REVISED CURRICULUM
OF
Metallurgy & Material Engineering

Curriculum Development Project
Sponsored by
Ministry of Science & Technology
Islamabad

HIGHER EDUCATION COMMISSION
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2003

CURRICULUM DIVISION, HEC

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*Composed by **Mr. Zulfiqar Ali,** HEC, Head Office, Islamabad*

CONTENTS

PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum of a subject, one can judge the state of intellectual development and the state of progress of a nation. The world has turned into a global village, new ideas and information are pouring in a constant stream. It is, therefore, imperative to update our curricula by introducing the recent developments in the relevant fields of knowledge.

In exercise of the powers conferred by Sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide Notification No.D773/76-JEA (Cur.), dated December 4, 1976, appointed Higher Education Commission as the Competent Authority to look after the Curriculum Revision Work beyond Class XII at Bachelor level and onwards to all Degrees, Certificates and Diplomas awarded by Degree Colleges, Universities and other Institutions of higher education.

In pursuance of the above decisions and directives, the Commission is continually performing curriculum revision in collaboration with the Universities. According to the decision of the special meeting of Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various Committees are constituted at the national level comprising senior teachers nominated by the Universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these Committees.

The National Curriculum Revision Committee on **Metallurgy & Material Engineering** in its meeting held in July 2003 at the H.E.C. Regional Centre, Karachi finalized the draft curriculum after due consideration of the comments and suggestions received from the Universities and Colleges where the subject under consideration is taught.

The Final draft prepared by the Curriculum Revision Committee duly approved by competent authority is being circulated for implementation by the Universities.

(PROF. DR. ALTAF ALI G. SHAIKH)
D.G. (CURRICULUM)

July 2003

INTRODUCTION

A final National Curriculum Revision Committee meeting in Metallurgy & Material Engineering was held at Higher Education Commission Regional Office, Karachi from July 1-3, 2003 to finalize the draft curriculum for B.E./B.Sc., M.E./M.Sc. degree program. The following attended the meeting.

1. Prof. Dr. Javed Iqbal, — Convener
   Director Advance Engineering Material Lab,
   Department of Material Engineering,
   University of Engineering & Technology,
   Lahore.

2. Mr. Muhammad Hayat Jokhio, — Member
   Associate Professor/Chairman,
   Department of Metallurgy & Material Engineering,
   Mehran University of Engineering & Technology,
   Jamshoro..

3. Dr. F.H.Usmani, — Member
   Associate Professor,
   Dawood College of Engineering & Technology,
   Karachi

4. Dr. Khalid A. Shahid, — Member
   Director General,
   National Engineering & Scientific Commission,
   (NESCOM), Islamabad

5. Mr. Shafi Haider Siddiqui, — Member
   Head,
   Mineral Development Department ,
   Pakistan Steel, Bin Qasim,
   Karachi.

6. Syed Shahabuddin, — Member
   General Manager (Vendor Development Cell),
   Pakistan Machine Tool Factory,
   Karachi.

7. Engr. Sahar Noor, — Secretary/Member
   Assistant Professor,
   NWFP University of Engg. & Technology,
   Peshawar.

The meeting was started with the recitation of Holy Quran. Mr.Muhammad Younus, Director Curriculum, Higher Education Commission, Islamabad welcomed the participants of the meeting on behalf of the Chairman, Higher Education Commission and explained about the comments received from Mehran University of Engineering & Technology, Jamshoro, on the first draft curriculum of the subject prepared during the first meeting held at HEC, Karachi on 22-24 October 2002. Mr. Dholan Khiyani, Director, HEC, Regional Centre, Karachi in his inaugural speech assured the participants for providing all possible assistance and secretarial work/typing enabling them to finalize the draft curriculum of the subject at graduate and post-graduate level.

The committee before taking up the regular agenda unanimously agreed to select Dr. Javed Iqbal as its Covenor and Engr. Sahar Noor as Secretary.

Dr. Javed Covenor of the committee welcomed the participants and thanked them for showing confidence in him. He also thanked the following universities/ organization on sending their representative to participate in the meeting.

2. University of Engineering & Technology, Lahore
3. Mehran University of engineering & Technology, Jamshoro
4. Dawood College of Engineering & Technology, Karachi
5. National Engineering & Scientific Commission, Islamabad
6. NWFP University of Engineering & Technology, Peshawar
7. Mineral Development Department, Pakistan Steel, Bin Qasim, Karachi
8. Pakistan Machine Tool Factory, Karachi

The committee has reviewed the first draft curriculum in the light of suggestions of the participants in the recent developments in the field of metallurgical and materials engineering. Emphasis was also given to the suggestions put forward by the participants from different universities, industries and R&D organizations and finalized the draft curriculum of B.Sc./B.E. Metallurgical and Materials Engineering at graduate and M.Sc./M.E. at post graduate level.

ENGR. SAHAR NOOR
Secretary

Prof. Dr. Javed Iqbal
Convener

SCHEME OF STUDIES
FOR
B.E./B.Sc

Compulsory Subjects

1. HM-101 (a) Islamic Studies and Pakistan Studies (compulsory for Muslim Students)

(b) Ethics & Pakistan Studies (compulsory for Non-Muslim Students)

Core Courses

1. MM-101 Introduction to Engineering Materials
2. MM-102 Mechanics of Materials
3. MM-201 Physical Metallurgy
4. MM-202 Fuels & Furnaces
5. MM-203 Materials Thermodynamics & Kinetics
6. MM-204 Foundry Engineering
7. MM-205 Ferrous Metallurgy
8. MM-206 Engineering Ceramics
9. MM-207 Non-Ferrous Metallurgy
10. MM-301 Polymeric Materials
11. MM-302 Vacuum Metallurgy
12. MM-303 Inspection & Testing of Materials
13. MM-304 Heat Treatment Processes
14. MM-305 Welding and Joining Processes
15. MM-306 Composite Materials
16. MM-307 Deformation Behavior of Materials
17. MM-308 Corrosion, Protection & Prevention
18. MM-309 Powder Metallurgy
19. MM-401 Nuclear Materials
20. MM-402 Materials Characterization
21. MM-403 Manufacturing Technology
22. MM-404 Phase Transformations
23. MM-405 Modern Steels
24. MM-406 Advanced Foundry Practices
25. MM-407 Selection and Applications of Materials
26. MM-408 Fracture Mechanics
27. MM-409 Computer Applications in Materials Engineering
28. MM-410 Project
29. Industrial Internship

NOTE: Depending on the specialization of a degree awarding department, upto 25 subjects may be included in the curriculum. Projects is compulsory.)

Basic/Allied Subjects

1. MT-101 *Mathematics-1
2. MT-201 Mathematics-II
3. MN-103 Mineral Processing
4. MT-203 Statistical Methods and Estimation
5. PH-101 *Applied Physics
6. CH-101 *Applied Chemistry
7. CH-102 Physical Chemistry
8. CS-201 Introduction to Computer Systems
9. CS-202 *Numerical Analysis & Computer Programming
10. EE-302 Instrumentation & Control
11. ME-101 *Engineering Drawing & Graphics
12. ME-102 *Workshop Practice
13. EE-101 *Applied Electricity & Electronics
14. MM-310 Industrial Economics & Management
15. HM-102 *English/Communication Skills

Technical Electives

1. Advanced Materials Manufacturing
2. Electronic, Magnetic and Optical Materials
3. Surface Engineering
4. Industrial Safety
5. Design Standards and Quality Assurance
6. Maintenance Management
7. Environment Engineering
8. Energy Conservation in Materials Related Industries
9. Solid Waste Management
10. Design Standards and Quality Assurance

NOTE: Universities/Institutions may offer any twelve of the above listed Basic Allied and Technical Electives subjects. Courses with asterisk * are compulsory.

At least 25 courses from those proposed core courses and 12 courses from basic/allied and technical electives must be completed to meet the degree requirements. Industrial internship of at least 8-12 weeks is recommended as requirement for all students. These students must present a report of internship experience.

TERM / SEMESTER-WISE LAY-OUT OF COURSES

First Year (1st Term / Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1	MT- 101 Mathematics-I	03	00
2.	HM-101 Islamic Studies / Ethics and Pakistan Studies	02	00
3.	MM-101 Introduction to Engineering Materials	02	01
4.	CH-101 Applied Chemistry	03	01
5.	MM-102 Mechanics of Materials	03	01
	Total	**13**	**03**

First Year (2nd Term/Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1.	HM-102 English / Communication Skills	02	00
2.	ME-101 Engineering Drawing and Graphics	03	00
3.	ME-102 Workshop Practice	00	01
4.	PH-101 Applied Physics	02	01
5.	MN-103 Mineral Processing	02	01
6.	EE-101 Applied Electricity and Electronics	03	01
	Total	**12**	**04**

Second Year (3rd Term / Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1	MT- 201 Mathematics-II	03	00
2.	CS-201 Introduction to Computer Systems	02	01
3.	MM-201 Physical Metallurgy	02	01
4.	MM-202 Fuels and Furnaces	03	01
5.	MM-203 Materials Thermodynamics & Kinetics	02	00
	Total	**12**	**03**

Second Year (4th Term/Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1.	MM-204 Foundry Engineering	03	01
2.	MM-205 Ferrous Metallurgy	02	00
3.	MM-206 Engineering Ceramics	02	01
4.	MM-207 Non-Ferrous Metallurgy	03	01
5.	CS-202 Numerical Analysis & Computer Programming	03	01
	Total	**13**	**04**

Third Year (5th Term/Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1.	MM-305 Welding & Joining Processes	03	01
2.	MM-301 Polymeric Materials	03	01
3.	EE-302 Instrumentation and Control	02	01
4.	MM-303 Inspection & Testing of Materials	03	01
5.	MM-310 Industrial Economics & Management	02	00
	Total	**13**	**04**

Third Year (6th Term/Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1.	MM-304 Heat-treatment Processes	02	01
2.	MM-306 Composite Materials	02	01
3.	MM-307 Deformation Behaviour of Materials	02	00
4.	MM-308 Corrosion, Protection & Prevention	02	01
5.	MM-309 Powder Metallurgy	03	01
	Total	**11**	**04**

Final Year (7th Term/Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1.	MM-401 Nuclear Materials	03	00
2.	MM-402 Materials Characterization	03	01
3.	MM-403 Manufacturing Technology	02	01
4.	MM-404 Phase Transformations	02	00
5.	Electronic, Magnetic & Optical Materials	02	00
6.	MM-410 Project	00	02
	Total	**12**	**04**

Final Year (8th Term/Semester)

No.	Course Number & Title	Credit Theory	Credit Practical
1.	MM-405 Modern Steels	02	01
2.	MM-406 Advanced Foundry Engineering	03	00
3.	MM-407Selection and Applications of Materials	02	00
4.	MM-408 Fracture Mechanics	02	01
5.	CS-409 Computer Application in Material Engineering	03	01
6.	MM-410 Project	00	02
	Total	**12**	**05**

Work Load

Year / Semester	Contact Hours for Theory/Week	Contact Hours for Practical / Week	Total Contact Hours
1st / (1st)	13x1=13	3x3=9	13+(3x3)=22
1st / (2nd)	12x1=12	4x3=12	12+(4x3)=24
2nd / (3rd)	12x1=12	3x3=9	12+(3x3)=21
2nd / (4th)	13x1=13	4x3=12	13+(4x3)=25
3rd / (5th)	13x1=13	4x3=12	13+(4x3)=25
3rd / (6th)	11x1=11	4x3=12	14+(4x3)=23

4th / (7th)	12x1=12	4x3=12	13+(4x3)=24
4th / (8th)	12x1=12	5x3=15	12+(5x3)=27
Total	**98x1=98**	**31x3=93**	**93**
	98	31	98+93=191

Total Credits=98+31=129

Total contact hours=191x17*=3247
(* Nos. of weeks / semester)

NOTE: The above figures satisfy the minimum credits (i.e.,128) and contact hours (i.e.,3200 hrs) Requirements for the award of first degree in engineering laid down by the Pakistan Engineering Council.

DETAIL OF THE COURSES
FOR
B.E./B.Sc

1st Semester

MT- 101 Mathematics-I

Review of function of real variables and their graphs. Complex Numbers and Functions, Complex numbers and their graphical representation. De-Movivre's theorem and its applications, Hyperbolic and inverse hyperbolic functions, Circular and inverse circular functions, Logarithmic functions (complex form). Scalars and vectors, Equality of vectors, Collinear Vectors, Addition of vectors, Product of vectors by a constant, Commutative and associative laws of addition, Subtraction of vectors, Coplanar vectors, Scalar or dot product of two vector, Angle between two vectors, Geometrical meaning of dot product, Meaning of i,j,k, vector of cross product. Right hand and left handedsystem, vector area as a vector product, Triple products. Geometrical meaning of scalar trip product. Distributive law theorems. Applications of factor algebra to geometry, trigonometry and mechanics. Definition, Co-Factors, Minors, Properties of determinants, Solution of system of linear equations by Cramer rule, Multiplication of determinants.

Definition and basic concept, Equality of matrices, Addition of matrices, Multiplication of matrices by scalar, Multiplication of two matrices, Transpose of matrix, adjoin of matrix, inverse of matrix, transpose of product and sum of two and more matrices, inverse of product of two and more matrices, Rank of matrix, determinant of matrix, Solution of non homogeneous and homogenous system of linear equations (Gauss Elimination and Gauss-Jargon Methods). Analytical Geometry of three Dimensions Point, Definition, Distance between two points, division formula, Direction ratios and direction consigns of a line, Equation of a line in symmetric and vector form, angle between two lines, Condition of two lines to be paella or perpendicular. Definition and equation of a plane, Angle between two planes, Perpendicular distance of a point from a plane. Definition and equation of a sphere, Plane section of sphere, intersection of two spheres, General equation of sphere through a given circle, Tangent plane, Angle of intersection of two spheres. Definition and equation of a cylinder.

References:

- Anton, Howard: Calculus; A New Horizon, John Wiley, 1998
- Swokowski, E. W. et al. : Calculus, Brooks / Cole Publishing, 1994
- Zill, D. G. : Introduction to Differential Equations, Brooks / Cole Publishing, 2000

HM-101 Islamic Studies / Ethics and Pakistan Studies

As approved by PEC.

References

- "Islamic Studies" Allama Iqbal Open University Islamabad
- Abu Ala Moudioodi, " ethical View Point of Islam"
- Mazhar-u-ddin Sidiqui, " World Religions"
- " Pakistan Studis" , Allama Iqbal Open University Islamabad
- Zafar M.D , " Pakistan Studies" (English

MM-101 Introduction to Engineering Materials

Introduction to engineering materials, their scope and role in industrial development, raw materials for engineering materials: their availability and demand, fundamentals of engineering materials: atomic bonding, crystal structures of metals , introduction to polymers, ceramic and composite materials.

Processing, properties and applications of metallic, polymeric, ceramic and composite materials. An introduction to new breeds of engineering materials e.g, shape memory materials, smart materials, electrical , magnetic and optical materials. Materials of aerospace and transportation industries.

Reference:

- Flinn, R. A. & Trojan, P.K., Engineering Materials & their Applications, Houghton Mifflin, 1990.
- 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
- Shackelford, J.F, "Introduction to Materials Science for Engineers", Maxwell Macmillan Publishing Co. 1992
- Smith, W.F., "Structure and Properties of Engineering Alloys", McGraw Hill Book Co., 1993
- Smith, W.F., "Principles of Materials Science and Engineering", McGraw Hill, 1996
- Van-Vlack, L.H., "Elements of Materials Science and Engineering", Addison-Wasely, 1985
- Ashby, M.F. and Jones, D.R.H.,"Engineering Materials I & II", Butterworth-Heinemann, Oxford, 1996
- Narang, G.B.S, "Material Science and Processes", Khanna Publication, New Dehli, 1998

CH-101 Applied Chemistry

Introduction to chemistry, its scope and importance in Metallurgy and Materials Engineering. Classification of elements, periodic table and electronic configuration. State of matter (gas, liquid, solid) kinetic theory of gases, solutions. Basic laws: Roult's law, Henry's law, Sievert's law, Law of diffusion. Theory of crystallization, atomic bonding, crystal systems, properties of solid, liquid and gases.

Chemical equilibrium: Chemical reaction and equilibrium, chemical kinetics, theory of electro-chemistry, heterogeneous equilibrium, phase-rule, quantum theory. Introduction to oxidation and reduction reactions in iron and steel making. Oxygen potential diagrams. Organic chemistry: Introduction, nature and sources of compounds, hydrocarbon compounds, chemistry of hydrocarbon compound cracking. Analytical chemistry: Introduction, qualitative and quantitative analysis of ferrous and non ferrous metals, analysis of various ores, coals, liquid solution, etc.

Reference:

- P.J.Chenier," Introduction to Industrial Chemistry" , VCH, 1992
- H.L.White," Survey of Industrial Chemisrty" John wiley & Sons, 1996
- TL Brown at el , " Chemistry: the General Science" , Printice Hall, 1991
- Heaton & Blacly, " Introduction to Industrial Chemistry" , 1996
- An Introduction to Industrial Chemistry, A Heaton, 3rd ed, Blackie Academic and Professional, 1996

PH-101 Applied Physics

Thermometry, heat transfer, heat insulation, properties of materials for use in building geometrical optics, the focal length of a lens, magnification, compound lenses, resolving power, laws of illumination and photometry, sextant spectrometer. Principles of refracting telescope, polarization of light. Waves and oscillation, sound waves, resultant to two simple harmonic motions, response and beats, acoustics and its application, interference, wave length and frequency, units and measurement of intensity, reflection and refraction of sound, reverberation time.

Magnetic effect of current, CGS and practical units, relation between magnetism and electricity, magnetic field due to current in a long wire, force on a current carrying conductor in magnetic field, laws of electromagnetic induction, galvanometer, ammeter, voltmeter, avometer, condensers and dielectrics, magnetic materials, B-H curves, hystersis, magnetic circuits calculations, solenoids, pull of an electromagnet, principles of diode & triode, cathode ray tube and photo-multiplier tube. Atomic & nuclear physics, atomic structure, nuclear structure, radio activity, nuclear theory, fission & fusion.

References:

- Kittel C, " Introduction to Solid State Physics" , Willey New Yark 1976
- Wertc A, & Thomas RM, " Physics of Solid " , Mecgrahill 1970

2nd Semester

HM-102 English / Communication Skills

Grammar: Students should be able to: identify verbs in the present tense and past tense. Classify these verbs as regular or irregular, manipulate verb forms, e.g. changing verbs from active voice to passive voice etc. Listening and speaking comprehension. Although students will not be tested on their listening and speaking skills, they will be expected to take part in normal class room activities which require listening and speaking in English. This may include activities, like following instructions, answering questions, completing work tasks; etc.

Two specific aims of the listening component of the course are to enable students to extract relevant information from a listening passage. Make notes from a listening passage. Vocabulary: Match vocabulary items with their corresponding definitions, identifying odd items out from a list. Classify vocabulary items into lexical sets.

References:

- Swan m," Basic English Usage, ELBS-OUP", 1984

ME-101 Engineering Drawing and Graphics

Introduction to subject, use of instruments, Planning of drawing sheets, the projection of simple solids in simple position, the oblique and auxiliary plans, lettering, dimensioning, the principle requirement of working drawing. Geometrical drawing & graphics: Isometric and pictorial of solid figures, making of free hand sketches from solid project and from orthographic projections. Section of solid, tangent planes, two surface in contact, intersection of surface and interpretation of solids development of surfaces.

Machine drawing: Screw thread systems, keys and cutters, coupling and simple bearings, hanger, wall bracket, pipes and pipes fittings, shafts, connecting rods, piston and piston rod, valves stuffing boxes, pulling thread gearing.

References:

- Fundamental of Engineering Drawing, Warren J. Leozjedin
- Elementary Drawing, By N.D. Butt
- First Year Engineering Drawing, M.A. Gana
- Auto CAD Release 2000

ME-102 Workshop Practice

Bench fitting: Description, proper use and maintenance of the fitting tools: use and care of measuring instruments, Preparation of some specific jobs. Forging: Hand forging, Use and maintenance of forging tools, the fore anvils, hammers, chisels, fullers, swages, punches, drifts, tongs, Prepare some specific jobs using forging methods. Use of power hammer, drop and press forging, riveting.

Wood working: Use & care of wood working tools, clamps, saws, planes, files, rasps, chisels, drills, bits, planning, nailing, screwing, jointing, doweling, . Use and care of natural wood, chipboard, plywood, hardboard etc. Metal forming: Cold working processes for sheet metals; e.g. pressing stamping, embossing, drawing, bending, piercing etc. Use of common presses and dies. Foundry practice: Bench and floor sand casting; sand and binders, sand conditioning, molding tools, flasks, boards, spurs, cutters, reamers, bellows, brushes, vent pins, trowels, spoons, etc. Preparation and care of patterns, metal melting and pouring. Safety and care: Precautions necessary in many shops machine accidents, general cleanliness of shop, proper appraisal, accident alarms and evacuation..

MM-102 Mechanics of Materials

Theory of elasticity, brittle fracture. Unsymmetrical bending and shearing. Horizontal shearing stresses shear flow, flow deflection due to shear , photo elastic method. Plasticity, relationship between stress and deformation moment of inertia of different axes. Ellipse of inertia, determination of principal axes. Fault plate, rectangular and circular plates simple supported and claimed at ends general theory of bending. Introduction to stress strain diagram, working stresses, unit design, strain energy in tension and compression.

Analysis of bi-axial stresses, principal planes, principal stress-strain, stresses in thin walled pressure vessels. Mohr's circles of bi-axial stress. Torsion of circular shafts, coiled helical spring, strain energy in shear and torsion of thin walled tubes, torsion of non-circular sections. General case of plane stresses, principal stress in shear stresses due to combined bending and torsion plane strain. Thermal stresses, buckling.

References:

- Parsad I.B., Applied Mechanics and Strength of Materials, Khanna Publications

MN-103 Mineral Processing

Theory of crushing, operation and application of jaw-, gyrator-, cone-, roll, gravity stamp- and special crushers. The theory and application of liberation techniques. Theory and attributes of communition and use of ball, rod and tube mills. Industrial screening, types and operating characteristics screens, the movement of solids in fluids. Stoke's, Newton-, Rettinger's Law. Reynolds number free setting ratio and hindered setting ratio.

Heavy fluid separation, heavy liquids and suspension, principles of jigging. Hydraulic and pneumatic jigs, flowing film concentration and tabling. Flotation and dispersion. Magnetic separation and magnetic properties of substances. Miscellaneous processes of separation depending on colour and general appearance, heat properties, electrical properties, differential hardness, amalgamation. Separation of solids from fluids by thickening process, filtration, dust elimination and draying. Theory and techniques of concentrates, palletizing, nodulizing and briquitting. Flow sheets and circuit diagrams of typical mills treating ores, non-metallic and the solid fuels.

References:

- Couradian, "Mineral Dressing"
- Mineral Processing Technology, BAWills 6th ed Butterworth Heinemann,1997

EE-101 Applied Electricity and Electronics

Electric circuits: Circuit parameters, passive and active circuit elements. Superposition theorem. Kirchoff's law. Thevenin's theorem. Delta-Star and Star-Delta transformation, DC/AC distribution system. Magnetic field due to an electric current solenoid. Force on current carrying conductor, electromagnetic induction and Faraday's laws. Fleming's right hand rule, Len's law, magnitude of induced emf. Direct and alternating current: Generation of alternating emf in rotating coil. Slip rings, relationship between frequency, speed and number of pole pairs. Two segments and four segments commutator action. Instantaneous peak, average and rms value of AC form factor and peak factor. Average and rms values of sinusoidal current and voltages. Representation of an alternating quantity by a phaser.

DC machines: Generator, fundamentals of DC generators; types and characteristics emf equation, voltage regulations, parallel operation, automatic voltage regulation. Molar's speed and torque equation, types and characteristics. Starting and speed control of motors, breaking and reversing. AC machines: Transformers, theory and emf equation, losses, equivalent circuits. Some special types of transformers, emf of elementary alternators, rotating magnetic field; types and characteristics of induction motors, polyphase induction motors. Slip losses and efficiency of induction motors, electrical measurements, types of strain gauges and their uses, voltmeters and current meters. Measurements of power and power factor. Introduction to oscilloscope.

References:

- Electrical Technology, Long Man, 5th Edition 1997

3rd Semester

MT- 202 Mathematics-II

Limits, continuity and discontinuity of a function, derivatives and elementary functions; algebraic, trigonometric, transcendental, logarithmic, exponential, hyperbolic. Successive differentiation, Liebnit'z theorem, Taylor's and Maclaurin's series and their applications. Application of differential calculus, maxima and minima, point of inflection, tangents and normals, curvature and radius of curvature, partial differentiation, Euler's theorem. Integration, indefinite integrals, double and triple integrals, application of integration to area, volume, surface area, moment of inertia and center of gravity. Symposia's rule its application. Vector analysis, vector differentiation, and integration, line integrals, divergence gradient, curl and their geometrical interpretation, gauss and green's theorem.

In depth treatment of curve tracing and some well known curves. Ordinary concept and ideas, geometrical considerations, geometrical interpretation of the 1st and 2nd order differential equations, separable equations, equations reducible to separable from, exact differential equations, integrating factor, linear first order differential equations, families of curves orthogonal trajectories, application. Ordinary differential equations of orders, homogeneous linear equations of 2nd order, homogenous equations with constant coefficients, the general solution initial and boundary values problem, real, complex and repeated roots of characteristic equation, differential operators, cauchy equation, non-homogenous linear equations. Series solution of differential equations, ordinay and regular points and corresponding series solution, legender's equation and legender polynomial, bassel equation and basses function of 1st kind. Partial differential equations, method of seperable variables, application to engineering problems.

References:

- S.M.Yousuf, Calculus and Analytical Geometry
- Shaniti Naryan, Differential Calculus
- Shanti Naryan, Integral Calculus
- S.M.Yousuf, Vector Analysis
- Schaum Series,Vector Analysis
- Schaum Series, Calculus
- W.Shere and G. Love, Applied Mathematics for Engineering and Science, Printice Hall, 1969

- Erwin Kreyszing, Advance Engineering Mathematics
- Keplan, W., Elements of Differential Equations
- S.M.Yousuf, Mathematical Methods

CS-201 Introduction to Computer Systems

History and basic components of computer system, approaches to solving problems using computers, basic elements of C++ language, programming practice and case studies.

References:

- Introduction to Computer & C++ Programming by Robert Loffer, 3rd Edition

MM-201 Physical Metallurgy

Crystallography; Space lattice, Crystal system, Unit cell, Packing density, Coordination number, Allotropy, Rotational and Reflection Symmetries, Crystal planes and direction, Crystalline defects, Twining, Ordered and Disordered solutions. Crystallization; Solidification, Grain boundaries, Grain size, Cast structure, Segregation, Shrinkage defects,

Phase diagrams; Phase rule, Binary system, Ternary system, Solid Solution, Interstitial solid solution and Substitutional solid solution, Factor affecting the limit of solubility, Intermediate compound, Mixture, Iron -Carbon Diagram, Microstructure and properties of steel and Cast Iron, Microstructure of Copper based and Aluminum based alloys and their relationship to the properties, Metallurgical Microscope, Objectives lenses and their short comings, Polarized light microscopy,

References:

- Guy A.G and Hren J.J "Elements of Physical Metallurgy" 3rd ed.Addison-Wesley, Readding, Mass, 1974
- Physical Metallurgy Principles, R.E. Reed Hill and R.Abbaschian,3rd ed, PWS publ.Co 1994
- Introduction to Physical Metallurgy, Sydney, H.Avener, McGraw Hill 1985
- Applied Metallography, G.F.Eander Voort, Van Nostrand Reinhold, 1986
- Cahn, R. W. and Haasen, P. : Physical Metallurgy, North-Holland, 1996.
- Callister Jr., W.D. " Materials Science and Engineering", John Wiley & Sons, Inc, 1994
- Barrett, C.R., Nix, W.D. and Tetelman, A.S, "The Principles of Engineering Materials", Prentice Hall, 1973
- Petty, E.R., "Physical Metallurgy of Engineering Materials", Pitman
- Honeycombe and H. Bhaadeshia, " Steels Microstructure and Properties"
- Avner H. Sidny, "Introduction to Physical Metallurgy, McGraw Hill

- 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
- Smallman R.E "Modern Physical Metallurgy", 4th ed. Butterworths, Boston,1985

MM-202 Fuels and Furnaces

Fuels: Classification, preparation, storage, handling, transportation. Combustion of Fuels, low and high temperature carbonization of coal, liquid fuels, study of petroleum, knock rating. Light and heavy oils., furnace oil. Gaseous fuels, producer gas, water gas, coke oven gas and LPG. Natural gas and its viscosity, calorific intensity, octane number and Cetane number of fuel, analysis of fuel and fuel economy.

Furnaces: Types of furnaces, electric, oil, gas, coal. Heat treatment furnaces, vacuum furnaces and controlled atmosphere furnaces. Design and construction of furnaces, temperature measurement procedures and instruments, energy management and cost effectiveness.

References:

- J.D. Gilchrist, Fuels, Edward Arnold Publisher, London
- Dame and King, Fuels Technology Edward Arnold Publisher, London
- Gupta O.P. Elements of Fuels, Furnaces and Refractories, Khanna Publishers, New Delhi, 1990

MM-203 Materials Thermodynamics and Kinetics

First law, enthalpy, internal energy. Second law, entropy, Gibbs, Helmoltz free energies. Third law. Use of thermodynamic data. Equilibrium, quasi-static equilibrium. Relationship between heat and work. reversible and irreversible processes. Measurement of heat reactions, Phase equillibria in single and multi-component systems. Behaviour of solutions, non-ideal solutions, thermodynamics of phase diagrams. Experimental methods of evaluating thermodynamics functions, estimation and calculation of the values of thermodynamic functions, free energy of formation, free energy diagrams.

The Arrhenius equation, the activated complex theory, collision theory, calculation of reaction rates. Heterogeneous reactions, gas-solid reactions, liquid-solid reactions, liquid-liquid reactions at slag-metal interface, gas-liquid reactions. Kinetics of phase transformations under non-equilibrium conditions.

References:

- Regone, D. V. “Thermodynamics of Materials”, Vol. I & II, John Wiley, New York, 1995
- Rao, Y.V.C. “Theory and Problems of Thermodynamics”, Wiley Eastern India, 1994
- Gaskell, D. R.: Introduction to Thermodynamics of Materials, Taylor and Francis, Inc., 1995.
- Kubaschewski, , 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

4th Semester

MM-204 Foundry Engineering

Introduction to Foundry Engineering and Practice, Scope and importance of the subject, Simple foundry plant layout, Tooling, equipment, machines and types of furnaces used in foundry, Selection of suitable molding and core materials, Properties of molding and core materials, Analysis, testing and control of molding and core materials requirements.

Types of pattern, pattern making, shrinkage and contraction allowances, melting furnaces i.e. pit furnaces, induction melting furnaces, cupola furnaces, selection and control of melting processes, control of chemical compositions, casting and fettling operation, metal gas interaction, causes of defects in sand casting and their remedies, inspection and quality assurance, introduction to new casting techniques.

References:

- Principles of Metal Casting Philip C. Rosenthal Metallurgical Principals of Foundry

MM-205 Ferrous Metallurgy

Iron ores and Iron bearing minerals. Iron making and its importance. Fluxes and slags, their sources chemistry and uses. Agglomeration and testing of blast furnace burden. Sintering and roasting, blast furnace theory, construction, chemistry and the process. Factors affecting the reducibility and other metallurgical properties of burden viz L.T.B, reduction under load, strength, abrasion resistance etc.in blast furnace, use of natural gas and steam in blast furnace. Wrought Iron and sponge Iron. Direct reduction processes of iron making.

Description of steel making processes, chemistry of steel making, rate of slag removal during refining, reaction of carbon, oxygen, deoxidization, removal of impurities, killing of steels. Alternative routes of steel making, Bessemer, open health, top-blown and bottom-blown processes, acid and basic processes. Secondary steel making process, e.g., AOD, VOD, ESR, VAR.

References:

- Modern Iron and Steel Making, Tupkary.
- Principles of Extractive Metallurgy, by T. Rosenqvist, McGraw Hill 1983
- Extraction Metallurgy, J.D.Gilchirist, Pergamon Press, 1989

MM-206 Powder Metallurgy

General concepts, preparation of powders, gas atomization, chemical processes, electrolysis, gaseous reduction, mechanical comminition, spray deposition, powder characterization, bulk, density, particle size, surface area, consolidation of powder.

Types of presses, mechanical press, cold isostatic press, hot isostatic pressing, molds and dies, consolidation mechanism, effect of lubricants, binders, compaction defects, sintering mechanism, theory of sintering, sintering defects, sintering environments, infiltration, advantages of powder metallurgy, limitation of powder metallurgy, application of powder metallurgy, merits and demerits of powder metallurgy, applications of P/M parts

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
- Srivatsan, T. S. and Sudarshan, T. S. Rapid solidification Technology, Technomic Publishing, 1993.
- Picatinny, N.Y. and Otooni, M.A. : Elements of Rapid Solidification, Fundamentals and Applications', Springer Verlag, 1997.
- Powder Metallurgy Science, R.M.German, 2nd ed. 1994
- Fontana, M.G., Corrosion Engineering, McGraw Hill, Inc, 1987

MM-207 Non-Ferrous Metallurgy

Introduction to Non Ferrous metals and its ore deposits in Pakistan, Introduction to Non- Ferrous Extractive Metallurgy its scope and importance in Pakistan, Aluminum and its ores, Preparation of Alumina, Preparation of Cryolite, Production of metallic Aluminum, Thermal process of Aluminum, Alloys production, Recovery of other values from Aluminum ores, Aluminum and its alloys, Properties, Microstructure and application. Copper and its ores, Preparation of concentrate, Extraction of Copper ores by pyrometallurgical methods, Matte smelting, Pier Smith converter, Top Blown Rotary Converter, Electrolyte and fire refining of Copper, Recovery of values such as Gold and Silver from Copper ores, Copper and its alloys, Properties and applications.

Zinc and Zinc ores, General Preparation of extraction of Zinc, Roasting of Zinc concentrate, Leaching of roasted Zinc concentrate, Electrolysis of Zinc Sulphate solution, Melting of Cathodic Zinc, Production of Zinc retort and blast furnace method, Refining of Zinc, Zinc and its alloys, Properties and application. Lead and its ores, Extraction of lead, Blast roasting of lead concentrate, Blast furnace smelting of lead bullion, Recovery of Cadmium and other metals from lead concentrate, Lead and its alloys, Properties microstructure and applications.

Magnesium and its ores, Chromium and its ores, Extraction of magnesium and Chromium by Alumino-thermic and slico- thermic method, Refining of Magnesium and Chromium and its alloys, Properties microstructure and application. Titanium and its ores, Treatment of its ores concentrate, Production of Titanium metals by reduction with Sodium and Magnesium, Titanium and its alloys, Properties microstructure and applications.

References:

- Polmear, I.J. “light Alloys”, Edward Arnold, 1989
- Pehlke, R.D. “Unit Processes of Extractive Metallurgy” Elesvier Science Publishing Co. 1973
- Lee, E.W.W., Frazier, W.E., Jata, K.V., and N.J. Kim., ‘Light Weight Alloys for Aerospace
- Polmear, I.J., ’Light Alloys: Metallurgy of the Light Metals’, Edward Arnold, 1989.

MM-208 Ceramics

Traditional ceramics, brick and tile, refractory and insulating materials, china, porcelain, enamels, abrasives, cements, coordination number, interstitial sites, solid solutions, types of transformations, silica and silicate structures, mullite and spinels, glass and glass processing, glass ceramics.Advanced structural ceramics, oxide ceramics, nitride ceramics, fracture toughness, micro crack formation, high temperature application of ceramics, processing of ceramics, shaping and binding, molding, firing, sintering.

Refractories: Raw materials for refectories such as fire clay, china clay, silica materials, alumina, magnesite, dolomite, chromite, graphite, carbon materials, Zirconia, classification of refractories, application and selection methods of manufacturing of refrectories for ferrous and non ferrous industrial furnaces.

References:

- Richerson, D.W. "Modern Ceramic Engineering", Marcel Dekker Inc, 1992
- Moulson, A.J. and Herbert, J.M. "Electro-ceramics", Chapman and Hall, 1990
- Dame and King, Fuels Technology Edward Arnold Publisher, London

5th Semester

CS-301 Numerical Analysis & Computer Programming

Numerical Analysis: Finite difference and theory of interpolation, iterative methods for collocation polynomials. Approximate zeros (roots) Numerical integration and differentiation. Interactive methods for solution of linear systems. Design value problems. Numerical solutions of ordinary differential equations. Basic Computer Concepts: Computer history, main types of computer, Number Systems, Field of Computer applications, Input/Output and Control processing units.

Flow Chart Techniques: Main features of an efficient programming. How to organize the problem. Representation of various operations in flow-charts. Computer Programming: Kinds of computer languages, Arithmetic operators and priorities constants and types of their expressions.

References:

- Numerical Methods for Engineers by Canal & Chopra
- Applied Numerical Analysis by Curits F. Gerald
- Advanced Engineering Mathematics by Evein, Lyrzigg
- Applied Numerical Methods for solution of Partial Differential Equations by Chuny You and Lam
- First Year Course for Numerical Methods by Saeed A.

MM-301 Polymeric Materials

Review of polymer chemistry, introduction to polymers, classification of polymers, polymerization, co-polymerization, structure and properties of thermoplastic and thermosetting polymers, elastomers and rubber, vulcanization, additives and fillers.

Manufacturing, properties and applications of polymers, polystyrene, polybutadiene, polyester, polymethyl meth acrylate (PMMA), nylon 6:6, acrylonitrile-butadiene-styrene (ABS), silicon resin, epoxy resin, phenol-formaldehyde and other advanced polymers, forming processes, testing and identification of polymers, fibers, foams and adhesives,

References:

- Billmeyer, Polymeric Materials
- Tobolsky A.V. "Properties and Structure of Polymers", Wiley, New York, 1960
- Principles of Polymer Engineering, N.G McCrum, C.P. Buckley and C.B. Bjucknall, Chapman & Hall London 1991
- Introduction to Polymers, R.J. Young and P.A.Lovell.
- Principal of Polymer Chemistry, P.J.Flory, Cornell University Press, New York
- 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.
- Richerson, D.W. "Modern Ceramic Engineering", Marcel Dekker Inc, 1992

EE-302 Instrumentation and Control

The functional elements of instruments. Pyrometry, Active and passive transducers, Calibration, Accuracy, Sensitivity. Threshold, Resolution, Hysteresis and Dead Space, Linearity. Permanent Magnet Moving coil instrument. Pen recorder, Cathode ray Oscilloscope, Transistor as Amplifire. Measuring instruments for motion, pressure, level, temperature and heat flux. Optical pyrometers, rheotubes, temperature recorders, digital portable temperature indicators, analog temperature controllers, types of thermocouples, pressure gauges, flowmeter and flow gauges.

Introduction to open loop and closed loop control systems, Dynamics of first and second order system. Lapalace Transform, Transfer Function, Stability, steady State error and its elimination, Introduction to frequency response techniques. Electromechanical relay, Silicon controlled rectifier, Servo Motor, Logic Gates (NOR AND NAND)

References:

- Industrial Instrumentation Fundamentals by Friebal, McGraw Hill

MM-303 Inspection & Testing of Materials

Introduction to inspection and testing of materials, its scope and importance. The Brinell test, the Vicker test, the Rockwell test, the Knoop test, the Scleroscope test, conversion tables for various scales of hardness. Stress and strain, load extension diagrams, modules of elasticity, elastic limit, yield stress, proof stress, work hardening, tensile testing, (equipment and specimens).

Compression testing, bend testing, torsion testing. impact testing. Toughness, brittleness and ductility, notched bar impact testing, the Charpy and Izod impact tests, brittle and ductile fractures.The fatigue test, different types of fatigue fractures, Goodman diagram, endurance limit-ultimate tensile strength. The Creep Test.

References:

- Hertzberg, R. W.: Deformation and Fracture Mechanics of Engineering Materials, John Wiley, 1996
- Dieter, G. E.: Mechanical Metallurgy, McGraw-Hill, 1988
- 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

6th Semester

MM-304 Heat-treatment Processes

Review of iron carbon phase diagram, Effect of common alloying additions on the equilibrium diagram, annealing and its types, normalizing, oxidation and decarburization during heat treatment, hardening of steel, quenching rates and quenching media, martensitic transformation, time temperature transformation diagrams, effects of austenizing, grain size and alloying element on the transformation diagram, continuous cooling diagrams.

Hardenability and its measurement, austempering, martempering, retained austenite, tempering of martensitic steel. secondary hardening, heat treatment of dies and tool steel , , surface hardening, carburizing, nitriding, cyaniding, carbonitriding, induction and Flame hardening, heat treatment of cast iron heat treatment of non ferrous metal and alloys, age hardening/precipitation hardening, defects caused during heat treatment and their remedies,subzero treatment.

References:

- Steels Heat treatment & Processing, G.Krauss,ASM1995. Physical Metallurgy principles, by R. Reed Hill & R. Abbaschian, pub PWS-Kent pub Boston 1991
- Precipitation Hardening, J.W.Martin, IoM, 1996
- Rajan T.V, Sharma C.P. and Sharma A., Heat Treatment Principles and Techniques, Prentice Hall Publications, India
- Thelning K.E., Heat Treatment of Steel
- Wilkins D.C.A, Heat Treatment and Quality Control of metals
- Precipitation Hardening, J.W.Martin, IoM, 1996

MM-305 Welding and Joining Processes

Introduction to welding and joining , weld defects, selection of appropriate welding process, effect of heat on metals, pre heating , stress, strain, weldability , type of joints, types of welds, filler metals, welding problems, producing good weld . Gas welding and equipments, fluxes, torch gases hoses and hose conection, tarches, mixers, welding tips, regulaters clamps outfits. Arc welding, power sources, DC and AC power sources, cables, electrodes, current and circuit polarity, electrode selection, weld deposit. TIG & MIG welding; Introduction, principles, non-consumable tungsten electrodes, gas supply and equipment, and TIG joint preparation, spot welding, electrode wire, gas supply, spray metal transfer method, CO_2 – MIG welding, MIG spot welding.

Submerged arc and other shielded methods, equipment, current, flux, electrodes, atomic hydrogen welding, plasma arc welding electro slag welding under water shielded metals, arc welding, vapor shielded metal arc welding- CIG welding. Resistance welding , resistance spot welding, multiple spot welding, PIGME welding process, flash and upset welding, percussion welding.

Thermit welding, equipment techniques, process, ignition powder removing the mold inspection. Other welding processes; laser welding, electron beam welding, pressure welding, ultrasonic welding. solders principles, Equipment , fluxes, automatic soldering systems, soldering aluminum and aluminum alloys, magnesium and magnesium alloys, brazing, equipment , copper and coper aloys, aluminum brazing, dissimilar metals joining, plastic welding, adhisive bonding, bonding materials, inspection and testing of weldment

References:

- Easterling, K.: Introduction to the Physical Metallurgy of Welding, Butterworth-Heinemann, 1992.
- Linnert, G.E., "Welding Metallurgy", American Welding Society.
- 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.
- Welders guide James, E. Brumbaugh, Mc Millan Pub. Co. N.Y.
- Joining Processes-An Introduction, D.G.Brandon and W.D.Laplan, 1999
- Ferrous Alloys Weldments, Proc,eds.D.L.Olson and T.H.North, Trans-Tech Publ, 1992

MM-306 Composite Materials

Introduction to Composite materials, classification characteristics, mechanical behavior potential advantages, properties and applications. Composite material design, specific stiffness and strength, and recent developments such as metal matrix composite, ceramic matrix composites, carbon fiber reinforced composite, production and processing of fibres and other reinforcements, polymeric matrix composites, processing principles and design of ply and laminate structures, filament winding and pultrusion.

References:

- Composite Materials, Engineeering & Sciences, F.L.Matthew and R.D.Rawlings, Chapman
- Fiber-Reinforced Composites, P.K.Mallick
- Matthews, F. L. & Rawlings, R. D., "Composite Materials: Engineering & Science", Chapman

MM-307 Deformation Behaviour of Materials

Introduction, concepts of Crystal Geometry, Lattice Defects, Deformation by Slip, Slip in a Perfect Lattice, Slip by Dislocation Movement, Critical Resolved Shear Stress for Slip, Deformation of Single Crystals, Deformation of Face-Centered Cubic Crystals, Deformation by Twinning, Stacking Faults, Deformation Bands and Kink Bands, Microstrain Behaviour, strain Hardening of Single Crystals.

Introduction, Observation of Dislocations, Burgers Vectors and the Dislocation Loop, Dislocations in Face-Centered Cubic Lattice, Dislocations in the Hexagonal Close-Packed Lattice, Dislocations in the Body-Centered Cubic Lattice, Stress Fields and Energies of Dislocations, Forces on Dislocations Forces between Dislocations, Dislocation Climb, Intersection of Dislocations, Jogs, Dislocation Sources, Multiplication of Dislocations, Dislocation-Point Defect Interactions, Dislocation Pile-Ups. Introduction, Grain, Boundries and Deformation, Strengthning from Grain Boundries, Low Angle Grain Boundries, Yield Point Phenomenon, Strain Aging, Cold Worked Structure, Strain Hardening, Annealing of Cold-Worked Metal, Bauschinger Effect, Preferred Orientation (Texture).

References:

- Hirth J.P. and Lothe J. “Theory of Dislocations”, McGraw Hill, New York, 1984
- Mechanical Metallurgy, Dieter G.E. McGraw Hill 1991
- The Plastic Deformation of Matals, 2nd ed.,R.W.K.Honeycombe, 1985
- Hull, J.B. and John, V. B.: Non-Destructive Testing, Macmillan Education, Ltd., 1988
- Textbook Non-destructive testing, Waren J. Mc Gonnagle, Gordon & Breach Science, Publishers,N.Y. London, Paris

MM-308 Corrosion, Protection & Prevention

General concepts, corrosive environments, atmosphere, water, chemicals, gases, general corrosion, galvanic corrosion, oxygen concentration cell, atmospheric corrosion, chemical corrosion, corrosion in gas, types of scale, mechanism of scale protection, oxide, defect structure, oxidation rates, high temperature gas reactions, localized corrosion, pit and crevice corrosion.

Mechanically assisted corrosion, stress corrosion cracking, corrosion fatigue, hydrogen damage, corrosion in ceramics and plastics, atmosphere water, chemical corrosion, corrosion prevention and protection. chemical inhibiters, environmental control, anodic and cathodic protection, mechanical protection, coatings, anodizing, painting, corrosion resistant materials, corrosion of carbon steels, stainless steel, aluminum alloys, case studies.

References:

- Corrosion Engineering, M.G.Fontana, 1997
- Corrosion, L.R.Shrier
- The Fundamentals of Corrosion, J.C.Scully
- Basic Corrosion and Oxidation, J.M.West
- Corrosion Engineering, M.G.Fontana
- Electrodepositing and Corrosion Processes, J.M.West.
- Fontana, M.G., Corrosion Engineering, McGraw Hill, Inc, 1987

MM-309 Industrial Economics & Management

Introduction to Industrial Management scope and importance in Metallurgical Plants, Factory Organization,: Factory and type of organization, Principles of Organization, Organizational Structure, Communications Plants Location, type of plant Layout,

Production and Management: Type of Production, production management, Production Planning and Control, Product design and development, Management, functions of management, management techniques, work study, critical path method, Operational research, quality control, cost estimation fore casting, material handling and inventory control, system design and engineering.

References:

- Factory Production Management by K.G. Lakyeir, Pitman, 1980
- Industrial Engineering and Management by Sharma, 1990

7th Semester

MM-401 Nuclear Materials

Nuclear structure, Radioactive decay, Nuclear fission and fusion reactions, Neutron absorption cross section, Nuclear energy, Nuclear reactors, Type of reactors, Nuclear fuels, Uranium, Thorium, Plutonium, Fuel cladding materials, aluminum alloys, stainless Steels, zirconium alloys, Reflecting materials, Graphite, Beryllium, Moderators, Light water, Heavy water, graphite, control rod materials, cadmium, boron.

Structural materials, low alloy steels, stainless Steels, super alloys, Inconel, Incalloy , Effect of radiations on materials , Electromagnetic radiations damage, particulate damage, Radiation hazards, Health physics, Disposal of radio active wastes.

References:

- Materials Science and Technology, Volume 10, Nuclear Materials, Parts I & II, Vol. Editor: Frost, B. R. T, VCH, 1994.
- Performance and Evaluation of Light Water Reactor Pressure Vessels, The American Society of Mechanical Engineers, 1987
- 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.
- Ruchle, Urinium Production Technology, Butter Worth Series Publications
- Cutbirth, Thorium Production Technology, Butter Worth Publication

MM-402 MATERIALS CHARACTERIZATION TECHNIQUES

Wet analysis, Image analysis, Electron diffraction, Transmission electron microscopy, Analytical transmission electron microscopy, Scanning electron microscopy**,** Electron micro probe analysis**,** Gas analysis by mass spectrometry, Production of X-Rays, Absorption of X-Rays, Use of filters, X-Ray diffraction, Bragg's law, Structure factor calculations, Diffraction methods,

Debye-Scherrer, lave back /reflection and rotating crystal method, X-Ray difractometer, Crystal structure determination, Orientation of single crystal, Pole figures, Applications of X-Ray diffraction, Stereographic projections; Orientation of crystal with respect to a reference, Rotation of crystal around and axis, Planes of a zone.

References:

- Barret C.S. and Massalski T.B, "Structure of Metals", McGraw Hill, New York, 1980
- Characterization of Materials, J.W.Watchman, Butterworth-Heinemann, 1993
- Microstructural Characterization of Materials, D.Brandson and W.D.Kalplan, 1999
- Wachtman, J.B.: Characterization of Materials, Butterworth-Heinemann, 1993
- Subarao, Experiments in Material Science, McGraw Hill

MM-403 Manufacturing Technology

Scope and importance of manufacturing technology in Pakistan, Classification of mechanical working processes, Stress pressure, Mechanism of plastic deformation, Theory of dislocations, Weldability work hardening, forging, tubedrawing, sheet metal forming process, machining , rolling principles, rolling of ingot, bloom, billets, sheet and structural components, rolling of bars and rods, rolling mills design and calculations, manufacturing process and system design manufactures defects causes and remedies, quality control in manufacturing processes CAD/ CAM technology.

Introduction to Non-conventional manufacturing processes such as water jet cutting, and lashing cutting, tool design. Surface Measurement and inspection, telesurf tolerances and specification. Material Selection and design, overview, the selection of materials, service conditions materials and primary processes, Secondary process, welding, machining, thermal treatment, finish Operations, Strength-to-density and modulus-to-density ratios, reading and using specifications, safety and reliability, quality control and quality assurance, help from the computer, prototypes and experimentation, Cost Analysis for a component, the recycling and reuse of materials.

References

- Manufacturing Processes of Engineering Materials, Kalpakjian
- Introduction to Manufacturing Processes, Scey
- Paul De Garmo, Mlack, Kohsar, Processing Methods in Manufacturing, Prentice Hall, USA

MM-404 Phase Transformations

Driving force for phase transformation, Diffusional studies, self-diffusion, Volume and grain boundary diffusion. Free energy changes during phase transformation, Concept of Gibbs's free energy, Critical radius. Liquid-solid and solid-solid transformation. Nucleation & growth, homogeneous and heterogeneous nucleation, nucleation on crystalline defects and on grain boundaries.

Precipitation reactions, GP zones, Intermediate and stable precipitate, Coherency strain, Volume free energy, strain free energy, Spinodal decomposition, diffusion transformation, diffusion-less transformation, Ordered and disordered transformation, Recovery, crystallization and grain growth.

References:

- Phase Transformations in Metals and Alloys, D.A.Porter and K.E.Easterling, 1st ed. Van Nostrand Reinhold Co, 1987
- Reed-Hill, R. E. and Abbaschian, R.: Physical Metallurgy Principles, PWS Publishing, 1994
- Smallman R.E "Modern Physical Metallurgy", 4th ed. Butterworths, Boston,1985
- Christian, J. W..: Transformations in Metals and Alloys, Pergamon Press, 1975

8th Semester

MM-405 Modern Steels

Introduction to High strength low Alloy (HSLA) steels, microalloyed steels, stainless steels, duplex steels, high yield steels, super alloys, inconels haste alloys,nickle maraging steels, classifications, production and processing principles, thermomechanical processing and properties, advantages and limitations, dual phase steels, IF (interstitial-free) and utralow carbon steels for structural and automotive applications, modern bainitic and martensitic steels.Stainless steels, nitrogen containing fine grained steels, orthopedic steels, duplex and superduplex corrosion stainless steels, special Steels, TRIP steels, maraging steels, alloys and special steels for low to moderate temperature applications for nuclear and thermal power plants, heat resistance steels for superheaters, tool and die steels, processing and properties, Iron base super alloys and shape memory alloys

References:

- Honeycombe, R. W. K., Steels, Microstructure & Properties, Edward Arnold, London, 1981.
- Pickering, F. B., Physical Metallurgy and Design of Steels, Applied Science Publishers, 1978.
- Marshall, P., Austenitic Stainless Steels, Microstructure and Mechanical Properties, Elsevier Applied Science Publishers, 1984.

MM-406 ADVANCED FOUNDRY ENGINEERING

Introduction to advanced Foundry Engineering and Practice, Scope and Importance, Foundry plant design and calculations, Design for casting, Pattern making, Gates, Riser, Feeders etc, Advanced design techniques and calculation using personal computer,

Melting methods and their effect upon metal quality, Gases in metal, their control and removal, Solidification, Nucleation and growth phenomenon, Microstructure of cast metal and alloys, Causes of defects and their remedies, Quality control techniques in advanced foundry practice, Permanent mold casting, Centrifugal casting, Gravity and pressure die casting methods, Selection of die casting alloys, Molding materials and mold dressings, Metallurgy of die casting alloys, Shell molding, Lost wax, Investment and Precision casting processes, Casting techniques of Ferrous and Non- Ferrous metals.

References:

- Campbell, J.: Castings, Butterworth-Heinemann, 1991.
- Hagel, W. C. Stoloff, N.S. and Chester T.S., 'Superalloys II', John Wiley & Sons, 1987.
- Kirkaldy and Ward, Aspect of Medern Ferrous Metallurgy, Tronto University Press

MM-407 Selection & Application of Materials

Overview, the selection of materials, service conditions, materials and primary processes, secondary processes, welding, machining, thermal treatment, finishing operations, strength-to-density and modules-to-density ratios, reading and using specifications, safety and reliability, quality control and quality assurance, help from the computer, prototypes and experimentation, cost analysis for a component, the recycling and reuse of materials

References:

- Selection and Use of Engineering Materials, J.A.Charles, F.A.A.Crane and J.A.G.Furness,
- 3rd ed. Butterworth-Heinemann, 1997
- Thoronton, E. A., 'Aerospace Thermal Structures and Materials for a New Era', American Institute of Aeronautics & Astronautics, 1995.
- Picatinny, N.Y. and Otooni, M.A. : Elements of Rapid Solidification, Fundamentals and Applications', Springer Verlag, 1997.

MM-408 Fracture Mechanics

Theories of creep and fatigue fracture mechanism in ductile and brittle materials. Brittle and ductile fracture comparison. The theoretical cohesive strength of solids. Stress concentration at a notch and at a crack. Plane stress and plane stain fracture toughness. Fracture toughness parameters and testing.

Fractography: Micro Mechanism of crack nucleation and propagation inter crystalline brittleness. Fracture mechanics in stress corrosion. Impact testing, characteristics of fracture observed in ductile and brittle material. The crack opening displacement approach and empirical methods for assessing crack propagation in thick sections.

References:

- Deformation and Fracture Mechanics, R.W.Hertzberg,3rd ed. John Wiley, 1989
- Frature Mechanics, H.L.Ewalds and R.J.H.Wanhill,3rd ed. Edward Arnold, 1984

CS-401 Computer Application & Materials Engineering

Basic computer modeling and simulation technology, Computer modeling and simulation of blast furnace and basic oxygen converter operations. Computer modeling for microstructures, Phase transformation, mechanical properties and materials processing including rolling, forging, casting, extrusion and machining operations etc.

References:

- Computer Application in Materials Engineering, ASTM Series

MT-203 Statistical Methods and Estimation

Statistical treatment of data, frequency distribution and graphs, measures of central tendency, measures of variation. Probability, samples, spaces and events, counting probability, the axioms of probability, some elementary theorems, conditional probability, Bay's theorem, mathematical expectation and decision making. Probability distribution, random variables, the binomial distribution, Poisson approximation to the binomial distribution, Poisson processes, probability densities, normal distribution, statements "T" distribution.

Sampling distribution, populations and samples. Curve fitting regression analysis by least square method, correlation, linear, polynomial, power, regression analysis by least square method, incorporation of linear polynomial, exponential or power function. Correlation coefficient of determination. Application and exponential model of reliability and life testing

References:

- D.C Montgomery and G.C.Runger, Applied statistics and probability for engineers, John Wiley & Sons, 1994
- N.A Weiss, Introductory Statistics, Adsition Wesely, 1995
- R.E.Walpole, ntroduction to Statistics, Collier Macmillan, 1982

CH-102 Physical Chemistry

Thermo-chemistry, the gaseous state and the kinetic. Molecular theory, physical properties and chemical constitution, solutions, theory of dilute solutions, chemical equilibrium, distribution law, the phase rule, chemical kinetics, adsorption, electrolysis and electrical conductance. Ionic Equilibria.

MM-302 Vacuum Metallurgy

Vacuum technology: Different units of measuring pressure vacuum regimes, mean free path, collision frequency. Vacuum pumps: Water pumps, positive displacement pumps, rotary and roots pump, vapour ejector and vapour entrainment pumps, diffusion pump, turbo-molecular pump, ion pumps, sieve pumps, adsorption pumps. Classification and working principles of vacuum measuring devices: Manometers, McLoad gauge, Penning gauge,Pirani gauge. Calculation of vacuum systems, conductance and through put, effective pumping speed, gas flow through pipes and orifices. Sources of leakage, leakage detection and remedies.

Application of vacuum in materials processing.. Vacuum induction melting, vacuum arc melting. Metal refining in vacuum, degassing in liquid state, vacuum heat treatment, vacuum sintering, vacuum coating, use of vacuum technology in the production of strategic materials. Design of vacuum Furnaces.

Vacuum Coatings: Introduction, purpose of Vacuum Coating, process of Vacuum coating, vacuum coating system by Electro bio-bombardment beating, valves used in vacuum technology.

References:

- Vacume Metallurgy by O,W Inker and R. Bakish Elsevier 1971

TECHNICAL ELECTIVES

1. Electronic, Magnetic and Optical Materials

Classification of materials according to magnetic properties, origin of magnetic moment of atoms, theories of all types of magnetism. Magnetization curves, hysteresis, magnetic domains, domain walls, methods of observations of domains, soft magnetic materials, hard magnetic materials, powder magnets, semiconductor devices and VLSI, thin film technology, metalization, packaging, opto-electronic devices and solar cells.

References:

- Solymar L. and Walsh D., "Lectures on the Electrical Properties of Materials", Oxford University Press, Oxford, 1984
- Brailsford F. " An Introduction to the Magnetic Properties of Materials", Longmans, London, 1968
- Hatfield, W.H. and Miller, J.H., "High Teperature Superconducting Materials", Marcel Dekker, 1988
- Campbell, P.L. "Permanent Magnet Materials and their Applications", Cambridge University Press, 1994
- Ferromagnetic Materials, Structure and Properties, S.M.SZE VLSI Modern Ferrite Technology, Agoldman
- Semiconductor Materials, L.I.Berger, 1997

2. Surface Engineering.

Elements of physical chemistry of surfaces and interface bonding Advance coatings for friction/wear / abrasion/corrosion resistance. Coating technology PVD, CVD, electrochemical deposition, thermal spraying, and characterization of coatings.

References:

- Surface Engineering, An Introduction, John B.Hudson, Butterworth Heinemann, 1992

3. Advanced Materials Manufacturing.

Latest developments in steel making and alloy making technology recent advancement in metal forming methods. Of casting techniques. Principles of computer aided design automated manufacture, product-manufacturing studies, and design prototyping and production process of manufactured goods, including cars, automotive parts, domestic appliances and medical equipment. Laser based machining and cutting of engineering materials. Laser welding

References:

- Fundamentals of Modern Manufacturing Materials, Processes and Systems, M.P. Groover, Prentice Hall 1996
- Engineering Chemistry, M.M.Uppal
- Engineering Materials, Vol. 1 72, M.F.Ashby and D.R.H.Hones, Pergamon Press, 1986

4. Industrial Safety.

Assessment of site layout designing for safe industrial practices, industrial hazards and precautionary measures, disposal of hazardous wastes.

Fire safety engineering Control of ignition, fire safety management, regulatory control fire precautions during construction and maintenance, assessment and repair of fire damaged structures

Maintenance scheduling, safety equipment and its maintenance, safety standards and their implementation. First aid training and

5. Design Standards and Quality Assurance.

Introduction to standards. Familiarization of standards for testing of materials, ASTM,BS,JIS GOST and ISO. Pakistan Standards, Quality assurance for final products, Measures for quality control, ISO9000 and ISO 14000 standards.

6. Maintenance Management.

Organization and control of maintenance systems, maintenance policies and strategies, preventive maintenance predictive maintenance and condition improvement total productive maintenance reliability and failure analysis, scheduling maintenance unique challenges of software maintenance , maintenance performance measure and improvement.

7. Environment Engineering.

The environment, the impact of humans upon the environment, the impact of the environment on humans, improvement of environmental quality the role of environment engineer.

Water quality definitions, characteristics, and perspectives. Engineered systems for water purification Engineered systems for wastewater treatment and disposal.

Air quality definitions, characteristics and perspectives. Air quality management systems.

For Air pollution Control. EPA standards and their scope. Environment impact assessment methodology.

8. Energy Conservation in Materials Related Industries.

The energy problem, The economics of energy saving schemes. Steady state loads and comfort, transient heating and air conditioning loads, thermal performance monitoring, lighting energy targets.

Energy conversion Fuels and combustion efficient combustion waste as fuel steam and gas cycles, electrical conversion.

Energy recovery recuperative heat exchangers, run-around coil systems, regenerative heat exchangers, heat jumps, heat pipes selection of energy recovery methods.

9. Solid Waste Management.

Solid wastes definitions, characteristics and perspectives. Types of solid wastes, sources of solid waste management.

Engineered systems for solid waste management Solid waste generation, on site handling, storage and processing. Collection of solid wastes, Transfer and transportation, processing techniques, ultimate disposal.

Engineered systems for resource and energy recovery, processing techniques, materials recovery of biological conversion products, recovery of energy from conversion products and energy recovery systems.

Plastic waste, composition quantities and disposal alternatives. Recycling of wastes, recycling of plastics, metals and glasses.

10. Design Standards and Quality Assurance.

Introduction to standards. Familiarization of standards for testing of materials, ASTM,BS,JIS GOST and ISO. Pakistan Standards, Quality assurance for final products, Measures for quality control, ISO9000 and ISO 14000 standards.

Proposed Curriculum of M.Sc Metallurgy & Materials Engineering

(A) Core/Compulsory Courses (5 subjects can be opted from this group)

1. Phase Transformations in Solids
2. Solidification Processes
3. Ferrous and Non-Ferrous Production Metallurgy
4. Deformation and Fractures
5. Corrosion Engineering
6. Manufacturing Processes
7. Engineering Ceramics and Composites
8. Production Management
9. Characterization Techniques

(B) Technical Electives (3subjects to be opted from this group)

1. Powder Metallurgy
2. Welding Engineering
3. Electrical and Magnetic Materials
4. Coating Techniques
5. Nuclear Reactor Materials
6. Heat Treatment of metals and Alloys.

(C) Project (Compulsory)

Presently University of Engineering & Technology, Lahore is the only university, which is offering courses at post-graduate level in the field of Metallurgy & Materials Engineering. They have designed courses in metallurgy & Materials Engineering, which can be implemented by the other universities with or without modification according to their requirement. The rest of the public sector university may be asked to send their recommendations and proposals regarding the M.Sc Programme. M.Sc Programme by University of Engineering & Technology based on course work.

Full time M.Sc (one year programme)

Part time M.Sc (two year programme)

A full time student can opt. Maximum of five subjects in one term and a part time student can opt. A maximum of three subjects in one term. A term comprises of 18 weeks teaching.

DETAIL OF COURSES
FOR
M.E./M.Sc

Compulsory Courses

1. **Phase Transformation in Solids**

Diffusion in the solid state, Nucleation and growth processes. Free energy changes associated with precipitation. Stacking faults, dislocation arrangements and impurity content. Intermediate and stable precipitates. Loss of precipitate/matrix coherency. Over-aging. Order disorder reactions. Shear transformation, Kinetic and crystallographic features. Athermal and isothermal transformation. Nurst phenomenon. Stabilization. Thermodynamics of martensitic transformations in materials.

References:

- Reed-Hill, r.E. and Abbaschian, R.: Physical Metallurgy Principles, PWS Publishing, 1994.
- Phase Transformations in Metals and Alloys, D.A. Porter and K.E. Easterling, 1st ed. Van Nostrand Reinhold Co., 1987.
- Smallman R.E. "Modern Physical Metallurgy", 4th ed. Butterworths, Boston, 1985.
- Christian, J.W.: Transformations in Metals and Alloys, Pergamon Press, 1975.

2. **Solidification Processes**

Theories of the casting properties of alloys: fluidity, hot shortness and feeding. Nucleation and growth theories. Applications to the origin of structure in castings. Flow of metal into moulds and heart transfer theories of feeding casting.

References:

- Campbell, J.: Castings, Butterworth-Heinemann, 1991.
- Hagel, W.C. Stoloff, N.S. and Chester T.S., Superalloys II, John Wiley & Sons, 1987.
- Kirkaldy and Ward, Aspect of Modern Ferrous Metallurgy, Tronto University Press.

3. **Ferrous and Non-Ferrous Production Metallurgy**

Science and practice of the reduction of Iron oxide. Phase equilibria involved in the refining reactions. Refining of irons for various engineering applications. Science and practice of steel-making. Refining techniques for engineering steels. Design of HSLAS, Low Alloy, Medium Alloy and High Alloy Steels. Current Status of Iron and Steel Industry.

Science and practice of recovery of non-ferrous group of engineering metals and alloys. Engineering of Refining practices for requisite Non-ferrous systems. Development of commercial Non-ferrous metals and alloys. Science and practice of recovery of rate earths. Development of Rare earths for various commercial applications. Development, phase equilibrium and characterization of Metallurgical grade and Electronic grade Silicon.

References:

- Principles of Extrative Metallurgy, by T. Rosenqvist, McGraw Hill 1983.
- Extraction Metallurgy, J.D. Gilchirist, Pergamon Press, 1989.
- Polmear, J.J. Light Alloys, Edward Arnold, 1989.
- Pehlke, R.D. Unit Processes of Extractive Metallurgy, Elesvier Science Publishing Co. 1973.
- Polmear, I.J., Light Alloys: Metallurgy of the Light Metals, Edward Arnold, 1989.

4. **Deformation and Fractures**

The relationship of mechanical properties to crystal structure and to microstructure. Applications of crystallography and modern theories of plasticity to the deformation and fracture behaviour of materials used in Engineering. Structural features controlling flow strength, work hardening and fractures. Effects of compositions on Yield point and strain aging. The development of preferred orientations in metals and alloys. Deformation and annealing textures. Sources of directional mechanical properties in metals. Application of controlled anisotropy.

References:

- Hull, J.B. and John, V.B.: Non-Destructive Testing, Macmillan Education, Ltd., 1988.
- Textbook Non-destructive testing, Waren J. McGonnagle, Gordon & Breach Science, Publishers, N.Y. London, Paris.
- Hirth J.P. and Lothe J. theory of Dislocations, McGraw Hill, New York, 1984.
- Mechanical Metallurgy, Dieter G. E. McGraw Hill 1991.
- The Plastic Deformation of Matals, 2nd ed., R.w.K. Honerycomble, 1985.

5. **Corrosion Engineering**

Stoichiometric and non-stoichiometric crystals. Effects of impurities. Solid state electrochemistry. Oxidation of metals and alloys. Electrochemistry of corrosion. Pourbaix diagrams, Activation Polarization. Concentration Polarization, Combined Polarization. Reference electrodes. The three electrode cell and the F/log I Plot. Mixed Potential Theory. Mechanisms of growth and breakdown of passive films. Application of thermodynamics to corrosion. Crevice and Pitting corrosion, intergranular corrosion. Erosion corrosion, Cavitatin damage, De-alloying. Environmental-sensitive cracking, Mechanisms of environment-sensitive cracking. Street corrosion Electrode Kinetics, Practical aspects of environment-sensitive cracking. Electroplating, methods of corrosion prevention. Cathodic and Anodic protection, Inhibitors and types of inhibitors.

References:

- Corrosion Engineering, M.G. Fontana, 1997.
- Corrosion, L.R. Shrier
- The Fundamentals of Corrosion, J.C. Scully
- Basic Corrosion and Oxidation, J.M. West
- Corrosion Engineering, M.G. Fontana
- Electrodepositing and Corrosion Processes, J.M. West.
- Fontana, M.G., corrosion Engineering, McGraw Hill, Inc, 1987.

6. **Manufacturing Processes**

Metal working theory: Stress analysis of metal working processes. Slip-line field theory. Upper-bound theory. Plastic flew in extrusion-forging and other complex. Metal working processes: Factors influencing quality in hot flat rolling and their subsequent influence on cold strip production. Effect of roll war. Effects of tool profiles and lubrication in hot extrusion. Speed and temperature variables. Principles of hydrostatic extrusion. Impact and cold extrusion process: economic and lettalugical evaluation.

Automatic rod drawing equipment. Wet and dry drawing of wire and tubes. Tool design and analysis of metal flow. Properties of drawn materials. Reduction work in wire drawing.

Selection of tool materials for close-die forging Factors affecting shape, performance in bending, stretch-forming and deep drawing, Influence of material variables on Tool forms and lubrication. The problem of analyzing complex asymmetric pressings. Experimental approach to identification of critical factors of metal working processes. Quality Control of technique. Recent developments in material working processes.

References:

- Foundamentals of Modern Manufacturing Materials, Processes and systems, M.P. Groover, Prentice Hall 1996.
- Engineering Chemistry, M.M. Uppal.
- Engineering Materials, Vol.1 72, M.F. Ashby and D.R. H. Hones, Pergamon press, 1986.

7. Engineering Cramics and Composites

I. Structure and Properties of Ceramics

Crystal Structures, Silicate Ceramics, Imperfections in Ceramics, Ceramic phase Diagrams, Mechanical Properties of Ceramic Materials.

II. Brittle Fracture of Ceramics

Stress-Strain behaviour, Miscellaneous Mechanical Considerations.

III. Application and Processing of Ceramics

Glasses, Glass Properties, Glass Forming, heat Treatment of Glasses, Glass Ceramics, The Characteristics of Clay, compositions of Clay Products, Fabrication Techniques, Drying and Firing, Characterization of Ceramics, Pottery Ceramics, Stone Rare, Refractories.

IV. Application and Processing of Carbide and Nitride Ceramics

Carbides and Nitrides, Carbides and Nitrides Forming, Thermal Treatment of Carbides and Nitrides, Development Fabrication and Processing of Carbides and Nitrides, Characterization of Carbide and Nitride Ceramics.

V. Composite Structures

Introduction, Particle Reinforced Composites, Large-Particle Compsites, Dispersion Strengthened Composites, Fiber-Reinforced Composites, Influence of Fiber Lengt, Influence of Fiber Orientation and Concentration.

VI. Composites

Metal Matrix composites, Ceramic Matrix Composites, Hybrid composites, Processing of Fiber-Reinforced Composites, Development Processing and Characterization of Structural Composites.

a) Treatment of thermal, electrical, optical and magnetic properties of materials in terms of basic physical concepts with which these properties can be described.

b) Relationship of structural and processing variables to the microstructure and service behaviour of ceramic and composite materials.

References:

- Richerson, D.W. Modern Ceramic Engineering, Marcel Dekker Inc, 1992.
- Moulson, A.J. and Herbert, J.M. Electro-ceramics, Chapman and hall, 1990.
- Dame and King, Fuels Technology Edward Arnold Publisher, London.
- Composite Materials, Engineering & Sciences, F.L. Mathew and R.d. Rawlings, Chapman.
- Mathews, F.L. & Rawlings, R.D., Composite Materials: Engineering & Science, Chapman.

8. **Production Management**

Principles of Organization charts based on line-staff-committee aspects. Social psychology. Personnel. Legal aspects of labour relations. Unions. Factory Laws, Health and safety in industry. Costs, depreciation, Yields, Scrap.

Financial controls. Investment assessment. Accounting, Interpretation of balance sheets, stocks, limited Liability companies, Financial Direction. Bank. Money market. Stock Exchange. Current economic problems.

Introduction to principles of operational research and work study. Selection and assessment of materials. Management statistics. Introduction to management Information Systems, People, Organizations, systems and Management, Systems and Models, Management and Decision making.

Information technology Concepts

Fundamentals, Software Fundamentals, Database management, Telecommunication Transaction processing and management, decision support systems, knowledge based system, office Information Systems.

Building Management Information Systems

Requirement Analysis, System design, system Acquisition, Information and Mintenance. End user computing and development. M/s Management. Information Resource Management, Selected issues in M/s Management.

References:

- Factory Production Management by K.G. Lakyeir, Pitman, 1980.
- Industrial Engineering and Management by Sharma, 1990.

9. **Characterization Techniques**

I. **Classical, Electrochemical and Radiochemical Analysis**

Classical Wet Analytical chemistry, Elemental and Functional Group Analysis, High-Temperature combustion, Inert Gas Fusion, Radio-Analysis.

II. **Optical and X-Ray Spectroscopy**

Inductively Coupled Plasma Atomic Emission Spectroscopy, Atomic Absorption Spectrometry. X-Ray Flourscene Spectrometry.

III. **Mass Spectroscopy**

Spark Source Mass Spectrometry, Gas Analysis by Mass Spectrometry.

IV. **Metallographic techniques**

Optical Metallorgraphy, Image Analysis.

V. **Diffraction Methods**

X-Ray Powder Diffraction, X-Ray Diffraction Residual Stress Techniques. Serigraphic projection and relative determination.

VI. **Electron Optical Methods**

Analytical transmission Electron Microscopy, Scanning Electron Microscopy, Electron Probe X-Ray Microanalysis, Low-Energy Electron Diffraction.

VII. **Chromatography**

Gas Chromatography, Mass Chromatography, Ion Chromatography.

References:

- Barret C.S. and Massaiski T.B, Structure of Metals, McGraw Hill, New York, 1980.
- Characterization of Materials, J.W. Watchman, Butterworth-Heinemann, 1993.
- Microstructural Characterization of Materials, D. Brandson and W.D.Kalplan, 1999.
- Watchman, J.B: Charactrization of Materials, Butterworth-Heinemann, 1993.
- Subarao, Experiments in Material Science, McGraw Hill.

TECHNICAL ELECTIVE

1. **Powder Metallurgy**

Commercial methods for production of metal powders, powder characterization and testing, powder conditioning and function of addition agents. Consolidation of metal powders, Cold Isostatic Compacting, Hot Isostatic Compacting, Powder Rolling, Powder Forging, Powder Extrusion, Powder Injection Molding, Spray Forming.

Theory of Sintering, Sintering Practice, Sintering Atmospheres, Sintering Furnaces. Powder Metallurgy of Refractory and Reactive Metals, Powder metallurgy of Super Alloys, Dispersion-Strengthened materials. Secondary Operation Performed on P/M parts and products. Inspection and Quality Control for P/M Materials. The Economic of P/M Production.

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.
- Srivatsan, T.S. and Sudarshan, T.S. Rapid Solidification Technology, Technology, Technomic Publishing, 1993.
- Picatinny, N.Y. and Otooni, M.A.: Elements of Rapid Solidification, Fundamentals and Applications, Springer Verlag, 1997.
- Powder metallurgy Science, R.M. German, 2nd ed. 1994.
- Fontana, M.G., Corrosion Engineering, McGraw Hill, In, 1987.
- German, R.M., Powder metallurgy Science, Metal Powder Industries Federation, 1984.
- Gressinger, G.H.: Powder metallurgy of Superalloys, Butterworths, 1984.

2. **Welding Engineering**

Science and Practice of materials joining processes metallurgy of Welding, defects in welded structures, testing and Evaluation of stresses and defects in weld structures. Weldability of Engineering Materials as per ATM and ASME codes and specification. Weld design, welding codes and symbols fabrication of Engineering components. Thermal cutting of Engineering Materials Adhesive Bonding Application and analysis of welded structures. Discussion on relevant case studies.

References:

- Easterling, K.: Introduction to the Physical Metallurgy of Welding, Butterworth-Heinemann, 1992.
- Linnert, G.E., Welding Metallurgy, American Welding Society.
- 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.
- Welders Guide James, E, Brumbaugh, McMillan Pub. Co., New York.
- Joining Processes-An Introduction, D.G. Draudon and W.D. Laplan, 1999.
- Ferrous Alloys Weldments, Proc, eds. D.L. Olson and T.H. North, Trans-Tech Publ, 1992.

3. **Electrical and Magnetic Materials**

Classification and concepts of Electrical and Electronic materials. Development, processing and characterization of materials. Environmental effects. Reaction of materials/components to very low and moderate temperatures. Operation of materials in corrosive environments. Selection of materials and design considerations.

Development, processing and characterization of semi-conductor materials via bulk and thin film deposition routs. Graphical representation of magnetic properties, magnetizationcurve, Hystersis loop. Squareness factors. Types of magnetic behaviour. Ferromagnetic domains. Experimental evidence for domains. Single domain particles. Domain wall motion. Hindrance to wall motion. Ferromagnetic materials.

Soft magnetic Materials: Desirable properties for soft magnetic materials. Iron-Silicon Alloyes, Ni-Fe alloys, soft ferites. Potential applications of soft magnetic matyerials. Hard magnetic Materials: Properties of Hard magnetic materials, Alnico alloyes, hard ferrites, origin of Ferromagnetism in rare Earth transition Permanent Magnets. Rare earch based permanent magnets. Processing and physical metallurgy of RFeB permanent magnets. Coparison of RfeB and SmCo Magnets. Effect of alloying additions in NdFeB based permanent magnets. Potential application of permanent magnets.

References:

- Campbell, P.L. Permanent Magnet Materials and their Applications, Cambridge University Press, 1994.
- Ferromagnetic Materials, Structure and Properties, S.M.SZE VLSI Modern Ferrite Technology, Agoldman.
- Semiconductor materials, L.I. Berger, 1997.
- Hatfield, W.H. and Miller, J.H., High Temperature Superconducting Materials, Marcel Dekker, 1988.

4. **Coating Techniques**

Basic principles of corrosion control, Corrosion control by design. Corrosion control by environmental change. Corrosion control by barrier coatings. Hard chorme plating, Decorative Chromium plating, Ni Plating, Electroless Ni Plating, Electroless Ni-P-Co coating. Thin magnetic coatings for magnetic applications. Zn plating, Brass plating, Silver Plating, Gold Plating. Hot dip Galvanized coating, Al coating of steel. Oxidation spray coating. Oxidation protective coatings, Phosphate conversion coating. Chromate conversion coatings, aluminum anodizing. High Temperature coatings, high temperature coating systems, physical vapour deposition (PVD). Chemical vapour deposition (CVD).

5. **Nuclear Reactor Materials**

thermodynamics of Metallurgical Reactions. Ellingham Diagrams. Kinetics of Metallurgical Reactions. General Properties and Requirements of Materials Used in Nuclear Reactors. Materials for Nuclear Fuel and Production. Fabrication Processing and Characterization of Fuel Materials. Fuel Elements for Nuclear Power plants. Materials for Reactor Pressure Vessel. Piping and Heat Exchangers. In-service Surveillance of Primary Loop Components. Reactor Control Materials.

6. **Heat Treatment of Metals**

Relation of structural changes and kinetics of transformation to continuous heat-treatment. Applications of thermodynamics and mass transport theory. Thermomechanical treatment. Austermpring, Matermpring, Maraging, Ausoforming, Zero rolling. A detail study of defect caused during heat treatment and their remedies. Heat treatment of Special Steels.

References:

- Steels Heat Treatment & Processing, G.Krauss, ASM 1995.
- Physical Metallurgy Principles, by R. Reed Hill & r. Abbaschian, Pub PWS – Kent Pub. Boston 1991.
- Thelning K.E., Heat treatment of Steel.
- Wilkins D.C.A., Heat Treatment and Quality Control of Metals.
- Precipitation Hardening, J.W. Martin, LoM, 1996.
- Rajan T.V, Sharma C.P. and Sharma A., Heat Treatment Principles and Techniques, Prentice Hall Publications, India.

RECOMMENDATIONS

1. The committee recommended that in order to make uniformity and discipline, all the universities should offer the degree of metallurgy and material engineering which is being offered in most of the universities of Pakistan.

2. It is proposed that recommendations of the committee may be considered at appropriate level for implementation.

3. The total curriculum should spread over four academic years or eight academic terms/semesters.

4. The committee recommended that all the universities should switch over to semester.

5. The contact hours for theory and practical have been suggested for each course based on term/semester system and should be modified suitably for annual system.

6. A minimum of 17 weeks of teaching is recommended for term/semester system and 34 weeks teaching is recommended for annual system.

7. The total curriculum should cover a set of core/compulsory courses, basic allied and a set of elective courses. The core/compulsory courses are recommended as mandatory for all engineering college/universities of Pakistan, however minor deviation in names and contents may be made.

8. A set of at least 38 courses comprising compulsory, core and elective courses must be completed.

9. One credit hour is equivalent to one lecture hour or 2/3 hours of practical work per week.

10. It may be the discretion of university to adopt the course according to the set-up and suitability.

11. The committee decided that final year projects should be industrial-based.

12. Some mechanism may be developed for facilitating the students to obtain internship with various industries and public sector organizations. It is strongly recommended that Govt. of Pakistan may issue a directive to such industrial organizations.

13. Universities should arrange short visits of students to industries to enhance their confidence about relevant engineering subjects, jobs in the field. The students must submit a report whose evaluation must be incorporated in the relevant subjects.

14. To facilitate the provision of high quality education, the latest text books should be provided to the students on affordable prices.

15. It was strongly recommended to ensure quality engineering education, the recommended books/soft wares and relevant laboratory facility be available at all the universities. The Higher Education Commission may take necessary steps in this regard.

16. It was also proposed that the recommended books may be published by the National Book Foundation for distribution to the universities.

17. It was also agreed that computer soft wares / programmes /online technical research journal facility should be available in the libraries of all the universities to strengthen the graduation programme.

18. It is also recommended that the training of teachers in teaching methodologies be increased, university – industry interaction and regular participation of teachers in relevant conferences must be ensured. Universities should take necessary steps and provide financial resources for this purpose.

ENGR. SAHAR NOOR
Secretary

PROF. DR. JAVED IQBAL
Convener