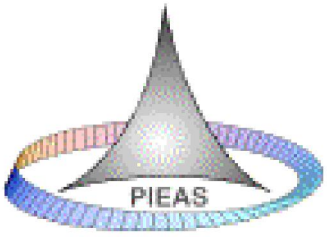
MS MATERIALS ENGINEERING

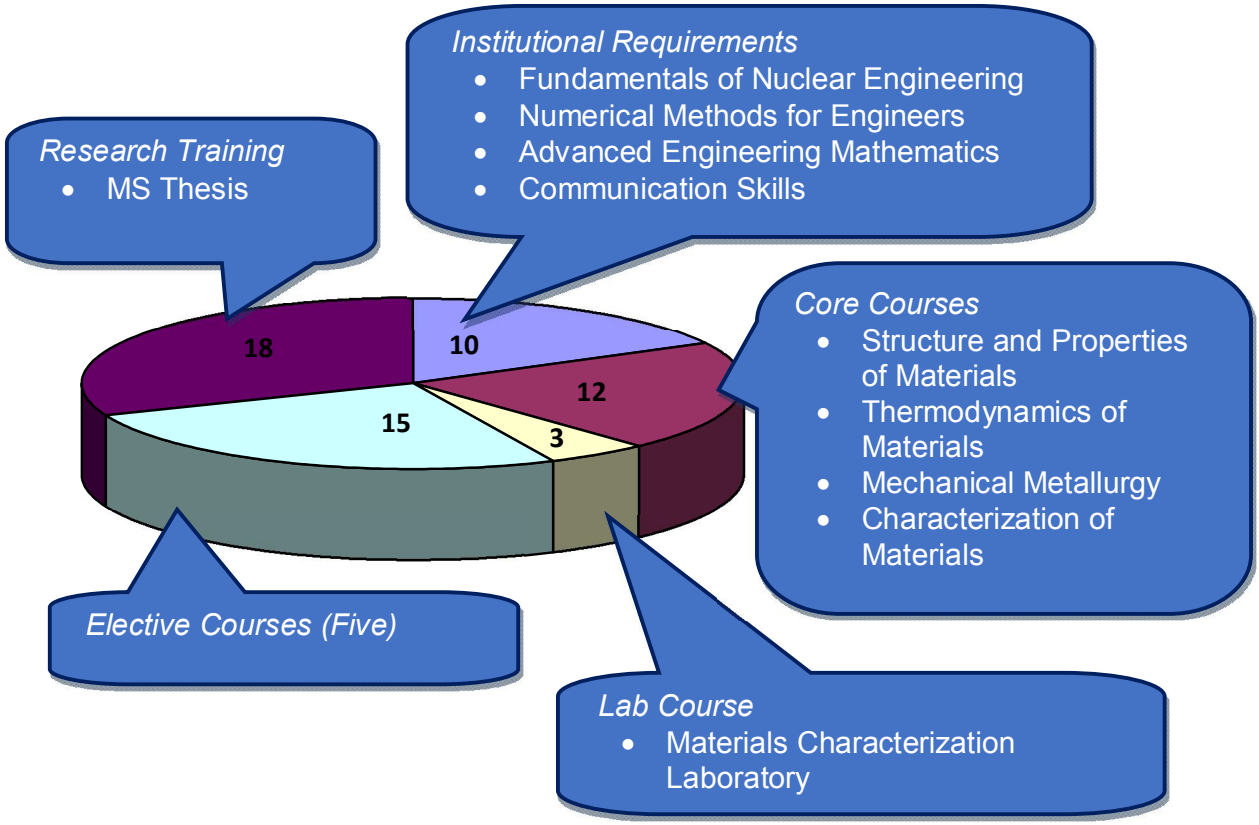
COURSE OUTLINE



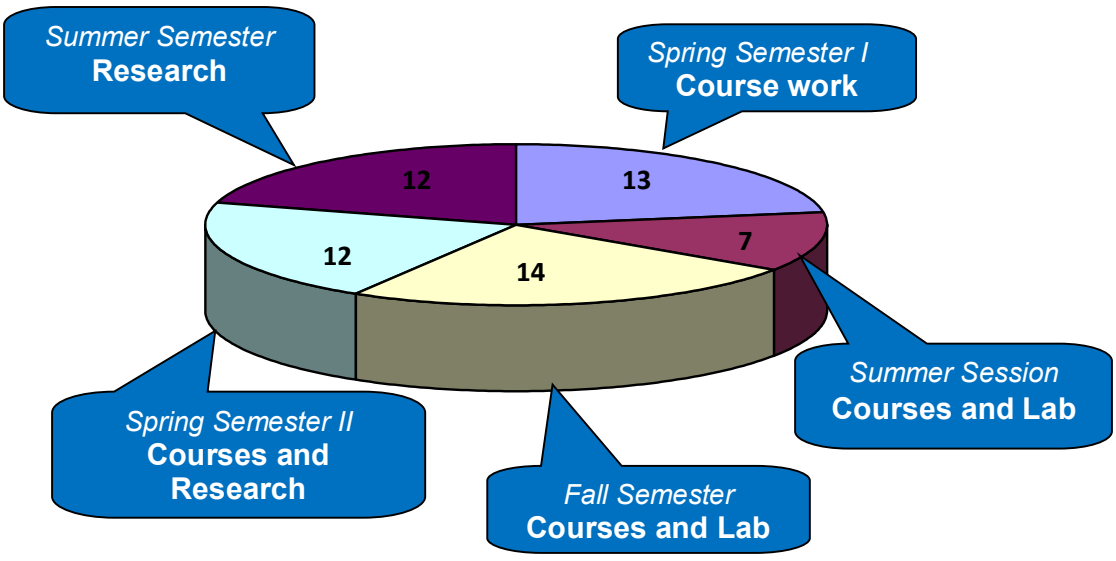
DEPARTMENT OF
METALLURGY AND MATERIALS ENGINEERING

PAKISTAN INSTITUTE OF ENGINEERING AND APPLIED SCIENCES

Distribution of credit hours is shown in the chart. Three courses are the institutional requirements. Four other taught courses, in addition to one lab course, are compulsory being core courses of Materials Engineering Program. Elective / optional courses have to be opted from a specified list of Materials Engineering Program, as decided on the basis job requirements.



Semester-wise Break-up of MS Materials Engineering Program has been shown in the following, excluding the Zero-Semester meant for orientation. Two regular semesters and one summer session are dedicated for taught and laboratory courses. Research starts from Spring Semester-II, in which half of the work load is shared with courses. The last semester is fully allocated for research.



Following table shows the list of the courses in Materials Engineering Program.

S. No.	Course Code	Name of the course	Credit hours	Nature
Compulsory Courses				
1.	NE-501	Fundamentals of Nuclear Engineering	3	IR
2.	NE-511	Numerical Methods for Engineers	3	IR
3.	MME-500	Advanced Engineering Mathematics	3	IR
4.	CMS-501	Communication skills	1	IR
5.	MME-502	Structure and Properties of Materials	3	Core
6.	MME-503	Thermodynamics of Materials	3	Core
7.	MME-504	Mechanical Metallurgy	3	Core
8.	MME-507	Characterization of Materials	3	Core
9.	MME-505	Materials Characterization Laboratory I	1(lab)	Compulsory
10.	MME-506	Materials Characterization Laboratory II	2(lab)	Compulsory
Elective Courses (Five courses will be opted by MS students out of the following list)				
1.	MME-508	Ferrous Alloy Design	3	O
2.	MME-509	Non-Ferrous Alloy Design	3	O
3.	MME-521	Ceramic Science and Engineering	3	O
4.	MME-522	Mechanics of Composites	3	O
5.	MME-523	Science and Technology of Polymers	3	O
6.	MME-524	Special Topics in Materials Engineering-I	3	O
7.	MME-526	Casting and Solidification	3	O
8.	MME-527	Powder Metallurgy	3	O
9.	MME-528	Near-net Shape Manufacturing	3	O
10.	MME-540	Corrosion and Its Control	3	O
11.	MME-542	Selection of Materials and Processes	3	O
12.	MME-543	Welding and Non-Destructive Testing	3	O
13.	MME-547	Special Topics in Materials Engineering-II	3	O
14.	MME-600	Kinetics of Phase Transformations	3	O

15.	MME-601	Fracture, Creep and Fatigue of Materials	3	O
16.	MME-602	Nanomaterials Engineering	3	O
17.	MME-603	Vacuum Metallurgy	3	O
18.	MME-604	Surface Engineering	3	O
19.	MME-605	Thin Film Processing and Characterization	3	O
20.	MME-606	The Science and Engineering of Micro-fabrication	3	O
21.	MME-608	Advanced Topics in Materials Engineering	3	O
22.	MME-622	Metal- and Ceramic-Matrix Composites	3	O
23.	MME-623	Polymeric Matrix Composites	3	O
24.	MME-641	Nuclear Reactor Materials	3	O
25.	CMS-505	Project Management	3	O
26.	NE-510	Nuclear Power Plant Systems	3	O
27.	CHE-519	Extractive Metallurgy	3	O
Research Courses				
1.	MME-697	Thesis Research-I (2nd last Semester, 6 CH)	18	Compulsory
2.		Thesis Research-II (last Semester, 12 CH)		

Details of the Courses

CMS-501 Communication Skills

Nature	*Compulsory Institutional Requirement*
Credits	*0+1*
Prerequisite	*Nil*
Course Format	*Three hours of lectures/lab per week*

Importance and Benefits of Effective Communication, Components of Communication Cycle, Concepts and Problems of Communication, Nonverbal Communication, Introduction to 7Cs and some Grammar review, detailed discussion of the 7Cs. Basic Organizational Plans, Beginning and Closing Paragraphs, Composing the Message. Business Letters, Memorandums. Introduction to Short Reports, Informational Memo Reports, Analytical Memo Reports, Letter Reports: Informational and Analytical, Prefatory Sections of Long Reports, Supplemental Sections, Presentation of the Long Report. Purposes and kinds of Proposals, Parts of Proposals, Short and Long Proposals: Writing Styles and Appearance. Strategies for Improving Oral Presentations, Strategies for Reducing Stage Fright, Strategies for Improving Listening Skills. Introduction to Definition of Group Meetings and Formation of Groups, Purposes and Kinds of Meetings, Problem solving in meetings or groups, Leadership Responsibilities, Participant responsibilities. Self-assessment, Market assessment, Resume, Cover Letter to Resume, Preparation for Job Interviews, Successful Negotiating. Organization Plan, Good news messages, Bad news messages. Organization of Persuasive Messages, Persuasive requests

References:

- Effective Business Communications by Murphy, Hildebrandt and Thomas (7th edition).

NE-501 Fundamentals of Nuclear Engineering

Nature	*Compulsory Institutional Requirement*
Credits	*3*
Prerequisite	*Nil*
Course Format	*Three hours of lectures per week*

Role and importance of nuclear energy; Nuclear cross-sections. Reaction rates; Nuclear fission and chain reaction; Criticality conditions; Criticality calculations and applications for size specified and composition specified cases; Conversion and breeding, Reactor components and their characteristics; Classification and design features of research, production, and power reactors, Introduction to fast and fusion reactor systems.

Different types of fuel cycles; Core and feed-material preparations; Uranium enrichment; Fabrication of fuel; Reprocessing of irradiated fuel; Process waste

disposal. Reactor fuel requirements; Burnup studies of nuclear fuels; In-core fuel management and fuel management strategies.

References:

- Lamarsh, J.R, Introduction to Nuclear Engineering, Addison-Wesley. 1983.
- Glasstone, S. and A. Sesonske, Nuclear Reactor Engineering, D Van Nostrand. 1981.
- Rahman, I.U. and P.S. Sheikh, Introduction to Nuclear Engineenng, Krieger, 1981.
- Graves, H.W., Jr., Nuclear Fuel Management, John Wiley, 1979

NE-511 Numerical Methods for Engineers

Nature	*Compulsory Institutional Requirement*
Credits	*3*
Prerequisite	*Nil*
Course Format	*Three hours of lectures per week*

Solution of systems of linear and non-linear algebraic equations: eigenvalues, eigenvectors: solution of ODE's, higher order differential equations and systems of first order ODE's: Partial differential equations: Recent developments

References:

- Burden, RL, J.D. Faires, and A.C. Reynolds, Numerical Analysis, Prindle, Weber and Schmidt, 1993.
- Faires, J.D., and RL. Burden, Numerical Methods, Prindle, Weber and Schmidt, 1993.
- Yakowitz, S. and F. Szidarovszky, An Introduction to Numerical Computations, Macrnillan, 1986.
- Brebbia, C.A. and A.J. Ferrante. Computational Methods for the Solution of Engineering Problems, Pentech, 1986
- Bajpai, A C., et.al, Numerical Methods for Engineers and Scientists, John Wiley, 1978.
- Gerald, C.F. and P.O. Wheately, Applied Numerical Analysis, Addison-Wesley, 1989.

MME-500 Advanced Engineering Mathematics

Nature	*Compulsory Institutional Requirement*
Credits	*3*
Prerequisite	*Nil*
Course Format	*Three hours of lectures per week*

Vector Calculus; Coordinate system transformation. Power series solution, Special functions; Bessel functions; Legendre polynomials; Laplace and inverse transforms,

Solution of linear differential equations by the Laplace transform method; Introduction to PDE's; Functions of many variables and their geometries.

References:

- Kreyszig, E ,Advanced Engineering Mathematics, John Wiley, 1988.
- Kaplan, W., Advanced Calculus, Addison-Wesley, 1970.
- Millar, K.S., Partial Differential Equations in Engineering Problems, Prentice-Hall, 1953.

MME-502 Structure and Properties of Materials

Nature	*Compulsor,*
Credits	3
Prerequisite	Nil
Course Format	Three hours of lectures per week

Electron structure of atoms, Bonding; Crystal structure and geometry: Common (close-packed) crystal structures, Miller indices, Space groups, Symmetries of crystal structures, Crystal structures and bonding in metals (alloys) and ceramics; Free electron Fermi gas theory, Band theory of metals and non-metals; Electrical properties and materials, Magnetic properties and materials, Thermal properties, Electrochemical properties; Structural defects, Mechanical properties and strengthening mechanisms, Microstructure and its control in engineering materials, Phase diagrams, Continuous cooling and time-temperature-transformation diagrams.

References:

- Smith, W.F., 'Principles of Materials Science and Engineering', McGraw Hill, 1996
- Shackelford, J.F., 'Introduction to Materials Science for Engineers', Maxwell Macmillan Publishing Co., 1992
- Kittle C., 'Introduction to Solid State Physics', 7th Edition, John Wiley and Sons, Inc., 1995
- Rohrer G. S., 'Structure and Bonding in Crytstalline Materials', Cambridge University Press, 2001
- Pillai S. O., 'Solid State Physics', 6th edition, New Age International Limited Publishers, 2006
- Nalwa H.S. (Editor), 'Handbook of Nanostructured Materials and Nanotechnology', Vol. 3, *'Electrical Properties'*, Academic Press, 2000
  Nalwa H.S. (Editor), 'Handbook of Nanostructured Materials and Nanotechnology', Vol. 4, *'Optical Properties'*, Academic Press, 2000

MME-503 Thermodynamics of Materials

Nature	*Compulsory*
Credits	*3*
Prerequisite	*Nil*
Course Format	*Three hours of lectures per week*

First Law of Thermodynamics, Enthalpy and Free Energy, Heat Capacity, Second Law of Thermodynamics, Entropy, Third Law of thermodynamics, Spontaneity Criteria, Gibbs Helmholtz Relationships. Fugacity and Chemical activity. Equilibrium constant and its variation with temperature. Vant Hoff's equation. Effect of temperature and pressure on phase transformations. Clausius-Clapeyron equation. Thermodynamics of solutions. Standard states. Raoult's law and Henry's law. Alternative standard states. Interaction coefficients and interaction parameter. Partial and Molar properties. Gibbs-Duhem equation. Thermodynamic properties and equilibrium phase diagrams. Mixing functions. Ideal and Regular solutions. Excess functions.

Reference:

- Gaskell, D. R.: Introduction to Thermodynamics of Materials, Taylor and Francis, Inc., 1995.
- Kubaschewski, 0., Alcock, C.B. and Spencer, P.J.: Materials Thermo-chemistry, Pergamon Press, 1993.
- Hudson, J. B. : Thermodynamics, An Advanced Text for Materials Scientists, Wiley, John & Sons, 1996.

MME-504 Mechanical Metallurgy

Nature	*Compulsory*
Credits	3
Prerequisite	Nil
Course Format	Three hours of lectures per week

Three-dimensional stress-strain relations; Stress-tensor; Coordinate transformations; Critical resolved shear stress; Criteria for plastic deformation; Dislocations and their interactions; dislocations sources; partial dislocations and stacking faults; Twinning; Mechanical testing: tension, compression, hardness, impact. Mechanical working, recovery, recrystallization, grain growth. Materials' behavior during forging, rolling, extrusion, etc. Fracture mechanics: stress concentration on cracks for brittle and ductile materials, various modes; Impact failure, fatigue, creep, fatigue-creep interaction; Life prediction; Tribology: friction, wear, lubrication.

Reference*:*

- Dieter, G. E., 'Mechanical Metallurgy, McGraw-Hill', 1988.

- William, H.F., 'Mechanical Behavior of Materials, Cambridge University Press', 2005.
- Rosler, J., 'Mechanical Behaviour of Engineering Materials ; Metals , Ceramics , Polymers and Composites', Springer Berlin Heidelberg New York, 2006.
- Hertzberg, R. W., 'Deformation and Fracture Mechanics of Engineering Materials' , John Wiley, 1996.
- Collins, J.A., 'Failure of Materials in Mechanical Design', John-Wiley, 1981.
- Felbeck, D.K. and Atkins A.G., 'Strength and Fracture of Engineering Solids', Prentice-Hall, 1884.

MME-505 Materials Characterization Laboratory -I

Nature	Compulsory
Credits	1
Course Format	Three hours of laboratory per week (Summer semester)

Experiments in following areas will be conducted:

1. Structural Characterization by XRD, SEM and AFM
2. Electrochemical behavior in corrosive media.
3. Sensitization and intergranular corrosion.

MME-506 Materials Characterization Laboratory -II

Nature	Compulsory
Credits	2
Course Format	Six hours of laboratory per week

Experiments in following areas will be conducted:

1. Elemental analysis (Wet analysis & XRF)
2. Thermal Characterization by TGA and DSC
3. FTIR and UV-Visible spectroscopy
4. Heat treatment and metallography
5. Mechanical testing (Tensile, hardness, and impac
6. Electrical characterization
7. Particle analysis (Laser size analyzer & BET)

MME-507 Characterization of Materials

Nature	*Compulsory*
Credits	3
Prerequisite	MME-502 / IC
Course Format	Three hours of lectures per week

Classification of analytical techniques, Atomic and molecular energy levels, Atomic absorption spectrometry (Flame, Furnce), Atomic emission spectrometry (Arc, spark and plasma), Atomic mass spectrometry (ICP-MS), Sample introduction techniques (Laser ablation, Spark or arc ablation, Glow discharge, pneumatic nebulization), Production, detection and properties of X-rays, X-ray diffraction: Braggs law, Laues equations, diffraction methods, Structure factor calculations, Phase identification, Indexing patterns of cubic and noncubic crystals, Effect of cell distortion on powder pattern, determination of atom positions and number of atoms in a unit cell, Electron specimen interactions, electron diffraction, Design and functions of Scanning Electron Microscope (SEM) subsystems, Topographic, compositional and other contrast mechanisms, Design of a Transmission Electron Microscope (TEM) and sample preparation, Contrast mechanisms in TEM, Scanning transmission electron microscopy, Quantitative and qualitative chemical analysis in SEM and TEM using Energy Dispersive and Wavelength Dispersive spectrometers.

References

- Skoog D.A., Holler F.J. and Crouch S.R., 'Principles of Instrumental Analysis', Thomson Brooks/Cole, 2007.
- Cullity B.D. and Stock S.R., 'Elements of X-ray Diffraction', Prentice Hall, 2001.
- Goodhew P.J., Humphreys F.J., Beanland R., 'Electron Microscopy and Analysis', Taylor and Francis, 2001.
- Loretto M.H., 'Electron Beam Analysis of Materials', Springer, 1993.
- Goldstein J., Newbury D.E., Joy D.C, Lyman C.E., Echlin P., Lifshin E, Sawyer L.C., Michael J.R., 'Scanning Electron Microscopy and X-ray Microanalysis', Springer, 2003.
- Williams D.B., and Carter C.B., 'Transmission Electron Microscopy', - A Textbook for Materials Science Springer, 1996.

MME-508 Ferrous Alloy Design

Nature	*Optional*
Credits	*3*
Course Format	*Three hours of lectures per week*

Crystallography, kinetics and morphological aspects of austenite-ferrite, austenite-cementite and austenite-pearlite transformations; Design and microstructure control of low alloy mild steels for cold-forming and (high-strength) packaging; Composition-

and microstructure-property relationship of low-alloy structural steels and medium-carbon ferrite-pearlite steels, Inclusion-shape control. Effects of alloying elements on ferrite- and austenite-phase fields, kinetics of austenite / ferrite and austenite/ pearlite transformations and resulting microstructures; Ferrite / alloy carbide aggregates. Crystallography, kinetics and morphologies of martensite and bainite transformations; Design of bainitic steels; Alloy design for hardenability and tempering resistance of ultra-high strength (martensitic) steels; Design and microstructure control of martensitic stainless steels, controlled transformation stainless steels, marageing steels; Design and microstructure control of ferritic stainless steels and austenitic stainless steels. Thermo-mechanical treatments of steels.

References:

- Honeycombe R. W. K., Bhadeshia, H.K.D.H., 'Steels: Microstructure & Properties', Butterworth-Heinemann 2000.
- Pickering, F. B., 'Physical Metallurgy and Design of Steels', Applied Science Publishers, 1978.
- Gadman, T. 'The Physical Metallurgy of Microalloyed Steels', Maney Publishers, 2002
- Llewellyn D.T. and Hudd R.C., 'Steels: Metallurgy and Applications', Reed Educational and Professional Publishing, 2000
- Beddoes, J. and Parr J.G., 'Introduction to Stainless Steels', ASM International, 1999.
- Sedriks, A. J., 'Corrosion of Stainless Steels', John Wiley & Sons, 1996.

MME-509 Non-Ferrous Alloy Design

Nature	*Optional*
Credits	3
Prerequisite	MME-503 / Instructor's recommendation to be approved by departmental committee's Consent
Course Format	Three hours of lectures per week

Introduction. Physical metallurgy of aluminum alloys: Principles of age hardening, Ageing processes, Wrought aluminum alloys: Designation of aluminum alloys and tempers, Heat-treatable and non-heat treatable aluminum alloys. Cast aluminum alloys: Designation and characteristics of cast aluminum alloys, Al-Si, Al-Cu, Al-Mg and Al-Zn-Mg system. Magnesium alloys: Alloying behaviour, Melting and casting, Designation of magnesium alloys and tempers, Zirconium free casting alloys, Wrought magnesium alloys, Novel alloys. Titanium alloys: α-alloys, α/β alloys, β alloys, cast titanium alloys, applications of titanium alloys.

Nickel-base superalloys, Micro-structure, Heat treatment, Mechanical properties, Major alloy groups like Nimonics, Waspalloy, etc. and their applications, Nickel-iron-base superalloys, Microstructure, High-temperature stress-rupture properties, Heat treatment, Major alloy groups like Inconels, Incoloys, etc. and their applications, Hot corrosion, Cobalt-base superalloys, Microstructure, Major alloy groups like Stellites, Haynes, etc. and their applications.

References:

- Lee, E.W.W., Frazier, W.E., Jata, K.V., and N.J. Kim., 'Light Weight Alloys for Aerospace Applications', Minerals, Metals and Materials Society, 1998.
- Thoronton, E. A., 'Aerospace Thermal Structures and Materials for a New Era', American Institute of Aeronautics & Astronautics, 1995.
- Polmear, I.J., 'Light Alloys: Metallurgy of the Light Metals', Edward Arnold, 1989.
- Smith, W. F., Structure and Properties of Engineering Alloys, McGraw Hill, 1993
- Hagel, W. C. Stoloff, N.S. and Chester T.S., 'Superalloys II', John Wiley & Sons, 1987.
- Gessinger, G. H., 'Powder Metallurgy of Superalloys', Butterworths, 1984.
- Thoronton, E. A., 'Aerospace Thermal Structures and Materials for a New Era', American Institute of Aeronautics & Astronautics, 1995.
- Flinn, R. A. & Trojan, P.K., Engineering Materials & their Applications, Houghton Mifflin, 1990.

MME-521 Ceramic Science and Engineering

Nature	*Optional*
Credits	*3*
Prerequisite	*MME-502 / Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Ceramic Classification; Ceramic Crystal Structures; Engineering Properties of Ceramics; Characterization Techniques for Engineering Ceramics; Defects in Ceramics and their Transport; Ceramic Phase Equilibria and Microstructure; Synthesis of Ceramic Powders; Ceramic Processing for Shape; Ceramic Processing for Strength; Special Topics - Case Studies. Electrical ceramics: Insulators and Dielectrics; dielectric strength, thermal shock resistance, conduction processes, Polarization. Applications as capacitors and electrical insulators.

References:

- Sherer, G.W., and Brinker, C.J., 'Sol-Gel Sciences: The Physics and Chemistry of Sol-Gel Processing', Academic Press, 2000
- Green, D.J., 'An Introduction to the Mechanical Properties of Ceramics', Cambridge University Press, 1999
- Chiang, Y.M., Birnie, D.P., and Kingery, W.D., Physical Ceramics, John Wiley, 1997
- Richerson, D.W., Modern Ceramic Engineering, Marcel Dekker, Inc., 1992
- Moulson, A. J. and Herbert, J.M., Electro-ceramics, Chapman and Hall, 1990
- Chapman & Hall, 1994.

MME-522 Mechanics of Composites

Nature	*Optional*
Credits	*3*
Prerequisite	*MME-504 / Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Definition and classification, natural composites, property enhancement by reinforcement and orientation, matrix interface, Constitutive relations for anisotropic materials; Stiffness and compliance matrices of lamina; Effective moduli of lamina; Macro-mechanical behaviour of cross-ply and angle-ply laminates; Interlaminar strength; Symmetric and anti-symmetric laminates; Failure theories for lamina and laminate; Micromechanics of single-fibre-composite; Statistical aspects of fibre strength; Viscous and dynamic behaviour.

References:

- R. E. Shalin., Polymer Matrix Composites, Chapman& Hall, 1995.
- Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman& Hall, 1995.
- Ramesh Talreja and Jan-Anders E. Manson; Polymer Matrix Composites, Elsevier 2001.
- Sperling, L. H.: Polymeric Multi-component Materials, John Wiley, 1997.
- Hull, D. and Clyne, T.W., 'An Introduction to Composite Materials, 2nd Ed. Cambridge University Press, 1996.
- Ochiai, S. : Mechanical Properties of Metallic Composites, Marcel Dekker, 1994.
- Vigo, T. L. and Kinzig, B. J., Composite Applications: The Role of Matrix, Fiber, and Interface, VCH Publishers, 1992.
- Surace, G., Carpinteri, A. and Sih. G.C., 'Advanced Technology for Design and Fabrication of Composite Materials and Structures' Kluwer Academic Publications, 1995.
- Matthews, F. L. and Rawlings, R. D., "Composite Materials: Engineering & Science", Chapman & Hall, 1994

MME-523 Science & Technology of Polymers

Nature	*Optional*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Introduction to polymer science, classification of polymers, polymer structure, molecular weight, polymer synthesis, step-growth polymerization, chain growth polymerization, polymerization techniques, structure-property relationship, thermal transitions and properties, mechanical properties, polymer modifications by grafting and crosslinking, polymer additives and blends, polymer degradation and stability,

recycling technologies, polymer composites, biopolymers and other naturally occurring polymers, engineering thermoplastics, specialty polymers.

References:

- J. R. Fried; Polymer Science and Technology, Pearson Education, 1st edition, 2005.
- A. Rudin; The Elements of Science and Engineering, Elsevier Science & Technology Books, 2nd edition, 1999.
- R O Ebewele, Polymer Science and Technology, CRC Press, 2000.
- G. Odian; Principles of Polymerization, John Wiley Interscience, 4th edition, 2004.

MME-524 Special Topics in Materials Engineering-I

Nature	*Optional (during 2nd semester)*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Lectures on specialized topics of specific technical interest may be arranged in this course, subject to approval of the Board of Studies or equivalent committee

MME-526 Casting and Solidification

Nature	*Optional*
Credits	3
Prerequisite	MME-600 / IC
Course Format	Three hours of lectures per week

Melt reactions; Fluid dynamics; Mould dynamics; Solidification dynamics; Solidification shrinkage; Linear contraction of the casting; Casting accuracy; Structure, defects and properties of the finished castings; Segregation; Nucleation and Growth in pure metals, Solidification in single-phase alloys, Solidification in eutectic alloys, Solidification of fusion welds, Solidification during quenching of molten alloys.

Thermodynamics of Solidification in Alloys, Free Energy curves and solidification of under-cooled alloys, Partitionless solidification, constitutional Under-cooling, Meta-stable Phases, effects of rapid solidification on structure, Rapid solidification by

substrate quenching, Nano-structured materials, their properties and applications, Techniques for directional solidification and single crystal growth and their applications, Effects of melt stirring during solidification, Techniques for melt stirring by mechanical agitation and electromagnetic fields

References

- Campbell, J.: Castings, Butterworth-Heinemann, 1991.
- Suryanarayana, C., “Non-equilibrium Processing of Materials”, Pergamon, 1999.
- Picatinny, N.Y. and Otooni, M.A. : Elements of Rapid Solidification, Fundamentals and Applications’, Springer Verlag, 1997.
- Porter, D.A. and Easterling, K.E.: Phase Transformations in Metals and Alloys, Chapman & Hall, 1992.
- Srivatsan, T. S. and Sudarshan, T. S. Rapid solidification Technology, Technomic Publishing, 1993.

MME-527 Powder Metallurgy

Nature	Optional
Credits	3
Prerequisite	Nil
Course Format	Three hours of lectures per week

Powder production: Inert gas atomization, Soluble gas process, centrifugal atomization, Metal oxide reduction, Sol-gel process, Mechanical attrition. Powder characterization: size, shape, texture, surface area. Mixing: Mechanical alloying. Powder consolidation: Effect of lubricants, binders, dispersants etc., Stages of compaction, Cold Isostatic Pressing, Hot Isostatic Pressing. Sintering: Removal of binders and lubricants, stages of sintering, Techniques of sintering. Practical applications of powder metallurgy.

References

- German, R. M., ‘Sintering Theory and Practice’, Metal Powder Industries Federation, 1996
- Bose, A. : Advances in Particulate Materials, Butterworth-Heinemann, 1995
- Yule, A.J., and Dunkley, J. D., 'Atomization of Melts for Powder Production and Spray Deposition’ Clarendon Press, 1994
- German, R. M., 'Powder Metallurgy Science’, Metal Powder Industries Federation, 1984
- Gessinger, G. H. : Powder Metallurgy of Superalloys, Butterworths, 1984

MME-528 Near-net Shape Manufacturing

Nature	*Optional*
Credits	3
Prerequisite	IC
Course Format	Three hours of lectures per week

Introduction; Hierarchy of Materials; Process Hierarchy; Component/Part and Shape Classification; Manufacturing Information for Design and Processing; NNSP of Metallic Systems and Metal-Matrix Composites, NNSP of Ceramic Systems and Ceramic-Matrix Composites, NNSP of Polymeric Systems and Polymeric-Matrix Composites; Process Selection Criteria; Costing Design Methodology; Cost Estimation Model Validation; Special Topics – Case Studies.

References:

- Swift, K. G. and Booker, J. D. : Process Selection from Design to Manufacture, Edward Arnold, 1997.
- Terpstra, R. A., Pex, P. P. A. C. and deVries, A. H. : Ceramic Processing, Chapman & Hall, 1995.
- Mutsuddy, B. C. and Ford, R. G., Ceramic Injection Molding, Chapman & Hall, 1995.

MME-540 Corrosion and Its Control

Nature	Optional
Credits	3
Course Format	Three hours of lectures per week

Electrochemical Phenomena in Corrosion; Mixed Potential Theory; Mechanisms, Causes and Control of Galvanic Corrosion, Crevice Corrosion, Pitting, Corrosion Fatigue, Stress Corrosion Cracking, Hydrogen Embrittlement, Erosion-Corrosion, etc.; Corrosive Media and Compatibility of Materials; Alloy Design for Passivation; Cathodic and Anodic Protections, Inhibitors, Corrosion-resistant Coatings; High Temperature Oxidation and Sulphidation, Alloy Design for High-Temperature Applications in Reactive Environment; Corrosion-resistant metals and alloys; Materials for Power Plants, Chemical Industry, Oil Industry and Domestic Applications, etc.

References

- Batchelor, A.W. *et al*., 'Materials Degradation and its control by Surface Engineering', Imperial College Press, 1999
- Fontana, M.G., ' Corrosion Engineering', McGraw-Hill, Inc., 1987
- Colangelo, V.J. and Heiser F.A., ' Analysis of Metallurgical Failures', John Wiley, 1974 Schweitzer, P. E., 'Atmospheric Degradation and Corrosion Control', Marcel Dekker, 1999

- Winston, R.R., Uhlig, H.H., 'Corrosion and Corrosion Control', John Wiley & Sons, 2008
- Ahmad, Z., 'Principles of Corrosion Engineering and Corrosion Control', Elsevier Sci. & Tech., 2006
- Bardal, E., 'Corrosion and Protection' Springer Publishers', 2004.

MME-542 Selection of Materials and Processes

Nature	Optional
Credits	3
Prerequisite	Nil
Course Format	Three hours of lectures per week

Properties of engineering materials, Intrinsic and extrinsic properties, Strength, Density, Moduli, Thermal Properties, Electrical and Magnetic Properties, Design Considerations, Ease of fabricability, Cost considerations. Material selector charts. Use of specific properties. Manufacturing Process Hierarchy; Component/Part and Shape Classification; Manufacturing Information for Design and Processing; Processing of Metallic Systems and Metal-Matrix Composites; Processing of Ceramic Systems and Ceramic-Matrix Composites; Processing of Polymeric Systems and Polymeric-Matrix Composites; Process Selection Criteria; Costing Design Methodology; Cost Estimation Model validation. Special Topics - Case Studies.

References:

• Ashby, M.F., 'Materials Selection in Mechanical Design', Butterworth-Heinemann, 1992.
• Charles, J.A., 'Selection and Use of Engineering Materials', Butterworth-Heinemann, 1995
• Johnson, H.V., 'Manufacturing Process, Bennett Publishing Company, 1979.
• Lewis, G.: Selection of Engineering Materials, Prentice Hall, 1990

MME-543 Welding and Non-destructive Testing

Nature	*Optional*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Welding techniques, Manual Arc Welding, Gas Shielded Arc Welding, Submerged

Arc Welding, Microstructure of Weld and Heat-Affected Zones, Pre- and Post-Weld Heat Treatments, Weld Joint Design, Welding of aluminum alloys, Nondestructive testing: Radiography, Magnetic-particle inspection, Fluorescent die-penetration inspection, Principles and Applications of Ultrasonic Inspection, Eddy current inspection.

References:

- Linnert, G.E., "Welding Metallurgy", American Welding Society.
- Easterling, K.: Introduction to the Physical Metallurgy of Welding, Butterworth-Heinemann, 1992.
- Hull, J.B. and V.B.John: Non-Destructive Testing, Macmillan Education, Ltd., 1988.
- Silk, M. G.: Ultrasonic Transducers for Nondestructive Testing, Adam Hilger Ltd., Bristol, 1984.

MME-547 Special Topics in Materials Engineering-II

Nature	*Optional*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Lectures on specialized topics of specific technical interest may be arranged in this course, subject to approval of the Board of Studies or equivalent committee

MME-600 Kinetics of Phase Transformations

Nature	Optional
Credits	3
Prerequisite	MME-503 / IC
Course Format	Three hours of lectures per week

Fick's first law: The diffusion coefficient, Fick's second law: Thin film solution, Boltzman-Matano Analysis, Kirkendale effect. Darken's Analysis: Importance of the activity coefficient of the solute. Point defects: Energies of formation and motion, equilibrium concentration, diffusion mechanisms, Effect of concentration on the reaction rate Diffusional and diffusionless transformations, Free energy-composition and Free energy-Temperature diagrams. Homogeneous and heterogeneous nucleation. Nature of interfaces. Nucleation on grain boundaries and dislocations. Influence of vacancies. TTT diagrams. Precipitation hardening, Particle coarsening;

Spinodal decomposition. Discontinuous transformations, Inter-lamellar spacing and growth rate. Order-disorder transformations; Characteristics of martensitic / displacive transformations.

Reference:

- Reed-Hill, R. E. and Abbaschian, R.: Physical Metallurgy Principles, PWS Publishing, 1994.
- Porter, D.A. and Easterling, K.E.: Phase Transformations in Metals and Alloys, Chapman & Hall, 1992
- Christian, J. W..: Transformations in Metals and Alloys, Pergamon Press, 1975

MME-601 Fracture, Creep and Fatigue of Materials

Nature	*Optional*
Credits	*3*
Prerequisite	*MME-504 / Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Introduction to Linear Elastic Fracture Mechanics (LEFM) background, Griffiths criterion, Modes of fracture mechanics, Stress intensity factor K, Shape of plastic zone using yield criteria, Fatigue crack groeth curve, Region I, II, and II explanation, Paris Law, Crack closure, Comparison of methods, Stress life, Strain life, and fracture mechanics LEFM approaches.
Phenomena of creep, Physical mechanism of creep, Convenient uniaxial constitutive relationships, Steady creep of a beam in bending. Introduction to creep resistance alloys, Creep damage parameters, Dependence of creep rate on stress, Dependence of creep rate on temperature, the θ projection, Ashby map, Diffusional creep, Low temperature transient creep, High temperature transient creep, Steady state power law creep, Dispersion strengthening.
Stress life relationship, S-N diagram, Mean stress effects, Modifying factors, Strain life relationship, Material behaviour, Cycle strain hardening and softening,, Cyclic stress strain curve determination, Stress plastic strain power law relation, Strain life curve, Mean stress effect.

References

- Boyle, J.T. and Spence, 'Stress Analysis for Creep', Butterworth & Co. Ltd., 1983
- Nabarro, F.R.N. and De Villiers, H.L., 'The Physics of Creep', Taylor and Francis Ltd., 1995
- Hertzberg, R. W., 'Deformation and Fracture Mechanics of Engineering Materials' John Wiley, 1996
- Bannantine, J.A., Commer, J.J., and Handrock, J.L., 'Fundamentals of Metal Fatigue Analysis', Prentice-Hall, Inc., 1990
- Caddell, R.M.: Deformation and Fracture of Solids, Prentice-Hall, Inc., 1980
- David, B., 'Elementary Engineering Fracture Mechanics', Martinus Nijhoff Publishers, Dordrecht, Netherlands, 4th ed. 1986

MME-602 Nanomaterials Engineering

Nature	*Optional*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Thermodynamics of non-equilibrium solidification, Supersaturated phases, Metastable crystalline phases, Amorphous and quasi-crystalline phases; Nano-structured materials and novel phenomena, Clusters, Nanoparticles, Nanowires, Thin films, Multi-layer coatings, Consolidated nanomaterials, Nanocomposites; Rapid solidification technology, Rapidly solidified alloys and ceramics, their properties and applications; Plasma, laser, melt-extraction and mlectron-beam processing of nanomaterials; Mechanical alloying; Synthesis of nano-materials by vapor deposition, buffer-layer assisted deposition of nanoclusters, physical vapor condensation, gas phase condensation, inert Gas nondensation; Sol-gel method, Swelling of polymes; Electrolytic synthesis of nanomaterials, Template-assisted synthesis of nanomaterials; Combustion synthesis of nanomaterials, Amorphous alloys and their nanocrystallization; Mechanical, magnetic and catalytic properties of nanomaterials and their measurement techniques; New trends.

References:

- Edelstein A.S. and Cammarata R.C. (Editors), 'Nanomaterials: Synthesis, Properties and Applications,' IOP publishing Ltd., 2002
- Nalwa H.S. (Editor), 'Handbook of Nanostructured Materials and Nanotechnology,' Vol. 1, '*Synthesis and Processing'*, Academic Press, 2000
- Groza J.R., Shackelford, J.F. Lavernia, E.J. Powers, M. T. (Editors), 'Materials Processing Handbook', Taylor and Francis Group, CRC press, 2007
- Tjong S.C., 'Nanocrystalline Materials: Their Synthesis-Structure-Property Relationships and Applications', Elsevier Ltd., 2006
- Gogotsi Y. (Editor), 'Carbon Nanomaterials', Taylor and Francis Group, CRC press, 2006
- Gogotsi Y. (Editor), 'Nanomaterials Handbook', Taylor and Francis Group, CRC press, 2006
- Cantor B. (Editor), 'Novel Nanocrystalline Alloys and Magnetic Nanomaterials', IOP publishing Ltd., 2005
- Kotov N.A. (Editor), 'Nanoparticles Assemblies and Superstructures', Taylor and Francis Group, CRC Press, 2006
- Liveri V.T., 'Controlled Synthesis of Nanoparticles in Microheterogeneous Systems', Springer Science plus Bussiness Media, 2006
- Srivatsan, T. S. and Sudarshan, T. S., 'Rapid solidification Technology,' Technomic Publishing, 1993.
- Suryanarayana, C., 'Non-equilibrium Processing of Materials', Pergamon, 1999.
- Picatinny, N.Y. and Otooni, M.A., 'Elements of Rapid Solidification: Fundamentals and Applications', Springer Series in Materials Science, 1997.

ME-603 Vacuum Metallurgy

Nature	*Optional*
Credits	3
Prerequisite	IC
Course Format	Three hours of lectures per week

Introduction to vacuum; Basic terms, definitions and units; Pressure and mean free path; Transport phenomenon in viscous state; Transport phenomenon in molecular state; Thermal diffusion and energy transport; Gas flow at low pressure; Physico-chemical phenomena in vacuum techniques. Types and working principles of various vacuum pumps for low, medium, high and ultrahigh vacuum regions; Measurement of pumping speed; Vacuum systems design; Devices for measurement of vacuum; Vacuum seals of various types; Leak detection in vacuum systems by search gas overpressure and vacuum methods, Mass spectrometer and tesla coil; Accessories such as pressure switching units; Traps of various types; Protective devices.

Thermodynamics and Kinetics in Vacuum Metallurgy: Fundamental Metallurgical Thermodynamics, The Law of Mass Action, Effect of Vacuum on Materials Processing, Equilibrium Between a Pure Condensed Phase and an Ideal Gas, Kinetics of Vacuum Metallurgical Processes. Vacuum Techniques in Extractive Metallurgy and Refining of Metals. Carbothermic and Metallothermic Reduction Processes, Use of Ellingham and Predominance Area Diagrams; Refining of Metals ina Vacuum, Vacuum Distillation and Zone Refining. Vacuum Melting and Vacuum Coating Practices: Vacuum Melting in Resistance Furnaces, Vacuun Induction Melting, Vacuum Arc Melting, Electron Beam Melting; Vacuum Evaporation and Cathode Sputtering.

References:

- Choudhury , Ashok , ‘Vacuum Metallurgy’ , ASM International , 1990
- Roth, A, ‘Vacuum Technology’, Elsevier Publishing Company, Netherland, 1989
- Winkler, 0. and Bakish, R., 'Vacuum Metallurgy', Elsevier Publishing Company, Netherlands 1971

MME-604 Surface Engineering

Nature	*Optional*
Credits	3
Prerequisite	IC
Course Format	Three hours of lectures per week

Surface chemistry; Coatings for corrosion resistance, wear resistance, aesthetic

appearance, optical and electronic applications, etc.; Carburizing, Nitriding, Carbonitriding, Induction hardening; Shot peening, Mechanical grinding and polishing, Electropolishing; Ion beam Implantation, Physical vapor deposition, Chemical vapor deposition; Electroplating, Electro-less Deposition, Anodizing, Phosphatizing, Chromate conversion coating, etc.; Applications of laser and plasma for surface modification; Characterization of coatings for surface hardness, wear resistance, topography, adhesion, microstructure and surface tribology.

References:

- Pierson H.O., 'Hand book of Chemical Vapor Deposition: Principles, Technology and Applications', Noys Publications, Park Ridge, New Jersey, USA, 1999
- Brooks C.R., 'Principles of the Surface Treatment of Steels', Technology Publishing Co., Inc., 1992
- Nalwa H.S. (Editor), 'Handbook of Nanostructured Materials and Nanotechnology', Vol. 1, '*Synthesis and Processing'*, Academic Press, 2000
- Gray A. G.,'Carburizing and Carbonitriding', American Society for Metals, USA, 1997
- Dahotre N.B., Sudarshan T.S., 'Intermetallics and Ceramic Coatings', Marcel Dekker, USA, 1999
- Cavaleiro A. and De Hosson J. T. M. (Editors), 'Nanostructured Coatings', Springer Science plus Bussiness Media, 2006
- Rosoff M., 'Nano-Surface Chemistry', Marcel Dekker, Inc., 2002
- Burnell J.S., Datta P.K., 'Surface Engineering Case Book', Woodhead Publishing Limited, 1996
- Batchelor, A.W., Lam L.N., Chandrasekaran M., 'Materials Degradation and its Control by Surface Engineering', World Scientific Publishing Co. Pte. Ltd., 1999
- Sproul W.D, and Legg, K. O., 'Advanced Surface Engineering', Technomic Publishing Co., 1993.
- Hudson J.B., 'Surface Science: An Introduction', John Wiley, 1998
- Venables J. A., 'Introduction to Surface and Thin Film Processes', University Press, Cambridge, 2001
- Bunshah R.F., 'Techniques for Metals Research' Vol 1, Part 3; John Wiley, 1968

MME-605 Thin Film Processing and Characterization

Nature	*Optional*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

An overview of material science of thin films and vacuum science, Physical vapor deposition (PVD): Glow discharges and Plasmas, Sputtering, Hybrid and modified PVD processes, Chemical vapor deposition (CVD): Reaction Types,

Thermodynamics of CVD, Gas Transport, Growth Kinetics, CVD processes and system, Nucleation and growth: Film growth modes, Capillarity theory of heterogeneous growth nucleation, Nucleation rate and its atomistic models, Kinetic models of nucleation, Cluster coalescence and depletion, Experimental studies of nucleation and growth, Structural aspects of Epitaxial films, Lattice misfit and Imperfection in Epitaxial films, Methods for depositing epitaxial semiconductor films, Optical and mechanical methods for measurement of film thickness, Structural, chemical and electrical characterization of thin films, Two probe and four probe resistivity measurement techniques, Electrical conductivity in metal, insulating and semiconducting thin films, metal semiconductor contacts and interfaces, Magnetic properties of thin films, Thin film applications

References

- Ohring M., 'Materials Science of Thin Films', Academic Press, 2nd edition 2001.
- Smith, D. L., 'Thin Film Deposition, Principles and Practice', McGraw-Hill, 1995.
- Tu K.N., Mayer J.W. and Feldman L.C., 'Electronic Thin Film Science for Electrical Engineers and Materials Scientists', MacMillan, 1992.
- Schuegraf K.K., 'Handbook of Thin-Film Deposition Processes and Techniques', Noyes,1988.
- Machlin E.S., 'Materials Science in Microelectronics', Giro Press, 1995.
- Chopra K.L.and Kaur I., 'Thin Film Device Applications', Plenum Press, 1983.

MME-606 The Science and Engineering of Microfabrication

Nature	*Optional*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

An overview of semiconductor materials, devices and process technology, Silicon and GaAs crystal growth techniques, Thermal oxidation process for silicon, The need for clean room, Optical and non optical lithography including photolithography, electron beam, EUV, ion beam and X-ray lithography, Exposure tools, masks and resists for lihthography, Resolution Enhancement Techniques for Photolithography, Wet chemical etching of Silicon, Silicon Dioxide, Silicon Nitride, Polysilicon and Gallium Arsenide, Dry Etching Mechanism and equipment: Plasma Diagnostics, Reactive Plasma Etching, Techniques for introduction of dopants in semiconductors: diffusion and ion Implantation. Film deposition techniques, Fabrication of integrated circuit resistor, capacitor and inductor, Process flows for critical process technologies, integrated devices, and microelectromechanical systems, Integrated circuit packaging

References

- Campbell S.A., 'The Science and Engineering of Microelectronic Fabrication', Oxford University Press, 2003.
- May G.S., Sze S.M., 'Fundamentals of Semiconductor Fabrication', John

Wiley & Sons Inc. 2004.

- Madou M.J., 'Fundamentals of Microfabrication" CRC Press, 2002.
- Mack C, 'Fundamentals Principles of Optical Lithography: Science of Microfabrication', Wiley Interscience, NY, 2008.
- Lieberman, and Lichtenberg, 'Principles of Plasma Discharges and Materials Processing', Wiley Interscience, NY, 1994.
- Jaeger R.C., 'Introduction to Microelectronic Fabrication', Prentice Hall 2001.

MME-608 Advanced Topics in Materials Engineering

Nature	*Optional (during 4th semester)*
Credits	*3*
Prerequisite	*Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Lectures on advanced specialized topics of specific technical interest may be arranged in this course, subject to approval of the Board of Studies or equivalent committee

ME-622 Metal- and Ceramic-Matrix Composites

Nature	*Optional*
Credits	*3*
Prerequisite	*MME-522 / Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Matrix alloys for MMC's, Types and materials of reinforcements. Processing of reinforcements. Powder metallurgy of MMC's, Compo-casting, Processing by melt infiltration. Pre-forms for infiltration, In-situ processing of MMC's, MMC's processing by electro-deposition, PVD and CVD, Aluminum-based, titanium-based and magnesium-based composites for light-weight applications. Nickel-based composites for high temperature applications, Copper- and iron-based composites. Mechanical degradation and failure of MMC's, Corrosion-behavior of MMC's, Merits and demerits of MMC's in comparison with PMC's, CMC's and matrix alloys, Applications of MMC's, Future trends.

The classification of CMCs, Dispersion Strengthened, Fibre Reinforced and Laminated CMCs; Strengthening mechanisms in CMCs,; Processing of CMCs; Microstructural control in processing of CMCs; Characterization and Engineering properties of CMCs, physical-, Chemical-, Tensile, Compressive-, Fracture-, Creep-, Fatigue-, Tribological-, Thermal-, Corrosion-properties of CMCs; Special topics – Case Studies.

References:

- Withers, P.J. and Clyne, T.W., 'An Introduction to Metal Matrix Composites', Cambridge University Press, 1995.
- Li, J. C. M., "Microstructure and Properties of Materials", World Scientific, 1996.
- Vigo, T. L., Kinzig, B. J., Composite Applications: The Role of Matrix, Fiber, and Interface, 1992.
- Suresh, S. Fundamentals of Metal Matrix Composites, 1993.
- Ochiai, S. Mechanical Properties of Metallic Composites, 1991.
- Rohatgi, P., Gupta N., 'Solidification Processing of Metal Matrix Composites',2006
- Chawla, K.K., 'Ceramic Matrix Composites', 2nd edition, Springer, 2003
- Ishida, H., 'Characterization of Composite Materials, Butterworth-Heinemann, 1994

MME-623 Polymer Matrix Composites

Nature	*Optional*
Credits	*3*
Prerequisite	*MME-523 / Instructor's recommendation to be approved by departmental committee's Consent*
Course Format	*Three hours of lectures per week*

Definition and classification, natural composites, property enhancement by reinforcement and orientation, matrix interface, synthetic fibers, properties and processing of composites with polymeric matrix, interface reactions. Hybrid composite materials. Principles for developing organic-fiber-reinforced polymers for aerospace engineering, mechanical and thermal properties, stress relaxation and creep studies, dynamical mechanical properties, toughening mechanism and mechanical failure in polymeric composites.

References:

- R. E. Shalin., Polymer Matrix Composites, Chapman& Hall, 1995.
- Matthews & Rawlings, Composite Materials: Engineering and Science, Chapman& Hall, 1995.
- Ramesh Talreja and Jan-Anders E. Manson; Polymer Matrix Composites, Elsevier 2001.
- L. H. Sperling, Polymeric Multicomponent Materials, Wiley, 1997.

MME-641 Nuclear Reactor Materials

Nature	*Optional*
Credits	3
Prerequisite	MME-502
Course Format	Three hours of lectures per week

Special properties of materials for nuclear applications; Crystal structure and radiation damage; Micro-structural changes: defects formation, atomic mixing, phase transformations, appearance of unusual phases, helium bubble formation and swelling; Nuclear materials for four safety classes; Metallic & ceramic fuels, dispersion fuels and their importance for various reactor designs; Advanced nuclear fuels; Cladding materials: stainless steels, zirconium alloys, effects of alloying additions and texture development; Fuel-cladding chemical and mechanical interactions; Structural materials for various components of water cooled reactors such as reactor pressure vessel, steam generators, steam turbine etc.; Moderator, Control and Reflector materials; Materials for spent fuel storage and transportation; Corrosion issues in nuclear power plants; Materials for future smart reactors.

References:

- Comprehensive Nuclear Materials, Rudy J.M. Konings (Editors), Volume 1-5, Elsevier Ltd, 2012
- Materials Science and Technology, Volume 10, Nuclear Materials, Parts I & II, Vol. Editor: Frost, B. R. T, VCH, 1994.
- Roberts, J.T.A.: Structural Materials in Nuclear Power Systems, Plenum Press, New York, 1981
- Ursu, I., Physics and Technology of Nuclear Materials, Pergamon Press Ltd., 1985

CMS-505 Project Management

Nature	Optional
Credits	3
Prerequisite	Nil
Course Format	Three hours of lectures per week

Introduction to management principles, Inter-disciplinary and multidisciplinary skill of a project manager; Project management vs. line management; Project life cycle, different phases of a project life cycle, dynamic and static project interfaces, integration and management of project interfaces; Team building for a project; selection of team members, concept of skills inventory and responsibility matrices; Project planning modeling, a five step-planning model, strategic planning techniques, project planning facilitation techniques; Development of work breakdown structure (WBS) for the project; Project networking techniques; Critical path method (CPM),

scheduling, cost and resource utilization techniques; Managing the project change, techniques to manage the scope changes and baseline changes; Project control techniques, formal and informal control, five-step model for project control, status reports an reviews; Earned value management techniques, achievement monitoring and accomplishment monitoring,; Supporting project management, software types, training and administration techniques.

References

- Ruskin, A. M. and Estes, W. E.: What Every Engineer Should Know About Project Management;, Marcel Dekker Inc., 1982.
- Cleland, D. I. and King, W. R.: Project Management Handbook, Van Nostrand Reinhold Publishers, USA, 1990.
- Lundy, J. L.: TEAMS (Together Each Achieves More Success), Dartnel Publishers, 1994.

NE-510 Nuclear Power Plant Systems

Nature	*Compulsory*
Credits	3
Prerequisite	Nil
Course Format	Three hours of lectures per week

Layout of nuclear power plants; Containment buildings; Prirnary containment vessels; Structure of reactor core; and mechanical stress in various structures. Description and analysis of power plant systems and components including steam generator, steam dryer and separator, pressurizer, reheater, heat exchanger, condenser, demineralizer, pumps ,turbine, generator, cooling tower; Auxiliary cooling systems. Fuel handling mechanisms; Control and mechanisms; Radwaste systems; Electrical Systems; Reactor grid interface and load following. Basic considerations in nuclear plant design; Components of nuclear power cost; Economic comparison of nuclear and fossil fueled plants; Dual and multipurpose nuclear plants; Future trends in nuclear power cost.

References:

- Rust, J. H., Nuclear Power Plant Engineering, Haralson, 1979.
- El-Wakil, M.M., Nuclear Energy Conversion, International Text Book, 1982
- Pedersen, E.S., Nuclear Power, Ann Arbor Science, 1978.
- El-Wakil, M.M., Power Plant Technology, McGraw-Hill, 1984.
- Lish, K.C., Nuclear Power Plant Systems & Equipment, Industrial Press Inc., 1972.

CHE-519 Extractive Metallurgy

Thermodynamics and reaction kinetics of extractive metallurgical processes; Thermodynamic stability diagrams. Pyrometallurgy: Roasting, agglomeration, calcination; oxidation-reduction reactions; smelting and converting; refining. Hydrometallurgy: Leaching under atmospheric and elevated pressures; microbial leaching; purification of leach liquors (ion exchange and solvent extraction); cementation and gaseous precipitation; kinetics of hydrometallurgical processes. Electrometallurgy: Electrowinning and electrorefining of metals from aqueous and fused salt systems.

Recommended Text**:**

- Rosenquis, T., Principles of Extractive Metallurgy. McGraw Hill. 1983
  Jackson, E., Hydrometallurgical Extraction and Reclamation. Jackson/Ellis Horwood Ltd. 1986

MME-697 M.S. Thesis Research

Nature	*Compulsory (during second last Semester)*
Credits	6
Prerequisite	Nil

It would be of 6 credits only. Students are expected to strengthen their background in the technical area of their project, develop skill for proper use of relevant equipment and initiate work on the planned project.

MME-697 M.S. Thesis Research

Nature	*Compulsory (during last Semester), Full-time*
Credits	12
Prerequisite	MME-697 Semester IV

It would be of 12 credits and would involve full-time work on the project for the entire semester. Students are expected to complete their project work, write their thesis and defend it.