of Be and its applications, Reactor pressure vessel embrittlement (indicating parameters, mechanisms, mitigation methods).	10 hours

3. Text Book(s)

1) Nuclear Reactor fuel elements – Metallurgy & Fabrications-Kaufmann, 1962.

4. Reference Books

1) Extraction of non ferrous metals- H.S.Ray, 2006.
2) Handbook of Nuclear Engineering: Vol. 1: Nuclear Engineering Fundamentals,edited by Dan Gabriel Cacuci, Springer, 2010.
3) Proceedings of Seminar on Nuclear metallurgy-Bombay chapter

5. Digital Learning Resources

https://www.euronuclear.org/1-information/energy-uses.htm

http://www.youtube.com/watch?v=ueainTAy7G0

http://www.cdc.gov/niosh/ocas/pdfs/abrwh/pres/2012/dc-nmi0912fc.pdf

http://en.wikipedia.org/wiki/Synthesis_of_precious_metals

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Modelling of Metallurgical Processes (Elective – 2)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0610			Semester**: VI**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	0	40	0	100

1. Course Outcomes

- Description of metallurgical and materials processes and some simulation applications.
- Fundamental principles, methods, and approaches of simulation and modeling.
- Developing the theoretical background of metallurgical processes' simulation and modeling.
- To understand the importance and necessity of simulation and modelling studies in metallurgical and materials processes.
- Improve his/her theoretical background on simulation and modelling of metallurgical and materials processes.
- Be aware of the resulting innovations by applying simulation and modelling software.
- Create a model of a given metallurgical process by considering the related control parameters.

2. Course Content

		Allotted hours
Unit1	Introduction to modelling & simulation, Basic principles of modelling & simulation, Mathematical and physical basis of modeling & its methodology, Basic approaches and techniques of modelling & simulation, Examples of metallurgical and materials processes.	8 hours
Unit2	Mass and energy balances, and simultaneous solutions, In-class demonstration of modelling software, Modeling and Simulation in Materials Science, Application of the methodology for materials behavior and processing problems, Modeling of structural materials, Description of certain metallurgical processes (roasting, smelting, leaching, precipitation, electrolysis, refining, etc.) and steps of their mathematical modelling and approaches.	10 hours

Unit3	Concepts of batch, and continuous processes in metallurgy, Determining the effect of controlling parameters, such as composition, temperature, particle size, concentration, pressure, gas/liquid/solid flow rate, stirring speed, current density, etc., and mathematical modelling thereof. Assigning these parameters to the student groups as term projects.	10 hours
Unit4	Case studies on mathematical modelling from iron and steel making will be discussed such as modelling of blast furnace, basic oxygen furnace, electric arc furnace, ladle furnace, ingot casting, continuous casting, forging, electroslag refining, sheet metal forming etc. some case studies on physical modelling such as ladle furnace, tundish, continous casting etc.	10 hours

3. Text Book(s)

1) Engineering Process Metallurgy, R. I. L. Guthrie, Oxford University Press.
2) Barber Z.H., 2005, "Introduction of Materials Modeling", Maney Publishing.
3) King P.R., 2001, "Modeling and Simulation of Mineral Processing Systems", ISBN:0-7506-4884-8.West

4. Reference Books

1) Mosterman P. J.,2013, "Realtime simulation technologies: principles, methodologies, and applications", (Eds. Popovici K., Mosterman P. J.), Taylor & Francis Group, LLC., CRC Press, Boca Raton, FL, USA. ISBN: 978-1-4398-4665-0.
2) Ghasem N., 2012, "Computer methods in chemical engineering", Taylor & Francis Group, LLC., CRC Press, Boca Raton, FL, USA. ISBN: 978-1-439-84999-6.
3) Peters E., Dreisinger D., 1990, "Mixing, Leaching and Modelling Course Notes", Metals and Materials Eng. Dept., Univ. of British Columbia, Vancouver, Canada.
4) Bautista G.R., Wesely J.R., Warren W.G., 1986, "Hydrometallurgical Reactor Design and Kinetics", A Publication of The Metallurgical Society, Inc., U.S.A.
5) Bryson W.A., 1981, "Modelling the Performance of Electrowinning Cells", Proceedings Hydrometallurgy 81, Manchester 1981, pp.G2/1-G2/11.

5. Digital Learning Resources

http://nptel.ac.in/

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Advanced Technical Communication And Soft Skills**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: SH0607			Semester: **VI**		
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
1	0	0	0	60	00	40	00	100

	Sr. No.	Content
Speaking	1	Vocabulary Games: Advanced Level
	2	Role Play 1
	3	Role Play 2
	4	Role Play 3
	5	Selected speeches & Songs: Declamation 1
	6	Selected speeches & Songs: Declamation 1
	7	Report Presentation Seminar
	8	Report Presentation Seminar
	9	Report Presentation Seminar
	10	Interview Skills (Mock Interview Sessions 2)

Writing	11	Writing Reports
	12	Making Proposals
	13	Resume Building
	14	Letter, Email application

Reference Books:

1. Fred Luthans, Organizational Behaviour, McGraw Hill
2. Lesikar and petit, Report writing for Business
3. M. Ashraf Rizvi, Effective Technical Communication, McGraw Hill
4. Wallace and masters, Personal Development for Life and Work, Thomson Learning
5. Hartman Lemay, Presentation Success, Thomson Learning
6. Malcolm Goodale, Professional Presentations

7. Farhathullah, T. M. Communication skills for Technical Students
8. Michael Muckian, John Woods, The Business letters Handbook
9. Herta A. Murphy, Effective Business Communication
10. Lehman, Dufrene, Sinha BCOM, Cengage Learning

Web resources/ MOOCs:

Introduction to English Language & Literature Mod-1 Lec-1
https://www.youtube.com/watch?v=xC3M9EqduyI

The English Language Mod-1 Lec-
https://www.youtube.com/watch?v=HsR4jFszFdw#action=share

International English Mod-1 Lec-4
https://www.youtube.com/watch?v=FT4cQkXCc8g

Effortless EnglishRule-1 English Phrases:
https://www.youtube.com/watch?v=r5z-lilm-gg

Pronunciation Training Techniques:
https://www.youtube.com/watch?v=wB8mr4iViy0

Make Body Language Your Superpower:
https://www.youtube.com/watch?v=wB8mr4iViy0

English Job Interviews | Best Answers to Questions:
https://www.youtube.com/watch?v=wB8mr4iViy0

7TH SEMESTER

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

B-TECH METALLURGICAL ENGINEERING, SEMESTER –VII TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017														
SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME						
								THEORY			PRACT		TOTAL
			L	T	P			CIE		ESE	CIE	ESE	
								MID	IE				
1	MT0701	Metal Joining Processes	03	00	02	04	05	30	10	60	40	60	200
2	MT0702	Non-Destructive Testing	04	00	00	04	04	30	10	60	00	00	100
3	MT0703	Alloy Design	03	02	00	04	05	30	10	60	00	00	100
4	MT0704	Material Testing and Standards	03	00	02	04	05	30	10	60	40	60	200
5	MT0705	Selection of Materials and Failure Analysis	03	02	00	04	05	30	10	60	00	00	100
6	MT0706	Advanced Ferrous Metallurgy (EL – 2)	04	00	00	04	04	30	10	60	00	00	100
	MT0707	Advanced Materials and Applications (EL – 2)											
	MT0708	Advanced Foundry Technology (EL – 2)											
	MT0709	Phase Transformations (EL – 2)											
	MT0710	Advances in Thin Film Technology (EL – 2)											
	MT0711	Industrial Welding Codes and Standards (EL – 2)											
	MT0712	MOOC Course – 2 (EL – 2)											
7	CV0712	Disaster Management	01	00	00	00	01	00	00	00	00	00	00
TOTAL			**21**	**04**	**04**	**24**	**29**	180	60	360	80	120	800

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

Subject: **Metal Joining Processes**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0701			Semester: **VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	60	60	40	40	200

1. Course Outcomes

- Understand the basics & importance of joining processes.
- Understand the various types of Joining operations used in the industries
- Co-relating the basic machine products with the of product applicability & use skills for specific joining processes.
- Developing the capability to analyze and select the various criteria of Quality joining of the metals
- Implement effectively and accurately the suitable joining process to improve the efficiency & life of the product / Machines
- Learn various quality dimensions of joints, cost factor, factor of safety etc.
- Understanding the advance processes of joining& its applicability;
- Joining any national institutes like IIT, NIT, IISc in specialized fields of metallurgical & materials engineering such as Welding technology.
- For a 'Metallurgist', there is lot of job opportunities with tremendous growth in almost all types of industrial sectors in the present scenario. These jobs include different functions such as, Material Scientist, Techno-commercial Manager, Quality control & assurance, Marketing & Sales, Project & Planning.
- Services such as ONGC, IOCL, SAIL, GAIL, ESSAR, ISPAT, laboratories of national and inter-national repute such as NASA,BARC, BARC,CSIR, NML, DRDO, DMRL, IPR, etc.

2. Contents

		Allotted hours
Unit 1	Introduction: History, Importance of metal joining processes, Classification of metal joining processes - Classification based on application of filler material & without filler material, source of energy, fusion and pressure welding processes, joint design and edge preparation, physics of arc, characteristic of arc. Welding	8 hours

	positions. Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, and their purpose and flux residue treatment, comparison with welding process.	
Unit 2	Metal transfer, forces acting on the arc, different modes of metal transfer, heat flow in metals, prediction of heating and cooling rates. Manual metal arc(MMA) or shielded metal arc (SMA) welding, Submerged arc welding (SAW), Gas metal arc welding (GMAW) or MIG/MAG welding, TIG welding, Plasma Arc welding: Principle, Equipment requirement, electrodes for welding of structural steels, electrode coating classification, process description, shielding gases, advantages and disadvantages, application of processes.	10 hours
Unit 3	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.	10 hours
Unit 4	Other welding processes like Electron beam welding, Laser beam welding, Friction welding, Friction Stir Welding explosive welding, ultrasonic welding, diffusion welding, Electroslag and Electro gas welding etc. Weldability and defects: introduction, Weldability test, Weldability of ferrous and non ferrous materials, joining metallurgy of the dissimilar metals, clad metals etc., Welding defects.	10 hours

3. Metal Joining Processes Lab (List of Experiments)

Experiment No	Title of experiment
1	To study the edge preparation and preparation of different types of weld joints.
2	To study effect of proportion of oxygen and acetylene on the gas welding flame.
3	To study the effect of welding parameters on weld quality by SMAW welding.
4	Characterization of weldments prepared by SMAW
5	Preparation of joints using Tungsten Inert Gas welding.

6	Characterization of weldments prepared by TIG
7	Preparation of joints using Metal Inert Gas welding.
8	Characterization of weldments prepared by MIG
9	Preparation of different type of joints uses spot welding and butt welding.
10	Characterization of weldments prepared by spot and butt welding
11	To study the effect of rpm on weld microstructure by friction welding.
12	Characterization of weldments prepared by friction welding
13	To study the effect of gas flow rate on weld quality by MIG welding.
14	Application of welding Gauge.
15	Effect of GTAW parameters on weld bead morphology.

4.Text Book(s)

1) The Metallurgy of Welding, Brazing and Soldering – J.F. Lancaster, George Alien and Unwin Ltd., London.
2) Introduction to Welding and Brazing – D.R. Milner & R.L. Apps. Pergamon Press, London.

5. Reference Books

1) Manufacturing Technology (Foundry, Forming and Welding)-P.N.Rao, Tata Mc- Graw Hill.
2) The Physics of Welding- L.F.Lancaster, Pergamon Press.
3) Principles of Welding- R.S. Parmar.
4) Welding Technology- O.P. Khanna, Khanna Pub.
5) ASM Handbook Vol – 6
6) AWS (American Welding Society)

6. Digital Learning Resources

www.nptel.ac.in

7. Question Paper Pattern for End Sem Exam:

As per Appendix A

Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	00	40	00	100

1. COURSE OUTCOMES :

- To understand the significance of testing of metallic and non metallic materials and components without destroying them.
- To study the application of these methods in assessing reliability of components & plants.
- To study the life time assessment of components.
- To understand the principle and application of visual testing methods
- To understand principle of liquid penetration testing technique.
- To understand the principle of magnetic particle testing and its applications

2. Content

		Allotted hours
Unit 1	Fundamentals and introduction to non-destructive testing. Scope and limitations of NDT Visual examination methods. Different visual examination aids. Leak and pressure testing of industrial components. Various methods of pressure and leak testing underlying principles of these testing systems.	8 hours
Unit 2	Dye penetrant Methods, Basic Principles, Capillary Action, Wetting and Non-Wetting Characteristics, Different Types of Penetrants, Detailed Procedure and Recent Developments in DPT. Magnetic Particle Testing methods, Basic Principles of MPT, magnetization methods demagnetization methods, MPT equipment & instruments, sensitivity calibration of MPT equipment. Ultrasonic methods of NDT-Basic principles of wave propagation, types of waves, transducers and transducer materials, advantages and limitations of UT.	10 hours

Unit 3	Pulse Echo and Through Transmission techniques of UT, Calibration methods, use of standard blocks, Thickness determination by ultrasonic method. Study of A, B and C scan presentations. Radiographic testing of metallic components. X-ray and Gamma-Ray radiography. Their principles, methods of generation. Industrial radiography techniques. Types of films, screens and penetrameters. Interpretation of radiographs. Film Processing. Radiography Contrast.	10 hours
Unit 4	Eddy current testing: Basic principles and applications such as detection of defects and characterization, sorting of materials, determination of film/coating thickness, measurement of electrical conductivity and magnetic permeability of materials. Eddy current testing equipments and its block diagram, different types of test coils and their applications. Acoustic Emission Technique. Conductivity & resistivity methods and their applications. Thermal methods of NDT. Selection Criteria for various NDT techniques.	10 hours

3. Text Book(s)

1) Practical Non-destructive Testing– Baldev Raj,T. Jayakumar &M. Thavasimuthu, Norosa Publishing House, New Delhi.
2) Non-destructive testing, Warren J. McGonnagle, Gordon Breach, Science

4. Reference Books

1) Ultrasonic Testing of Materials, J. Krautkramer
2) Treaties on Non-destructive testing, by Dr. E. G. Krishnadas Nair, Non-destructive testing, R. Hatmshaw.
3) Ultrasonic Methods of Testing Materials, Leszek Filipezynski, Zdzislaw Pawlowski

5. Digital Learning Resources

www.nptel.ac.in

6. Question Paper Pattern for End Sem Exam :

As per Appendix A

Subject: **Alloy Design**								
Program: **B. Tech Metallurgical Engineering**			Subject Code: MT0703				Semester**: VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	00	40	00	100

1. **Course Outcomes** :
   - To provide knowledge about the basic concept of alloys and its properties
   - To impart the importance of overall design in metallurgy.
   - To help them understand all newer types of alloys and its applications
   - To make them understand strengthening mechanisms used in alloying.
   - To study alloy design for particular mechanical properties & its overall importance
   - How newer materials can be developed and which can be useful in new technologies and development
   - Application of computer based alloy designing

2. Contents

		Allotted hours
Unit 1	**Concept & Effect on properties** Concept of alloy design, Steps in alloy design, Significance of alloy design Single phase, dual phase and multiphase materials, Effect of matrix on properties of materials, Effect of size, shape and distribution of second phase on mechanical properties of alloys.	8 hours
Unit 2	**Strengthening Mechanisms** Precipitation and particle coarsening, recrystallization and grain growth. Solid/Liquid phase transformation in pure metals, single phase alloys, constitutional super cooling and eutectic alloys.	10 hours
Unit 3	**Alloy Design for better mechanical properties** Alloy design for better tensile strength, ductility, toughness, fatigue strength, creep strength, wear resistance and elevated temperature.	10 hours

Unit 4	**Types of Alloy Steels & its applications** Types of Stainless Steels – Its Introduction, properties and applications High strength low alloy steels, Maraging steels, High speed steels, Hadfield steel and Super alloys. Alloy design of lightweight and high Strength powder metallurgical Al based alloys Application of computer-based methods for alloy designing.	10 hours

3. Text Book(s)

1) Boyer, H.E. (ed.), Selection of Materials for component Design: Source Book, American Society for Metals, Metals Park, Ohio.
2) Ashby, M.F. Materials Selection in Mechanical Design, New York: Pergamon, 1992.
3) Ranganathan S., Arunachalam V.S. and Cahn R.W. (Eds.), Alloy Design, Indian Academy of Science, Bangalore, 1981.
4) Tien John K. and Ansell George S. (Eds.), Alloy and Microstructural Design, Academic Press

4. Reference Books

1) ASM Handbook, Vol.1 & 2, Properties and Selection: Metals Park, Ohio.
2) Structure & Properties of Alloys – Robert M. Brick, Robet B. Gordon & Arthur Phillips, Eurasia Publishing House (private)Ltd., New Delhi
3) Metals Hand Book Ninth Edition – Vol 1.

5. Digital Learning Resources

www.nptel.ac.in

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Material Testing and Standards**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0704			Semester: **VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	60	60	40	40	200

1. Course Outcomes

- Understand different types of Mechanical testing (i.e. destructive testing and non destructive testing).
- Understand different types of standards related to different mechanical testing.
- Understand standard procedure for mechanical testing.

2. Contents

		Allotted hours
Unit1	Introduction: Importance of Material Testing. Classification of various types of testing methods. Selection of testing methods. Importance of calibration of testing instruments. Calibration methods and standards for various tests. Non-destructive testing – Importance, scope, advantages and limitations – Dye penetrant, radiographic magnetic, ultrasonic and eddy current testing and their application.	8 hours
Unit2	Tensile test: Engineering stress –strain curve, true stress –strain curve, Instability in tension, Stress distribution at neck, principle of stress and strain measurement, bend test measurement of ductility and formability, compression test, yield stress and proof stress, universal tensile testing machine and tensometer. Numericals of Tensile test, Fatigue and Ductile Brittle Transition Temperature Hardness test: Introduction, Brinell, Vickers and Rockwell hardness tests, Meyer hardness test, Analysis of indentation by an indenter, Relationship between hardness and the flow curve, Micro-hardness tests, Hardness conversion, Hardness at elevated temperature.	10 hours

Unit3	Impact testing: Types of impact tests and their relative merits and demerits. Ductile-brittle transitions behavior and its significance. Torsion test: Introduction, Mechanical properties in torsion, Torsional stresses for large plastic strains, Types of torsion failures, Torsion test vs. tension test, Hot torsion test.	10 hours
Unit4	Fatigue and Creep Testing – Elementary treatment of fatigue phenomenon, S – N curve and corrosion fatigue, fatigue testing principle, Signification of Creep testing procedure , creep curve and its interpretation, stress-rupture test. Metallurgical and mechanical factors affecting, creep and fatigue failures. Introduction to various standards for mechanical testing: ASTM E8/E8M - Standard Test Methods for Tension Testing of Metallic Materials, ASTM E21 - Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials, ASTM E18: Standard Test Methods for Rockwell Hardness of Metallic Materials, ASTM E384: Standard Test Methods for Standard Test Method for Strain-Controlled Fatigue Testing of Metallic Materials, ASTM 139: Standard Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials, ASTM E606: Standard Test Method for Strain-Controlled Fatigue Testing, ASTM E466: Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials, ASTM E9: Standard Test Methods of Compression Testing of Metallic Materials at Room Temperature, ASTM E209, SA 370- Hardness Testing, SA370-Impact Testing, ASTM E6- D- Ductility and Bend Testing, ASTM E6- E- Creep and Stress Relaxation Testing, ASTM E6- G- Measurement and Calibration, ASTM E 190, ASTM E 527, ASTM E 92, ASTM E 139.	10 hours

3. Testing of Materials Lab (List of Experiments)

Experiment No	Title of Experiment
1	To study the Brinell hardness testing machine & perform the Brinell hardness test.
2	To study the Rockwell hardness testing machine & perform the Rockwell hardness test.
3	To study the Vickers hardness testing machine & perform the Vickers hardness test.

4	To determine the impact toughness of a given specimen by Izod test and Charpy test.
5	To determine the tensile strength of specimen.
6	To study room temperature creep strength of specimen.
7	To study room temperature fatigue strength of specimen.
8	To perform compression & bending tests on UTM.
9	Visual Inspection of fractured surfaces.
10	To perform Dye Penetration Test for given sample.
11	Study of Magnetic particle tester.
12	Tostudy Ultrasonic Flaw Detector
13	To study Eddy Current Tester.
14	Detailed study of Radiographic Testing Method.
15	To study In situ Metallographic using replica technique

4. Text Book(s

1) G. E. Dieter, Mechanical Metallurgy, McGraw Hill Book Company, 1987.
2) Testing of metallic materials by A.V.K Suryanarayana, PHI
3) ASTM standards

5. Reference Books

1) Physical Metallurgy Principles by R.E. Reed-Hill, East West Press.
2) Deformation and Fracture Mechanics of Engineering Materials -R. W. Hertzberb
3) Mechanical Behaviour of Materials -T. H. Courtney
4) ASM Handbook, NDT and Quality control.
5) Testing and Inspection of Engineering Materials- Davies, Taroxall and Wiscosil
6) Mechanical Testing of Metallic Materials – D A Beument.
7) Engineering Materials Science – C W Richards
8) Non Destructive testing – Bac Gonnagle.

6. Digital Learning Resources

www.nptl.ac.in

7. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Selection of Materials and Failure Analysis**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0705			Semester**: VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	2	0	4	60	00	40	00	100

1. Course Outcomes:

- Objective 1 (Technical Knowledge) - To impart Broad knowledge of Metallurgical aspects of engineering materials selection & technology practices to support design, application, installation, manufacturing, operation and maintenance for successful careers in Academics/ Research & industry that meet the needs of Society and multinational companies
- Objective 2 (Technical Skills) – To develop basic scientific principles and engineering fundamentals necessary to formulate, analyze and solve engineering &technical problems & demonstrate the ability to synthesize data and technical concepts for application to product design & developments.
- Objective 3 (Professional Skills) - To Work effectively & efficiently as an individual and as a member of a multidisciplinary projects & social Activities.
- Objective 4 (Social Awareness & Life-long Learning) - To be awareness of social concerns and professional responsibilities & ethics in the workplace. & also to demonstrate professional training and ability to adapt to changes in the workplace through formal and informal education

2. Contents

		Allotted hours
Unit 1	Philosophy of material selection, motivation for selection, relationship to available resources, concept of resource base, Criteria for selection of engineering materials – service requirements, ease of manufacturing, availability of materials and cost effectiveness. Selection for mechanical properties like strength, toughness, stiffness, fatigue, creep and temperature resistance.	8 hours

Unit 2	Selection for surface durability like corrosion resistance, wear resistance. Relationship between material selection and material processing. Identification of required properties. Selection of materials based on available property data and optimization to select the best material. Case studies in material selection like materials for bearings, gears, automobile structures, aircraft components, ship structures, etc.	10 hours
Unit 3	Importance of failure analysis and its relationship to material selection, fundamental causes of failure, general practice in failure analysis. Failure- types and characteristics: Identification and characterization of ductile and brittle type of failures. Fracture mechanism, fracture modes and micro fractographic features	10 hours
Unit 4	Concept and Mechanism of Failure: Identification and characterization of fatigue failures, types of fatigue, corrosion fatigue and contact fatigue, etc. Corrosion and corrosion related failures such as hydrogen embrittlement, stress corrosion cracking and high temperature failures. In-process failures: Case studies, Service failures: Case studies	10 hours

3. Text Book(s)

1) Selection and Uses of Engineering Materials – F.A.A. Cranes & J.A. Charles, Butterworth & Com. Ltd., London.
2) Engineering Materials – Vol. 1 & 2 – Michael F. Ashby & David R.H. Jones, Pergamon Press, New York.
3) Engineering Materials-Selection and Value Analysis –H.J. Sharp, Elsevier Publishing Company Inc., New York.
4) Analysis of Metallurgical Failures- V.J. Colangelo & F.A. Heiser, John Wiley & Sons, New York.
5) Failure Analysis of Engineering Materials – Charlie R. Brooks and Ashok Chaudhary, McGraw Hill, New York.
6) Metallurgy of Failure Analysis – A.K. Das, McGraw Hill, New York.

4. Reference Books

1) Metals Handbook – Eighth edition – Failure Analysis and Prevention, American Society of Metals, Metals Park, Ohio.
2) Metals Handbook – Eighth edition – Fractography, American Society of Metals, Metals Park, Ohio.

3) Handbook of materials selection - Myer Kutz, John Wiley & Sons, New York.
4) Handbook of materials selection for engineering applications- G.T. Murray, M. Dekker

5. Digital Learning Resources

www.nptel.ac.in

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Advanced Ferrous Metallurgy (Elective – 3)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0706			Semester**: VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	00	40	00	100

1. Course Outcomes :

The students will be able to know the basic concept of advancement in ferrous metallurgy, able to know thermodynamics and reaction between oxides and make them clear with reaction part, understand modern developments that have taken place in blast furnaces and other production of iron &steel, different methods of sponge iron production and also secondary steel making processes, recent trends in steel making & iron making.

The 'Metallurgist' will be able to acquire M Tech /ME / MSc(engg) & PhD degrees in order to enhance , sustain and nurture his/her professional career by :
Joining any national institutes like IIT, NIT, IISc in various specialized fields of metallurgical & materials engineering such as Industrial metallurgy, Steel technology.
For a 'Metallurgist', there are a lot of job opportunities with tremendous growth in almost all types of industrial sectors in the present scenario. These jobs include different functions such as Managerial role, Material Scientist, Techno-commercial Manager, Quality control &assurance, Marketing &Sales, Project &Planning.
Services such as ONGC, IOCL, SAIL, GAIL, ESSAR, ISPAT,laboratories of national and inter-national repute such as NASA,BARC, BARC, CSIR, NML, DRDO, DMRL, IPR, etc.
There is plenty of scope and feasibility for a 'Metallurgist' to go for self employment by setting up an 'Enterprise/ Industrial Unit in Setup a small foundry of ferrous and non-ferrous metals.

2. Contents

		Allotted hours
Unit 1	**Thermodynamics of oxides and their reduction:** Thermodynamics and kinetics of iron oxide reduction. Kinetics of solid- solid and solid-gas reactions.	8 hours

Unit 2	**General Problems related to Indian Steel plants:** Problems of Indian Steel Plants. High temperature properties of iron bearing materials.	10 hours
Unit 3	**Pre-treatment Techniques:** Pre-treatment of hot metal. Physico-chemical aspects of pre-treatment processes. Status of hot metal treatment in India. Electric Arc Furnace (EAF) steel making. Design of EAF-AC, DC electric arc. Latest trends in EAF design and operation. Secondary steel making processes. Alloy steel making in EAF using secondary refining. Continuous casting.	10 hours
Unit 4	Roll of synthetic slags. Electro-slag refining. Slag-metal reaction in iron and steel making. Ferro-alloy production. Application of plasma technology.	10 hours

3. Text Book(s)

1) Principles of secondary Processing and Casting of Liquid Steel-Ahindra Ghosh, Oxford & IBH, New Delhi.
2) Electrometallurgy of Steel and Ferro-alloys, Vol. I & II – F.P.Edneral, Mir Pub., Moscow.
3) International Symposium on *Blast Furnace Iron Making*, Jamshedpur, Nov. 1985, Organised by the Indian Institute of Metals and Tata Iron & Steel Company Ltd.
4) Workshop on *Production of Liquid Iron using coal*, Eds. H.S.Ray et al, Allied Publishers Ltd., New Delhi, 1994.

4. Reference Books

1) Principles of secondary Processing and Casting of Liquid Steel-Ahindra Ghosh, Oxford & IBH, New Delhi.

5. Digital Learning Resources

www.nptel.ac.in

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Advanced Materials and Applications (Elective – 3)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0707			Semester**: VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	00	40	00	100

1. Course Outcomes

- The successful students will gain knowledge on special steels, alloy cast iron, light metals and some super alloys.
- After completion of this subject students will able to solve industrial problems and can replace tradition material by some of the advanced materials for better results.

2. Contents

		Allotted hours
Unit 1	Special steels Ferritic, Austenitic, Martensitic, Duplex and Precipitation hardenable stainless steels, Dual phase steels, TRIP steels, Maraging steels, High speed steels, Hadfield steels, Free cutting steels, Ausformed steels, Tool Steels, manganese steels, chrome steels, electrical steels, bearing steels, spring steels, heat resistant steels, creep steels, HSLA steels Alloy cast iron High silicon cast iron, Ni-hard, Heat resistant cast iron	8 hours
Unit 2	Light metals and their alloys Aluminum, magnesium and titanium alloys, Metallurgical aspects, Mechanical Properties and applications Super alloys Iron base, nickel base and cobalt base super alloys, Composition, Properties and their application Rapid Solidification Techniques, Production of metallic glasses, Atomic arrangement, Comparison with crystalline alloys, properties & applications	10 hours
Unit 3	Nanomaterials & technology Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Methods for creating nano structures, Processes for producing ultrafine powders -	10 hours

	physical synthesis and chemical synthesis, Physical and mechanical properties and their applications Smart materials Shape memory alloys, piezoelectric materials, Electro-rheological fluid, Magneto- rheological fluid	
Unit 4	Biomaterials Property requirement, Concept of biocompatibility, Cell-material interaction and body response to foreign materials, important biometallic alloys, Ni-Ti alloy, Co-Cr-Mo alloys Miscellaneous Advanced Materials Magnetic materials, Engineering polymers, ceramics and composites, aerospace materials, cryogenic materials, semi conducting and superconducting materials	10 hours

3. Text Book(s)

1) The Science and Engineering of Materials by D. R. Askeland and P. P. Phule, Thomson Publication, 2005.

4. Reference Books

1) Advances in Material Science by R. K. Dogra and A. K. Sharma, 2003.
2) Elements of Materials science by Van Black, 6th Edition, 2008
3) Engineering Materials and Applications by R. A. Flinn and P. K. Trojan, 1999.
4) Light Alloys: Metallurgy of Light Metals by I. J. Polmear, 1982.
5) Nano Technology by Gregory Tirp, Springer Verlag, 2005

5. Digital Learning Resources

http://www.ferrocare.com/specialsteels.pdf
http://nptel.ac.in/courses/103103033/module9/lecture1.pdf

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Advanced Foundry Technology (Elective – 3)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0708			Semester**: VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	00	40	00	100

1. Course Outcomes:

The students are expected to have adequate knowledge and understanding on the following four areas of foundry technology as the outcome of this course:

- Newer materials which are in the state of development so also the newer processes that are more competitive, case of solidification software and ISO 9000 as measures of producing quality castings.
- Mechanization of foundry plants for faster rate of production and specifications for major equipment.
- Layout of foundry plants, maintenance of machinery, equipment and material handling system.
- Quality control measures at various sections in foundry including analysis of defects and salvage of defective castings.

2. Contents

		Allotted hours
Unit 1	New materials, processes & software applications: new core & mould binders & additives, new lining & refractory materials, magnetic moulding process, full mould process, vacuum moulding process, ISO-9000 computer applications in metal casting, use of solidification software & simulation, energy conservation in foundry industries.	8 hours
Unit 2	Foundry mechanization: mechanical equipment in a foundry, sand preparation & control, sand handling & conveying system, moulding machines:- sand slingers, pneumatic rammers, simultaneous jolt & squeeze, high pressure moulding, typical specifications for major equipment in foundry	10 hours

Unit 3	Plant site location: plant layout of small scale & medium scale & large scale foundry, plant engineering /maintenance /services: plant machinery & equipment, environmental pollution & its control in foundry, consideration on layout & material handling system, modernization & mechanization of a foundry.	10 hours
Unit 4	Casting defects analysis & salvaging of defective castings by using techniques such as welding, brazing, braze welding & soldering, burning on, patches & plugs, impregnations of castings, quality control in pattern & mould making, melting & heat treatment, fettling & cleaning, use of statistical methods in quality control of casting.	10 hours

3. Text Book(s)

1) Metal Casting: Principles and Practice by T. V. Raman Rao, New-Age International (P) Ltd. Publishers, New Delhi, 1998.
2) A textbook of Foundry Technology by M. Lal Dhanpat Rai & Sons, 1998.
3) Steel Foundry Practices by P. Bindulya.

4. Reference Books

1) Principles of Solidification and Materials Processing (Vol. 1 & Vol. 2) by R. Trivedi, J. A. Sekhar & J. Mozumdar.
2) International Conference on Management and Pollution in Foundries, 1990.
3) IIF Transactions, 1998.

5. Digital Learning Resources

www.nptel.ac.in

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Phase Transformations (Elective – 3)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0709			Semester: **VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	00	40	00	100

1. Course Outcomes

- This course will provide the student with an understanding of the basic principles and mechanisms underlying both solid-solid and liquid-solid phase transformations with an emphasis on metallic materials.
- The objective is to apply the concepts of thermodynamics, diffusion and kinetics, and crystallography (crystal structure and symmetry in materials) to develop a clear understanding of the free energy changes and kinetics associated with various types of phase transformations.
- An ability to apply and couple the basic concepts of thermodynamics, diffusion, and crystallography.

2. Contents

		Allotted hours
Unit 1	**Review of Thermodynamics:** Equilibrium, Single Component Systems, Binary Solutions, Equilibrium in Heterogeneous Systems, Binary Phase Diagrams, Kinetics of Phase Transformations **Review of Diffusion:** Atomics Mechanisms of Diffusion, Interstitial diffusion, Self Diffusion, Vacancy Diffusion, Diffusion in Substitutional Alloys	8 hours
Unit 2	**Solidification:** Nucleation in pure metals, Growth of a pure Solid, Alloy Solidification, Solidification during Quenching from Melt	10 hours
Unit 3	**Diffusional Transformations in Solids:** Nucleation in solids - Homogeneous and Heterogeneous, Overall Transformation Kinetics – TTT Diagrams, Precipitation in Age Hardening Alloys, Cellular Precipitation, Eutectoid Decomposition, Massive Transformations, Ordering Transformations	10 hours

Unit 4	**Diffusionless Transformations:** Characteristics of Martensitic Transformations, Martensite Crystallography, Martensite Nucleation, Martensite Growth, Tempering of Ferrous Martensite, Strain induced transformation	10 hours

3. Text Book(s)

1) Phase Transformations in Metals and Alloys, Third Edition, David A. Porter, Kenneth E. Easterling, Mohamed Sherif; CRC Press.

4. Reference Books

1) Transformations in Metals, P.G. Shewmon, McGraw-Hill, 1969.
2) Principles of Phase Transformations and Heat Treatment, A. K. Mallik, I. I. T. Bombay.

5. Digital Learning Resources

NPTEL Lectures on Phase Transformation (www.nptel.ac.in)

6. Question Paper Pattern for End Sem Exam:

As per Appendix A

Subject: **Advances in Thin Film Technology (Elective - 3)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0710			Semester: **VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	00	40	00	100

1. Course Outcomes

- Discuss the differences and similarities between different vacuum based deposition techniques,
- Evaluate and use models for nucleating and growth of thin films,
- Asses the relation between deposition technique, film structure, and film properties,
- Discuss typical thin film applications,
- Motivate selection of deposition techniques for various applications.

2. Contents

		Allotted hours
Unit 1	Role of Thin films Technology and Devices; Vacuum evaporation- Hertz- Knudsen equation, evaporation from a source and film thickness uniformity.	8 hours
Unit 2	Basics of vacuum science, creation of vacuum: rotary, diffusion, getter ion, turbo molecular, and cryo pumps, measurement of vacuum: Penning, Pirani, ionization gauges, B-A gauge. Designing a typical vacuum system, vacuum leak detection: helium leak detector, residual gas analyzer.	10 hours
Unit 3	Thin film properties like Mechanical properties: adhesion and stress measurements, electrical properties, resistivity variation, Hall Effect, Optical properties: reflection, refraction, ellipsometry, reflecting and antireflecting films.	10 hours

Unit 4	Thin film analysis ion beam sputtering, selective surfaces, depth profiling, Study of inter Diffusion in thin films using XPS, AES, SIMS and RBS. Study on special coatings like Graphene and Photovoltaic	10 hours

3. Text Book(s)

1) M. Ohring, The materials science of thin films, Academic press
2) D. L. Smith, Thin-film deposition, principles and practice, McGraw-Hill
3) K. L. Chopra, Thin Film Phenomena, Robert E. Krieger publishing

4. Reference Books

1) D. M. Mattox, Handbook of physical vapor deposition (PVD) processing, Oxford, c2010. (2^{nd}ed.)
2) P. M. Martin (Eds), Handbook of deposition technologies for films and coatings, Oxford, 2009. (3^{rd}ed.)
3) D Clocker, S I Shah (Eds), Handbook of Thin Film Process Technology, Institute of Physics Publishing, London 1995.
4) W N G Hitchon, Plasma Processes for semiconductor Fabrication, Cambridge University Press, Cambridge 1999.
5) Elshabini-Riad, A. R. Aicha, Thin film technology handbook / New York: McGraw-Hill, c1998. (TK7872.T55 E47 1998)
6) H. Lüth, Solid surfaces, interfa ces and thin films, Heidelberg, New York, Springer-Verlag, c2010. (5^{th}ed.)

5. Digital Learning Resources

http://nptel.ac.in/

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Industrial Welding Codes and Standards (Elective – 3)**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0711			Semester: **VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
4	0	0	4	60	00	40	00	100

1. Course Outcomes

- Description of welding codes and materials specifications.
- Fundamental principles, methods, and approaches of welding processes.
- Developing the theoretical background of welding processes' applicability and effectiveness.
- To understand the importance and necessity of selection of appropriate consumable, welding processes, welding parameters and testing procedures.
- Improve his/her theoretical background on applicability of a welding process, parameters and weld testing.
- Be aware of the use of various welding codes and standards widely used in industries.

2. Contents

		Allotted hours
Unit 1	Fabrication In Piping Industry: Process and product standards for manufacturing of pipe – welding procedure and welder qualification, field welding and inspection. Structural Welding Codes: Design requirements, allowable stress values, workmanship and inspection.	8 hours
Unit 2	Fabrication of Pressure Vessel: Design requirements, fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydrotesting, (ASME Sec VIII-1 & 2).	10 hours
Unit 3	Welding procedure: Welding procedure specification, procedure qualification records. Welder Qualification: Performance qualification, variables.	10 hours

Unit 4	Materials: Introduction to materials standard and testing of materials, consumables testing and qualification as per ASME / AWS requirements. Consumables: Types of consumables, Consumable testing and qualification as per ASME / AWS requirements.	10 hours

3. Text Book(s)

1) Welding Engineering and Technology by R. S. Parmar, Khanna Publishers.

4. Reference Books

1) ASME Section VIII – Division 1,2
2) ASME Section IX
3) ASME Section II Part A and C
4) API 5L
5) API 1104.
6) AWS D1.1 Structural Welding Code

5. Digital Learning Resources

http://nptel.ac.in/

6. Question Paper Pattern for End Sem Exam

As per Appendix A

Subject: **Disaster Management**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: CV0712			Semester: **VII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
1	0	0	0	24/60	0	16/40	0	100

Course Objectives:

1. To explain students the conceptual applications and principles of management to mitigate various disasters.

Course Outcome:

1. Understand disasters, disaster preparedness and mitigation measures.
2. Understand role of IT, remote sensing, GIS in risk reduction.
3. Understand disaster management acts and guidelines along with the role of various stack-holders during disasters.

COURSE CONTENTS:

UNIT-I **[03]**

Introduction

Concepts and definitions: disaster, hazard, vulnerability, risk, capacity, impact, prevention, mitigation)

UNIT-II **[04]**

Disasters classification

Natural disasters (floods, drought, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills etc); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility

UNIT-III **[06]**

Disaster Impacts

Disaster Impacts (environmental, physical, social, ecological, economic, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate-change and urban disasters. Disaster Risk Reduction **Disaster management cycle**

Phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post-disaster environmental response (water, sanitation, food safety, waste management, disease control); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

UNIT-IV **[02]**

Applications of Science and Technology for Disaster Management and Mitigation

Geo-informatics in Disaster Management (RS, GIS and GPS), Disaster Communication System (Early Warning and Its Dissemination), Land use planning and development regulations, Disaster safe designs and Development Regulations, Disaster safe designs and Construction structural and Non structural Mitigation of Disasters. Science and Technology Institutions for Disaster Management in India.

Text Books:

1. Ghosh G.K., 2006, Disaster management, APH Publishing Corporation.

Reference Books:

2. Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
3. Singh B. K., 2008, Handbook of Disaster Management: techniques and guidelines, Rajat Publications

Web resources:

1. http://nidm.gov.in/PDF/Disaster_about.pdf
2. https://www.slideshare.net/Jyothi19587/disaster-ppt
3. https://www.slideshare.net/SayefAmin1/natural-disaster-its-causes-effects
4. https://www.slideshare.net/rahulp4/man-made-disasters-23947076
5. https://www.slideshare.net/urveshprajapati3990/disaster-management-in-india-56546805
6. www.ndmindia.nic.in/presentation/Presentation%20by%20JS%20(DM)%20(1).ppt
7. https://www.geospatialworld.net/article/information-technology-and-natural-disaster-management-in-india/
8. http://www.bvicam.ac.in/news/NRSC%202007/pdfs/papers/st_230_03_02_07.pdf
9. http://eagri.tnau.ac.in/eagri50/ENVS302/pdf/lec13.pdf
10. http://nptel.ac.in/courses/105105104/pdf/m16l39.pdf
11. https://www.unisdr.org/we/inform/events/50220

MOOCs:

1. https://www.mooc-list.com/tags/disaster-management

8TH SEMESTER

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

B-TECH METALLURGICAL ENGINEERING, SEMESTER –VIII TEACHING & EXAMINATION SCHEME WITH EFFECT FROM JULY 2017														
SR NO	CODE	SUBJECTS	TEACHING SCHEME			CREDITS	HOURS	EXAMINATION SCHEME						
								THEORY			PRACT		TOTAL
								CIE					
			L	T	P			MID	IE	ESE	CIE	ESE	
1	MT0801	Project	00	00	40	20	40	00	00	00	60	40	100
TOTAL			**00**	**00**	**40**	**20**	**40**	00	00	00	60	40	100

Approved Vide Agenda Item No. 03 of Minutes of Meeting of Academic Council held on 11 July 17

Subject**: Project**								
Program: **B. Tech Metallurgical Engineering**				Subject Code: MT0801			Semester**: VIII**	
Teaching Scheme				**Examination Evaluation Scheme**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
0	0	40	20	00	60	00	40	100

Evaluation Scheme:

A four member committee designated as project evaluation committee member duly nominated by the HOD from amongst the faculty member will evaluate the project of each student under the following headings

1) CIE Internal Evaluation (40 Marks):

   CIE component will consist of Report (40 Marks): This includes the Seminar Report writing. The report should include Abstract, Introduction, Literature Survey, Review of Experimental/Computational Work, Discussion and Conclusion.

2) End Sem Evaluation (60 Marks):

   Oral Presentation (40 Marks): A presentation is the process of presenting a topic to an audience of students and minimum two professors.

   Viva (20 Marks): This includes how the student handles Question and Answer session after presentation.