CURRICULUM

OF

METALLURGY AND MATERIALS ENGINEERING
For
Bachelor's & Master's Program

(Revised 2017)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled "Supervision of Curricula and Textbooks and Maintenance of Standard of Education". With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

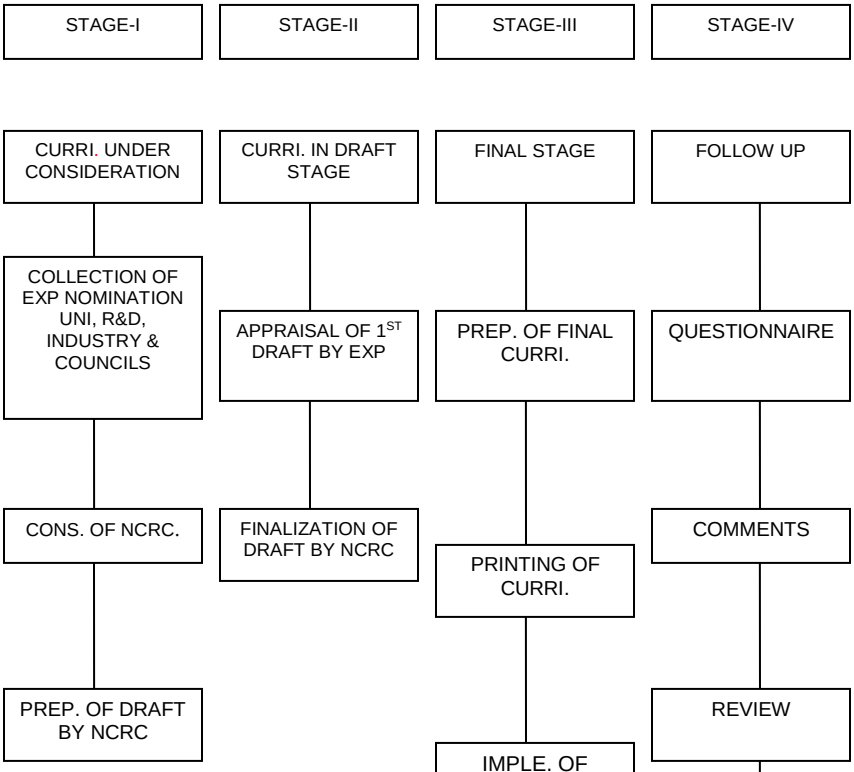
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC
http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx

(Muhammad Raza Chohan)
Director General (Academics)

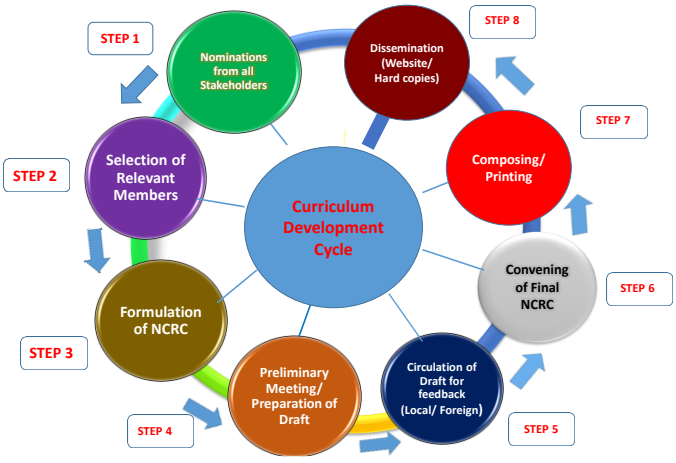
CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

NCRC.	National Curriculum Revision Committee
EXP.	Experts
COL.	Colleges
UNI.	Universities
PREP.	Preparation
LI	Learning Innovation
R&D	Research & Development Organization
HEC	Higher Education Commission

CURRICULUM DEVELOPMENT CYCLE



Introduction

The National Curriculum Revision Committee (NCRC) of Metallurgy and Materials Engineering had two meetings held on 17-19 February 2017 and 17-19 May 2017 at the Higher Education Commission Islamabad and Regional Centre, Lahore respectively, to revise and develop the curriculum for BE/BS and ME/MS degree programmes. The committee consisted of the following members:

1. Prof. Dr. Fazal Ahmad Khalid (SI)
   Vice Chancellor /**Convener**
   University of Engineering & Technology, Lahore.

2. Prof. Dr. Muhammad Mujahid,
   Dean /Principal **(Co-Convener)**
   School of Chemical & Materials Engineering,
   National University of Science & Technology, H-12,
   Islamabad.

3. Dr. Syed Wilayat Husain,
   Professor, **(Secretary)**
   Department of Materials Sciences & Engineering, Institute of Space Technology, Near Rawat Toll Plaza, Islamabad Expressway, Islamabad.

4. Engr. Prof. Dr. Abdul Aziz Mazhar
   Dean,
   Faculty of Engineering
   Imperial College, Shahkam Industries Road, Lahore.

5. Dr. Ibrahim Qazi,
   Professor, HoD
   Department of Materials Sciences & Engineering,
   Institute of Space Technology, Near Rawat Toll Plaza,
   Islamabad Expressway, Islamabad.

6. Prof. Dr. Ashraf Ali
   Dean, FMCE,
   GIK Institute of Engineering Sciences and Technology,
   Topi-KP7.

7. Dr. Yaseen Iqbal,
Chairman / Professor,
Department of Physics,
University of Peshawar, Peshawar.

8. Dr. Akhlaq Ahmad Malik.
Chairman / Professor,
Department of Metallurgical & Materials Engineering,
University of Engineering & Technology, Lahore.

9. Dr. Abdul Wadood,
Assistant Professor,
Department of Materials Sciences & Engineering,
Institute of Space Technology, Room 212, Building-II,
Near Rawat Toll Plaza, Islamabad.

10. Dr. Javed Iqbal Saggu
Assistant Professor,
Department of Physics,
Quaid-i-Azam University,
Islamabad.

11. Dr. Mohsin Ali Raza,
Assistant Professor,
Department of Metallurgical & Material Engg,
University of the Punjab, Lahore.

12. Dr. Aqil Inam,
Assistant Professor,
Department of Metallurgical & Material Engineering,
University of the Punjab, Lahore.

13. Dr. Ali Dad Chandio,
Assistant Professor,
Department of Metallurgical Engineering,
NED University of Engineering & Tech, Karachi.

14. Dr. Muhammad Sohail,
Assistant Professor,
Department of Metallurgical Engg,
NED University of Engineering & Tech,
University Road, Karachi.

15. Dr. Muhammad Uzair,
Lecturer / Coordinator,
Department of Physics,
University of Peshawar, Peshawar.

16. Engr. Dr. Hamid Zaigham
Metallurgical Division,
Nishtar Colony, Y-Cross Kahuta,
Rawalpindi.

17. Dr. Rashad M. Mirza
Chief Engineering / Director QA
Pakistan Atomic Energy Commission,
Islamabad.

18. Dr. Fahad Ali
Professor,
Department of Metallurgical & Material Engineering,
Pakistan Institute of Engineering & Applied Sciences
(PIEAS), Nilore, Islamabad.

Mr. Muhammad Raza Chohan DG Academics and Dr. Muhammad Idrees Director (Acad.) Division, Higher Education Commission (HEC) welcomed the members and participants to the meeting. They briefed the members on the academic programme and activities of the Higher Education Commission (HEC) and highlighted the important aspects related to national policy and guidelines for revision of curricula in all disciplines.

Prof. Dr. Fazal Ahmad Khalid, SI, the Convener thanked the Higher Education Commission (HEC) and members for providing an opportunity to participate and contribute in the revision of curriculum on Metallurgy and Materials Engineering. All members presented their point of view for revision of curriculum. The Convener highlighted the important benchmarks and international best practices to be considered for the development of the curriculum and adoption of Outcome Based Education (OBE). He also suggested that the Committee comprising professors and experts from academia, industry and R&D institutions has provided a useful input and suggestions covering new developments to incorporate in the curriculum. He also highlighted the importance of the field of metallurgy and materials engineering for development of new and advanced-materials, nanotechnology and mineral processing for economic development of the country which is consistent with HEC Vision 2025 and Pakistan Vision 2025. The revised curriculum is updated

with breadth and depth courses defining Program Learning Outcomes (PLOs) and Course Learning Outcomes (CLOs). It is envisaged that the curriculum will provide universities broad guidelines and benchmark to adopt in certain fields of specializations and research, for the education and training of graduates and engineers with attainment of Graduate Attributes (GAs).

In concluding session, Prof. Dr. Arshad Ali Executive Director thanked all the members and emphasized the participation of experts from industry in order to achieve the learning outcomes.

MISSION STATEMENT

The program aims to prepare engineers who can contribute to the society and to the science and technology of materials through innovation, research, leadership and entrepreneurship.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The main objective of this curriculum is to provide the guideline for the following programs:

1. Metallurgy/Metallurgical & Materials Engineering
2. Materials Engineering
3. Materials Science and Engineering
4. Metallurgical Engineering

The graduates will demonstrate knowledge, competence and expertise in materials and metallurgical processes, structure-property relations, design and analytical techniques. Graduates will have the attributes outlined in the Program Learning Outcomes (PLOs) as graduate attributes (GAs):

PROGRAM LEARNING OUTCOMES (PLOs)

The curriculum has been reviewed in order to incorporate implementation of Outcome Based Education and Assessment (OBE/A). The main purpose is to produce academically sound graduates for being successful in industry, research and development, national, multinational companies and organizations. Having followed this curriculum, the graduates will have the competency to successfully pursue post-graduate studies.

Apart from the engineering courses, a sufficient number of courses in English language, Communication skills, Ethics, Social and Management Sciences have been incorporated into the curriculum to enhance the quality and performance of the graduates having the following attributes:

PLO-01: Engineering Knowledge: Ability to apply knowledge of mathematics, science & engineering fundamentals and metallurgy & material engineering to the solution of complex engineering problems.

PLO-02: Problem Analysis: Ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PLO-03: Design/Development of Solutions: Ability to design solutions for complex engineering problems and design systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

PLO-04: Investigation: Ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

PLO-05: Modern Tool Usage: Ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.

PLO-06: The Engineer and Society: Ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

PLO-07: Environment and Sustainability: Ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PLO-08: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PLO-09: Individual and Team Work: Ability to work effectively, as an individual or in a team, on multifaceted and/or multidisciplinary settings.

PLO-10: Communication: Ability to communicate effectively, orally as well as in writing on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentations, make effective presentations, and give and receive clear instructions.

PLO-11: Project Management: Ability to demonstrate management skills and apply engineering principles to one's own work, as a member

and/or leader in a team to manage projects in a multidisciplinary environment.

PLO-12: Lifelong Learning: Ability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments.

In addition to incorporating the graduate attributes listed above as the program learning outcomes, the educational institution may include any additional outcomes if required.

SALIENT FEATURES

The curriculum revision is based on following considerations:
The undergraduate programme has been revised on the basis of HEC and PEC directives. The salient features of the revised curriculum are given below:

Duration:	4 years
Number of Semesters	8
Number of weeks per semester:	18 (Min. 15 weeks Teaching)
Total number of credit hours:	136
Number of credit hours per semester:	15 – 18
Engineering Courses:	68-72 %
Non-Engineering Courses:	32-28 %

This entire curriculum has been designed on the following lines:

- The curriculum matrix is composed of the foundation, breadth and depth courses so that different streams for specializations can be developed within each discipline.
- Foundation courses: The foundation courses are the compulsory courses. These courses provide students with the fundamental concepts and tools to pursue their studies at the higher level.
- Breadth Courses: The breadth courses introduce different specialties in the given discipline of engineering early in their studies comprising courses related to major based core breadth (MBCB) and Interdisciplinary engineering breadth courses (IDEB)
- Depth Courses: The depth courses offer various streams within each programme. All depth courses must integrate a substantial design component.
- The students may select electives from any of the streams with guidelines from their respective advisors.

- All courses are also identified as engineering or non-engineering.
- A university can offer a degree programme in:

    1. Metallurgy/Metallurgical & Materials Engineering
    2. Materials Engineering
    3. Materials Science and Engineering
    4. Metallurgical Engineering

The department may opt for a particular engineering programme (1-4) considering the mission of the program and the thrust areas as defined by university

This curriculum has been designed to facilitate the universities and departments to formulate their programs according to the industrial needs and recent developments in the field of Materials Science and Engineering.

FRAME WORK TEMPLATE FOR BE/BSc/BS METALLURGY AND MATERIALS ENGINEERING

Non-Engineering Domain								% Area	% Overall
Know-ledge Area	**Subject Area**	**Name of Course**	**Lec CH**	**Lab CH**	**CR**	**Total Courses**	**Total Credits**		
Humani-ties	English	Communication Skills	3	0	3	2	6		
		Technical Report Writing and Presentation Skills	3	0	3				
	Culture	Pakistan Studies	2	0	2	2	4		
		Islamic Studies/Ethics	2	0	2				
	Social Sciences	Social Science I (Engineering Economics)	2	0	2	3	5		
		Social Science II (Social Psychology)	2	0	2				
		Community Services	1	0	1				
Manage-ment Sciences (MS)									
		Industrial Safety and Environmental Engineering	1	0	1	2	4		
		Entrepreneurship & Marketing	3	0	3				
		Select Any Two Courses							
		Environmental Management and Control	3	0	3	2	6		
		Solid Waste Management	3	0	3				
		Metallurgical Plants and Quality Control	3	0	3				
		Total Quality Management (TQM)	3	0	3				
		Engineering Management	3	0	3				
		Energy Management	3	0	3				
		Production Operations	3	0	3				

		Management							
Natural Sciences (NS)	Physics	Applied Physics	3	1	4	1	4		
	Mathematics	Calculus	3	0	3	3	8		
		Differential Equations	3	0	3				
		Probability & Statistics	2	0	2				
	Chemistry	Applied Chemistry	3	0	3	1	3		
		Research Methodology	1	0	1	1	1		
SUB TOTAL						**17**	**41**	**100**	**30**

Engineering Domain								**% Area**	**% Overall**
Know-ledge Area	**Subject Area**	**Name of Course**	**Lec CH**	**Lab CH**	**CR**	**Total Courses**	**Total Credits**		
Compu-ting	Fundamentals	Introduction to Computing	2	1	3	3	9		
	Programming	Numerical Analysis & Computer Programming	3	0	3				
	Design	Computational Materials Science	2	1	3				
Engg. Found-ation (EF)		Engineering Drawing and CAD	2	1	3	9	25		
		Workshop Practice	1	1	2				
		Introduction to Engineering Materials	3	0	3				
		Engineering Mechanics	3	0	3				
		Materials Thermodynamics	3	0	3				
		Physical Metallurgy-I	3	0	3				
		Mechanical Behaviour of Materials	3	0	3				
		Inspection and Testing of Materials	3	1	4				
		Optional (PEO based)	1	0	1				

Major Based Core Breadth (MBCB)		Heat Treatment	3	1	4	9	30		
		Physical Metallurgy-II	3	1	4				
		Mineral Processing	2	1	3				
		Iron & Steel Making	3	0	3				
		Non-Ferrous Metallurgy	3	0	3				
		Engineering Ceramics and Glasses	3	0	3				
		Manufacturing Processes	3	1	4				
		Polymeric Materials	3	0	3				
		Composite Materials	2	1	3				
Major Based Core Depth (MBCD		Advanced Materials & Nanotechnology	3	0	3	5	16		
		Foundry Engineering	3	0	3				
		Joining of Materials	3	0	3				
		Corrosion Engineering	3	1	4				
		Design and Selection of Materials	3	0	3				
		Electives							
		Tribology and Surface Engineering	3	0	3	2	6		
		Advanced Steels	3	0	3				
		Materials Characterization	3	0	3				
		Powder Metallurgy	3	0	3				
		Biomaterials	3	0	3				
		Fracture Mechanics and Failure Analysis	3	0	3				
		Furnaces and energy conservation	3	0	3				
		Nanotechnology /Nanomaterials	3	0	3				
		Nuclear Reactor	3	0	3				

		Materials							
		Rare Earth Metals	3	0	3				
		Laser Materials Processing	3	0	3				
		Materials for Renewable Energy	3	0	3				
		Shape Memory Materials	3	0	3				
		Materials for Aerospace Applications	3	0	3				
		Materials for High Temperature Applications	3	0	3				
		Carbon Materials	3	0	3				
		Satellite Materials and their Quality Assurance	3	0	3				
		Magnetic, optical and electronic materials	3	0	3				
		Functional Materials	3	0	3				
		Vacuum Technology	3	0	3				
Inter-disciplinary Engineering Breadth (IDEB)		Instrumentation & Control	3	0	3	1	3		
Senior Design Project		Senior Design Project Part-I	0	3	3	2	6		
		Senior Design Project Part-II	0	3	3				
Industrial Training			0	0	0	0	0	0	0
SUB TOTAL						**31**	**95**	**100**	**70**
GRAND TOTAL						**48**	**136**		**100**

Note: ***The HEIs may have the flexibility to incorporate courses depending on their thrust area and labs scheme e.g., semester based labs and or course specific labs.***

Course Related Labs:

The following relevant labs have been identified.

Polymers, Ceramics, Composites, Surface Modification, Corrosion and its control, Joining Processes, Manufacturing, Foundry, Inspection and Testing, Mineral Processing, Heat Treatment, Physical Metallurgy, Instrumentations, Computational Materials Science, Powder Metallurgy, Applied Physics, Chemistry, Introduction to Computing, Engineering Drawing & Auto CAD, Pro-E, ANSYS, Workshop Practice, etc.

Note: ***All lab experiments must have compliance of Environmental Health and Safety (EHS) standards, procedures and protocols. The lab manuals should also incorporate necessary safety precautions and facilities.***

Teaching Methods:
Class Lectures, Discussions, Demonstrations, Videos, and Industrial visits

Assessment Methods

Quizzes
Project
Presentations
Assignments/Industrial Reports
Complex Engineering Problems
Open Ended Assignments
Midterm Exam
Final Exam

Scheme of Study
for BE/BSc/BS Metallurgy and Materials Engineering

First Year
(1st semester)

First Year
(2nd semester)

Course Title	Lec	Lab	CR	Course Title	Lec	Lab	CR
Communication Skills	3	0	3	Engineering Drawing and CAD	2	0	2
Applied Physics	3	0	3	Workshop Practice	1	1	2
Calculus	3	0	3	Introduction to Engineering Materials	3	0	3
Introduction to Computing	2	0	2	Engineering Mechanics	3	0	3
Applied Chemistry	3	0	3	Pakistan Studies	2	0	2
Islamic Studies/Ethics	2	0	2	Differential Equations	3	0	3
Semester Lab-1	0	2	2	Optional course (Based on PEOs)	1	0	1
				Semester Lab-2	0	1	1
Total	**16**	**2**	**18**	**Total**	**15**	**2**	**17**
First year Credit Hours	**35**						

Second Year (3rd semester)

Second Year (4th semester)

Course Title	Lec	Lab	CR	Course Title	Lec	Lab	CR
Inspection and Testing of Materials	3	0	3	Mechanical behaviour of Materials	3	0	3
Mineral Processing	2	0	2	Technical Report Writing and Presentation Skills	3	0	3
Numerical Analysis and Computer Programming	3	0	3	Physical Metallurgy-II	3	0	3
Materials Thermodynamics	3	0	3	Iron and Steel Making	3	0	3
Physical Metallurgy-I	3	0	3	Nonferrous Metallurgy	3	0	3
Social psychology	2	0	2	Community Services	1	0	1
Semester Lab-3	0	2	2	Industrial Safety and Environmental Engineering	1	0	1
				Semester Lab-4	0	1	1
Total	**16**	**2**	**18**	**Total**	**17**	**1**	**18**
Second year Credit Hours	**36**						

Third Year
(5th Semester)

Course Title	Lec	Lab	CR
Polymeric Materials	3	0	3
Heat Treatment	3	0	3
Instrumentation & Controls (Interdisciplinary)	3	0	3
Engineering Ceramics and Glasses	3	0	3
Probability and Statistics	2	0	2
Engineering Economics (Social Science I)	2	0	2
Semester Lab-5	0	2	2
Total	**16**	**2**	**18**
Third year Credit Hours	**35**		

Third Year
(6th Semester)

Course Title	Lec	Lab	CR
Manufacturing Processes	3	0	3
Management Sciences Elective I	3	0	3
Foundry Engineering	3	0	3
Joining of Materials	3	0	3
Corrosion Engineering	3	0	3
Semester Lab-6	0	2	2
Total	**15**	**2**	**17**

Final Year
(7th semester)

Final Year
(8th semester)

Course Title	Lec	Lab	CR	Course Title	Lec	Lab	CR
Composite Materials	2	0	2	MBCD Elective	3	0	3
Research Methodology	1	0	1	Management Science Elective II	3	0	3
Entrepreneurship and Marketing	3	0	3	Advanced Materials and Nanotechnology	3	0	3
Computational Materials Science	2	0	2	Design and Selection of Materials	3	0	3
MBCD Elective	3	0	3	Senior Design Project Part-II	0	3	3
Senior Design Project Part-I	0	3	3				
Semester Lab-7	0	1	1				
Total	**11**	**4**	**15**	**Total**	**12**	**3**	**15**
Final year Credit Hours	**30**						

ENGINEERING ECONOMY

Specific Objectives of Course: To impart knowledge of engineering economy.

Course Outline:

Introduction of engineering economy and the economic environment. Consumer and producer goods, measures of economic worth, Price, Supply, & Demand relationship; Production; Factors of production; Laws of return. Cost Concepts & Analysis: Sunk & opportunity costs; Fixed, variable, and incremental costs; Recurring & nonrecurring costs; Direct, indirect, and overhead costs; Standard costs; Unit cost of production. Time Value of Money: Simple interest; Compound Interest; Cash flow diagrams; Interest formulae; Nominal versus effective interest rates; Depreciation and Depletion: Purpose of depreciation; Types of depreciation; Production Concepts & Mathematical Models: Manufacturing lead time, Production rate; Capacity utilization; Availability; Work in process; Linear Programming: Mathematical statement of linear programming problems; Graphic solution; Simplex method; Duality problems. Capital Financing and Budgeting: Types of ownership; types of stock; partnership & joint stock companies; Banking & specialized credit institutions. Industrial Relations: Labour problems; Labour organizations; Prevention & Settlement of disputes.

Recommended Books:

1. George Owen Hoskins and Thomas Hall Burnham, “Engineering Economy”, Pitman, 2007
2. William Thomas Morris, “Engineering Economy”, University of Michigan Jan, 2007
3. Paul, E. Degarmo, “Engineering Economy”, OUP, 2005
4. John Charles and Lounsbury Fish, “Engineering Economics”, McGraw-Hill, 2005

SOCIAL PSYCHOLOGY

Specific Objectives of Course: To impart knowledge of social psychology of attraction; attitudes and prejudice; altruism and aggression; personal and social identities; conformity; group influence and their applications in the real world.

Course Outline:

Principles of sociology and psychology with emphasis on the individual and his/her reciprocal interaction with groups, basic psychological factors, attribution and perception of others, attitudes and attitudinal change, social attitudes, altruism, helping others, aggression, hurting others, prejudice, disliking others, discrimination and stereotypes, language and communication, society and cultures, culture and personality, small groups and their relation to the individual, leadership and group dynamics. Attraction, attitudes and prejudice; altruism and aggression; personal and social identities, conformity, group influence, moral and ethical issues, harassment, corruption and its control, thinking processes and decision making.

Recommended Books:

1. Edward Alsworth Ross, “Social Psychology”, Macmillan, 2006
2. Emory Stephen Bogardus, “Essentials of Social Psychology”, Univ. of Southern, California Press, 2006
3. Hewstone, M., & Stroebe, W. (Eds.), “Introduction to Social Psychology”, 3rd ed., Oxford: Blackwell Publishers, 2006
4. Lesko, W.A. “Readings in social psychology General, classic, and contemporary selections, 6th ed., 2006

COMMUNITY SERVICES

Course Objectives:

Community service-learning provides a variety of benefits to the students and the community service has a unique way of developing an individual's leadership skills, sense of community, civic ethic, self-esteem, and other personal characteristics. Every service activity benefits a specific individual or group. Whether it is building homes for the poor, serving victims of chronic or terminal illness, tutoring children, addressing environmental needs or any other service, there is a person or group who ultimately benefits from your time. Finally, the organization where you conduct your service benefits enormously. Volunteers can make important contributions to Community benefit agencies (nonprofit) and government programs in their attempt to deal with the complex and growing needs of society.

Course Outline:

1. Develop and implement service programs
2. Develop workplace communication strategies
3. Analyze impacts of sociological factors on clients in community work and services
4. Manage and promote diversity
5. Manage legal and ethical compliance
6. Facilitate workplace debriefing and support processes
7. Reflect on and improve own professional practice
8. Manage work health and safety
9. Assess co-existing needs
10. Coordinate complex case requirements
11. Develop, facilitate and review all aspects of case management
12. Provide case management supervision
13. Undertake project work
14. Lead and manage team effectiveness
15. Manage personal work priorities and professional development
16. Manage meetings

Recommended Books

1. Schools and Community: The Communitarian Agenda in Education By James Arthur; Richard Bailey, Falmer Press, 2000.
2. Studying Service-Learning: Innovations in Education Research Methodology by Shelley H. Billig, Alan S. Waterman , Lawrence Erlbaum Associates, 2003

INDUSTRIAL SAFETY AND ENVIRONMENTAL ENGINEERING

Specific Objectives of Course: To provide thorough knowledge of industrial safety and engineering environment.

Course Outline:

Industrial safety management, Understanding accident and hazard, Hazard control and loss control. Accident Prevention and Control, Accident reporting and investigation, Fire safety, Electrical Safety, Safety in boilers, Safety in material handling and storage, Safety in production operations. Process Safety Management: Development of facility operation and procedures, Analysis of process hazard. Hazard communication, Chemical inventory record. Industrial Hygiene and Workers Protection, Various hazards encountered in workplace, Types of personal protective equipment (PPE), Availability in market, their design standards and selection criteria. Environment Management: Environment pollution, Air emission management, Waste management, Waste water treatment and control, Soil and ground water protection, Introduction to Pakistan Environment Protection Act 1997 and National Environmental Quality Standards, Key elements of ISO 14000.

Recommended Books

1. Thomas J. Anton, "Occupational Safety & Health Management", 2nd ed., McGraw-Hill, 2006
2. Daniel E. Della-Giustina, **"**Safety and Environmental Management", 2001
3. Ronald Packman, "A Guide to Industrial Safety and Health" Longmans, 2007
4. James S. Angle, "Occupational Safety", Thomson Delmar Learning, 2004, ISBN 1401859038
5. Management of international health and safety by Dr. J Phelpstead, PhD, CMIOSH & Mrs. Zoe Neasham CMIOSH, Dip2OSH SPRING 2013.ed

ENTREPRENEURSHIP AND MARKETING

Course Objective:

Entrepreneurship is an important component in the process of economic development. The purpose of this course is to analyse the theories of entrepreneurship and to go for case studies of successful entrepreneurs.

Course Outline:

Introduction: The concept of entrepreneurship, the economist view of entrepreneurship, The sociologist view, Behavioural approach, Entrepreneurship and Management

The Practice of Entrepreneurship: The process of entrepreneurship, Entrepreneurial Management, The entrepreneurial business, Entrepreneurship in service institutions, The new venture

Entrepreneurship and Innovation: The innovation concepts, Importance of innovation for entrepreneurship, Sources of innovative opportunities, The innovation process, Risks involved in innovation

Developing Entrepreneur: Entrepreneurial profile, Trait approach to understanding entrepreneurship, Factors influencing entrepreneurship, The environment, Socio cultural factors, Support systems

Entrepreneurship Organization: Team work, Networking organization, Motivation and compensation, Value system

Entrepreneurship and SMEs: Defining SMEs, Scope of SMEs, Entrepreneurial, managers of SME, Financial and marketing problems of SMEs

Entrepreneurial Marketing: Framework for developing entrepreneurial marketing, Devising entrepreneurial marketing plan, Entrepreneurial marketing strategies, Product quality and design

Entrepreneurship and Economic Development: Role of entrepreneur in the economic development generation of services, Employment creation and training, Ideas, knowledge and skill development, The Japanese experience

Case Studies of Successful Entrepreneurs

Recommended Books:

1. Michael J Etzel, Bruce J Walker, William J Stanton, Marketing, McGraw-Hill 2010
2. William D. Bygrave and Andrew Zacharak, Entrepreneurship 2nd Edition, Wiley, 2012.
3. Entrepreneurship by Hisrich, McGraw- Hill, 2009
4. Principles of Marketing, Cotrell McGraw- Hill 2012
5. Paul Burns and Jim Dew Hurst: Small Business and Entrepreneurship
6. P.N. Singh: Entrepreneurship for Economic Growth
7. Peter F. Drucker: Innovation and Entrepreneurship Peter F. Drucker
8. John B. Miner: Entrepreneurial Success
9. “Marketing that Works: How Entrepreneurial Marketing Can Add Sustainable Value to Any Sized Company”, by Leonard Lodish, Howard Morgan, Shellye Archambeau and Jeffrey Babin, Pearson FT Press
10. "Entrepreneurial Marketing," *Lessons from Wharton's Pioneering MBA Course*, Morgan, H. L., A. Kallianpur, and L. M. Lodish, John Wiley & Sons, 2001.

Elective Courses in Management Sciences
See Annex - A

APPLIED PHYSICS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain fundamental laws of Physics and their applications.	Cognitive	2	1
2.	Explain general physical properties of materials.	Cognitive	2	2
3.	Relate materials structure with general properties	Cognitive	2	3

Course Outline:

N.B. ***Mechanics is covered in Engineering Mechanics***

1. Electricity & Magnetism

- Electric dipole and flux
- Gauss's Law and its Applications
- Electric Potential
- Capacitors and Capacitance
- Energy Stored in an Electric Field
- Dielectrics
- Electric Current and Current Density
- EMF
- Magnetic Field and Magnetic Force, Torque on a Current Loop
- Magnetic Dipole Moment;
- Biot-Savart Law,
- Ampere's Law,
- Magnetism types
- Hysteresis loops
- Inductance; Faraday's Law of Induction
- Lenz's Law
- Maxwell's equations

2. Waves & Optics

- Introduction
- Interference
- Diffraction
- Reflection
- refraction and polarization,
- Lenses, focal length, magnification and resolving power.

- Snell's law

3. Solid State Physics

- Introduction
- Thermal properties of solids,
- Free electron theory of metals

Recommended Books

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. (2010).
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed., (2010).
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed., (2010).
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern", McGraw Hill, 2nd ed., (1992).
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed., (2008).
6. C. Kittle, "Introduction to Solid State Physics", John Wiley, 8th ed. (2005).
7. M. A. Wahab, "Solid State Physics", Narosa Publishing House, (1999).

Journals/Periodicals
World Wide Web

CALCULUS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain fundamental formulae of calculus	Cognitive	2	1
2.	Apply general solving techniques of the subject	Cognitive	3	2
3.	Illustrate about the relationship of calculus principles with the other related subjects	Cognitive	3	2

Course Outline:

Basic Operations of complex numbers, De'Moivre's Theorem with applications, Circular, Hyperbolic, Exponential Functions of complex numbers and their inverse functions.

Limits-Indeterminate forms, Continuity, differentiability, Total differential with applications to errors, Newton's method of approximating roots of non-linear equations. Tracing of simple curves in Cartesian and Polar Coordinates, Curvature and radius of curvature. Partial differentiation with applications. Homogeneous functions. Tangent and normal. Review of basic integration methods. Application to Area, Arc Length, Volume and Surface of Revolution. Reduction formulae. Elementary Beta and Gamma integrals. Rectification and Quadrate. Centre of gravity. Centre of pressure. Moment of inertia of plane areas. Approximate integration, infinite series, Trigonometric and inverse trigonometric functions. Scalar and Vector quantities, physical and geometrical meanings. Algebra of vectors. Scalar and vector triple products. Green theorem, divergence theorem, Stoke's theorem

Recommended Books

1. G. B. Thomas, R. L. Finney, "Calculus and Analytic Geometry", National Book Foundation, 9th ed. (1995)
2. G. Strang, "Calculus", Wellesley-Cambridge, 2nd ed., (2010).
3. E. W. Swokowski, M. Olinick, D. Pence, and J. A. Cole, "Calculus"; Pws Pub Co; 6th ed. (1994).

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DIFFERENTIAL EQUATIONS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain fundamental solving techniques of ODE's	Cognitive	2	1
2.	Apply general techniques of differential equations	Cognitive	3	2
3.	Illustrate use of differential equation in engineering problems	Cognitive	3	3

Course Outline:

Introduction to ODEs (physical motivation), First order ODEs (separable variables, homogeneous equations, exact equations, linear equations, Bernoulli equation and other examples), applications of first order ODEs – linear and non-linear, linear differential equations of higher order (initial value and boundary value problems, linear dependence and independence, solutions of linear equations, constructing a second solution from a known solution, homogeneous linear equations with constant coefficients, undetermined coefficients, variation of parameters), applications of second order ODEs (simple harmonic motion, damped and forced oscillators, electrical circuits and springs), differential equations with variable coefficients (Cauchy-Euler equation, power series solution of differential equations – solutions about ordinary and singular points-Legendre's and Bessel's equations as examples), Laplace transform (Laplace transform and its inverse and properties, use in solving differential equations, Dirac delta function).

Recommended Books

1. D. G. Zill and M. R. Cullen, "Differential Equations with Boundary Value Problems", 3rd ed. National Book Foundation. (2008)
2. E. Kreyszig, "Advanced Engineering Mathematics", John Wiley, 8th ed. (1999).
3. K. F. Riley, M. P. Hobson and S. J. Bence, "Mathematical Methods for Physicists", Cambridge University Press (2006).

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PROBABILITY AND STATISTICS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain fundamental principles of probability and data arrays	Cognitive	2	1
2.	Apply the general techniques of application of data estimations	Cognitive	2	2
3.	Apply the principles in engineering problems	Cognitive	3	3

Course Outline:

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, mean, variance, standard deviations, 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.

Recommended Books

1. Susan Milton and Jesse C Arnold, "Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences," Fourth Edition, 2003, McGraw-Hill,
2. William Mendenhall and Terry Sincich, "Statistics for Engineers and the Sciences," Fifth Edition, 2007, Prentice Hall,
3. Kenneth. Lange, "Statistical Methods", Springer, 2002,
4. Montgomery, D.C., and Runger, G. C., "Applied Statistics and Probability for Engineers", John Wiley & Sons, 2001
5. N. A. Weiss, "Introductory Statistics", Addison Wesley, 1995

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APPLIED CHEMISTRY

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain the basic knowledge of chemical elements, their classification and bonding.	Cognitive	2	1
2.	Apply fundamental concepts of chemistry to engineering problems	Cognitive	3	2
3.	Analyze and correlate reaction parameters with equilibrium, kinetics	Cognitive	4	3

Course Outline

- Periodic table and Classification of elements; Electronic configuration; transition metals, noble metals, active metals, rare earths, semimetals and semiconductors;
- Chemical reactions; stoichiometry, mass and heat balance, oxidation and reduction reactions in ferrous and non-ferrous materials.
- Solution chemistry and analysis.
- Physical chemistry: equilibrium, kinetics and reaction rate laws, effect of physical variables (pressure, temperature etc.) on equilibrium and kinetics, phase rule
- Electrochemistry: Faraday's law and its applications, Nernst equations, EMF series, electrolytic and voltaic cells.
- Organic chemistry: hydrocarbon compounds, chemistry of hydrocarbon compound.
- Biochemistry, interactions of biological molecules with materials, micro-organism catalysed reactions
- Analytical chemistry
- Chemistry of natural resources (coal and minerals).

Recommended Books

1. Shultz, "Chemistry for Engineer" Brookes Cole, 1st Ed, 2006.
2. Fahlman, "Materials Chemistry", Springer, 2nd Edition, 2011.
3. Hyman D. Gasser, "Applied Chemistry", Springer 2002Edward Andrew Parnell, "Applied Chemistry", D. Appleton & Co., 2007
4. Thodore E. Brown, "Chemistry", Prentice Hall, 2005
5. M. Farhat, "Industrial Chemistry", McGraw-Hill 2004
   Journals/Periodicals/ World Wide Web

RESEARCH METHODOLOGY

Course Learning Outcomes:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Organize research data and appropriate literature	Cognitive	4	5,9
2.	Analyse, interpret and correlate the data for research/design project	Cognitive	6	11

Course Outlines:

Literature survey, Research questions, Research plan, Research methods, use of software, Data collection and analysis, Precision and accuracy, reporting and reliability of data, Project report writing, Research ethics

Recommended Books

1. Research Methodology: A Step-By-Step Guide for Beginners by Ranjit Kumar, Pearson Education, 2016
2. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by Dr. John W Creswell, SAGE Publications, 2013
3. The Scientific Approach, Basic Principles of The Scientific Method By Carlo L. Lastrucci, Schenkman Publishing Company, Massachusetts
4. Research Methods in Science and Engineering by Scott A. Gold, CRC Press

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INTRODUCTION TO COMPUTING

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain the basics of hardware and software	Cognitive	2	1
2.	Apply the general techniques and software	Cognitive	4	5
3.	Develop simple computer programs	Cognitive	4	3

Course Outline:

Introduction and Evolution of Computing, Computer Systems and its Components, Computer Hardware and Software, Binary Numbers and Logic Operations, Developing a Web Page using HTML, Operating Systems, JavaScript Interactive forms and Event Handling, Word Processing and Desktop Publishing, Spreadsheets, Developing Presentations, Introduction to Algorithm, Programming paradigms and languages, basic elements of Fortran / C++ language, Software Development Methodologies, Design Heuristics, Web Design for Usability, Arrays, Computer Networks, Internet Services, Graphics, Images and Animations, Intelligence Systems in computing, Data Management, Database Software, Cyber Crime, Social Implications of Computing, The Future of Computing

Recommended Books

1. Charles S. Parker, Understanding Computers: Today and Tomorrow, Boston, Massachusetts 02210, USA (2009).
2. Jerry Lee Ford, Jr. Prima Tech, Learn JavaScript in a Weekend, 2nd Edition, Priemer Press, Boston (2004)
3. O. Leary “Computing Essentials 2012”, McGraw-Hills, 22nd Ed 2011.
4. Andrew J. Herbert, Roger Michael Needham, “Computer Systems”, Springer, 2004.
5. Glenn, H. MacEwen, “Introduction to Computer Systems”, McGraw-Hill, 2007.
6. John A. Aseltine, “Introduction to Computer Systems”, Wiley, 2007,
7. Neil A.B.Gray “Intro to Computer Systems” Prentice-Hall 1987

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NUMERICAL ANALYSIS & COMPUTER PROGRAMMING

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Apply the basic programming techniques	Cognitive	2	1
2.	Demonstrate the applications of computer language to various problems	Cognitive	3	2
3.	Solve the numerical problems and prepare algorithms	Cognitive	2	3

Course Outline:

Computer Languages:
Computer language; Basic/C/C++/Pascal/Fortran. Data types, conditional branching and looping, defining and accessing a subroutine, arrays and strings.
known software packages of computation e.g. Mathematica/MATLAB

Numerical Methods:
Numerical Solutions of equations, Regression and interpolation, Numerical integration and differentiation. Error analysis and technique for elimination of systematic and random errors. Numerical techniques. Algorithm development

Recommended Books

1. M. L. De Jong," Introduction to Computational Physics", Addison Wesley, (1991).
2. S. T. Koonini, "Computational Physics", the Benjamin-Cummings, (1985).
3. H. Gould, J. Tobochnik and W. Christian, "An Introduction to Computer Simulation Methods", Addison Wesley, 3rd ed. (2006).
4. S. C. Chapra and R. P. Chanle,"Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill, (1990).
5. S. C. Chapra, "Applied Numerical Methods with MATLAB for Engineers and Scientists", McGraw Hill, 2nd ed. (2006).
6. Zhilin Li, Lubin and Vulkov, Jerzy Waśniewski, "Numerical Analysis and its Applications", Springer, 2005, ISBN 3540249370
7. Chopra and Canale "Numerical Methods for Engineers" McGraw-Hill, 2009

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COMPUTATIONAL MATERIAL SCIENCE

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Describe use of various soft wares for modeling of Materials Engineering processes.	Cognitive	1	5
2.	Analyze and model Materials problems using modern computational tools	Cognitive	3	5
3.	Work as a team member on a relevant project.	Psychomotor	P-3	9

Course outline:

- **Modeling and simulations**
  Basic computer modelling and simulation techniques. Monte Carlo technique

- **Modeling structure and properties**
  Computer modelling of phase transformation and microstructural evolution. Estimation of physical and mechanical properties.

- **Modeling processes**
  Computer modelling of material processes such as solidification, casting, plastic deformation, machining, heat treatment

- **Use of software**
  Use of computer software such as MATLAB, LabVIEW, solidcast, magma, material studio, Thermocalc, CALPHED, FEM software such as ANSYS, ABACUS. Dante, SORPAS. QForm 2D/3D

Recommended Books:

1. R. LeSar, Introduction to Computational Materials Science: Fundamentals to Applications 1st Edition, CUP, 2013.
2. Mark F. Horstemeyer, Integrated Computational Materials Engineering (ICME) for Metals: Using Multiscale Modelling to Invigorate Engineering Design with Science, Wiley-TMS 2012.
3. June Gunn Lee, Computational Materials Science: An Introduction, CRC Press, 2011.

4. P. V. Roy and S. Haridi, “Concepts Techniques and Models of Computer Programming”. MIT Press, 2004
5. ASTM Series “Computer Application in Materials Engineering”, 2000
6. Tetsuya Saito, “Computational Materials Design”, December 2010
7. June Gunn Lee, “Computational Materials Science: An introduction”, 1st Edition, September 2011
8. Koenread George Frans Janssens, Dierk Raabe, Ernest Kozeschnik, Mark A. Miodownik, Britta Nestler, “Computational Materials Engineering: An Introduction to Microstructure Evolution”, first ed, 2007
9. Celyustkin, A.B., “The Application of computing Technique to Automatic Control Systems in Metallurgical Plant”, Mac Milan, 2004
10. National Research Council (USA) “Computer Aided Materials Selection” National Academies Press 1995

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ENGINEERING DRAWING AND GRAPHICS / AUTO CAD

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Make drawing of engineering components	Cognitive	2	10
2.	interpret engineering drawings to real models using CAD	Cognitive	3	5
3.	work as a team member on a relevant project.	Psychomotor	P-3	9

Course Outline:

Introduction to subject, use of instruments, planning of drawing sheets using sketch book drawing, 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 surfaces 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.

Recommended Books:

1. Thomas Ewing French “Engineering Drawing” McGraw-Hill 2006
2. Henry Loren Thompson, “Engineering Drawing Practice and Theory and Practice”, International textbook company, 2007
3. Charles William Weick “Elementary Mechanical Drawing” McGraw-Hill, 2006
4. Frederick Ernest Giesecke, “Engineering Graphics”, Prentice Hall, 2003

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WORKSHOP PRACTICE

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Demonstrate the basic workshop skills	Cognitive	C-3	1
2.	Display and perform various machining operations	Psychomotor	P-4	5
3.	Work as a team member on a relevant project.	Psychomotor	P-3	9

Course Outline:

Workshop health and safety precautions.
Bench fitting: Description, proper use and maintenance of the fitting tools. Hand filing, cutting and measurements
Introduction to hand and machine tools: lathe machine operation, turning, taper turning, facing, knurling, threading, boring and shaping. Milling machine operation, shaper machining, hand and bench drilling operations and CNC machines. Surface and precision grinding operations.
Wood working: use of 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.
Electrical circuits and fittings.

Recommended Books

1. Henry Wright Baker, “Modern Workshop Technology”, Cleaver-Hume Press, 2006
2. Alfred Parr Longmans, “Machine Tools and Workshop Practice” Green & Co. 2007
3. Raymond Francis Yates “Model Making Including Workshop Practice” The Norman W. Henley publishing company, 2007
4. S. K. Garg, “Workshop Technology”, Laxmi Publication’s 2005, ISBN 8170086353
5. Alfred Parr Longmans, “Workshop Practice”, Green, and co, 2007

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INTRODUCTION TO ENGINEERING MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Identify basic properties based on knowledge of the atomic composition and chemical bonding and structures of various materials.	Cognitive	1	1
2.	Describe and account for the processing routes and mechanical properties of the main classes of materials.	Cognitive	2	2
3.	Use binary phase diagram to describe the composition, phases and microstructures.	Cognitive	3	2

Course Outline:

1. **Engineering Materials**
   Classification and Types
2. **Atomic structure and bonding**
   Atomic structure, binding forces and energies, bondings.
3. **Structure of Materials**
   Crystal systems, unit cell, crystallographic directions/plane, Miller indices, density computations, metallic and ceramic crystal structures, polymorphism, allotropy, polycrystalline materials, amorphous materials.
4. **Mechanical Properties**
   Elastic deformations, stress-strain behavior, anelasticity, true stress-strain, shear & torsion deformation. Ductility, resilience, toughness, hardness, design/safety factors. Mechanical behavior of metals, ceramics & polymers.
5. **Phase diagrams**
   Interpretation of Phase diagrams, Development of microstructure in Binary, isomporphous systems, Binary Eutectic Phase Diagram Eutectic, Eutectoid and peritectic reactions. Iron-Iron Carbide Phase Diagram.

6. **Polymeric and composite materials**
   Polymer molecule, Molecular weight, shape and its structure configurations, thermoplastic & thermosetting and crystallinity of polymers. Particle, fibre and laminate composites.
7. **Advanced materials**
   Smart materials, biomaterials and functional materials.
8. **Processing of materials**
9. Fabrication and processing of metals, polymers and ceramics.

Recommended Books:

1. William D. Callister, David G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach, 4th Edition, Wiley 2012
2. Callister, "Materials Science and Engineering : An Introduction", John Wiley and Sons, 8th Edition, 2009
3. Donald R. Askeland, Wendelin J. Wright, "The Science and Engineering of Materials", 7th Edition, Jan 2015.
4. William Smith, Javad Hashemi, "Foundations of Materials Science and Engineering", 5th Edition, April 2009
5. Ashby, M. F. and Jones, D.R.H., "Engineering Materials-I & -II", 4th Edition, Butterworths- Heinemann, 2011.

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ENGINEERING MECHANICS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain the implications of Newton's laws of motion	Cognitive	2	1
2.	Interpret the equations describing equilibrium, rectilinear motion, rotational motion	Cognitive	3	2
3.	Analyse mechanical structures and different materials	Cognitive	4	2

Course Outline:

1. Statics and kinematics of Particles: Forces in a plane; Free body diagram; Forces in space (rectangular components); Equilibrium of a particle in space. Dynamic equilibrium; Rectilinear and curvilinear motion; Impulsive forces and conservation of momentum
2. Rigid Bodies: Centre of mass and centre of gravity of a three-dimensional body. Centroid of body. Moments of inertia, radius of gyration, parallel axis theorem.
3. Equilibrium of Rigid Bodies: Free-body diagram; Equilibrium in two and three dimensions; Reaction of supports and connections; Equilibrium of two-force and three-force bodies. Shear force and bending moment diagrams. Thin and thick shells
4. Plane Motion of Rigid Bodies: Forces and acceleration; Energy and momentum; Conservation of linear and angular momentum.
5. Analysis of Structures: Internal forces and Newton's Third Law; Simple and space trusses; Joints and sections; Frames and machines. Forces in cables.

Recommended Books:

1. R. C. Hibbeler, "Engineering Mechanics (Statics)" 12th Edition, 2009
2. J. L. Meriam and L. G. Kraige "Engineering Mechanics (Statics)" Wiley, 2011
3. F.P. Beer and E.R. Johnston, "Mechanics of Materials"
4. P.P. Benham, R.J. Crawford and C.J. Armstrong, "" Mechanics of Engineering Materials", Pearson-Prentice Hall, 1996

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MATERIALS THERMODYNAMICS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain various thermodynamics criteria for a spontaneous process to occur.	Cognitive	4	1
2.	Apply thermodynamic principles to explain possibility of a reaction such as oxidation, reduction and apply these concepts in extraction, refining, corrosion, etc.	Cognitive	4	2
3.	Illustrate the principles of phase equilibrium. He/she will be able to construct phase Diagram from thermodynamic data.	Cognitive	6	2
4.	Differentiate spontaneous and nonspontaneous processes appreciating the concepts of second law of thermodynamics. He/she will be able to give a presentation organizing applications of thermodynamics on various processes.	Affective	A-4	12

Course Outline:

1. Introduction: Thermodynamics, materials thermodynamics, state, extensive and intensive properties.
2. Laws of thermodynamics: First law, internal energy, heat capacity, enthalpy, reversible/irreversible processes, spontaneity, 2nd law, entropy, free energy, spontaneity criteria, Maxwell relations,third law.
3. Solutions: Gaseous, liquid and solid solutions, behaviour of ideal and non-ideal solutions.
4. Phase equilibria: One component system, phase equilibria, binary phase diagrams from thermodynamic data.
5. Reaction equilibria: Reactions of gases, reaction of gas with condensed phase, Ellingham diagrams, reaction equilibria in condensed phases, Gibbs phase rule.

6. Electrochemistry: Chemical and electrical driving force, EMF, determination of thermodynamic properties from electrochemical data.
7. Use of thermodynamic data: Sources of data and utilization of data.

Recommended Books:

1. Gaskell, D. R , “Introduction to the Thermodynamics of Materials”, Taylor and Francis, 5th Edition, 2008
2. David Ragone, “Materials Thermodynamics” MIT Press, 2002
3. Y. Austin Chang, W. Alan Oates, “Materials Thermodynamics (Wiley Series on Processing of Engineering Materials”, first ed, December 2009
4. Kaufman. M., “Principles of Thermodynamics”, CRC, 2002
5. Machlin E. S., “An Introduction to Aspects of Thermodynamics & Kinetics”, Giro Pr; 2nd Edition, Dec 2001
6. Hudson, J. B, “Thermodynamics, An Advanced Text for Materials Scientists”, John-Wiley, 1996
7. Ahindra Gosh, “Textbook of Materials and Metallurgical Thermodynamics”, PHI Learning Pvt Ltd, 2009

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MECHANICAL BEHAVIOUR OF MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Predict deformation behaviour of materials in different loading conditions	Cognitive	2	2
2.	Identify and explain mechanisms and techniques correlating the structure and mechanical properties	Cognitive	2	4
3.	Organize the information and present a report on Failure analysis of an engineering component.	Cognitive	6	4

Course Outline:

Stresses and strains and their types, elastic and plastic deformations, flow curves, Strain and stress tensors, Generalized Hooke's law, Mohr's circle of stress and strain in 2D and 3D, Principal stresses and strains, Hydrostatic and deviator strain and stress components, Anisotropy of materials, Crystallographic aspects of plastic deformation, Dislocation and its types, Mechanisms of deformation, Critical resolved shear stress, Strain hardening of single crystal FCC, Barriers to dislocation glide, Strengthening mechanisms, Theories of failures, Fracture toughness, Creep, Creep fracture and mechanisms, Stress rupture, Larson-Miller parameters, Fatigue and Fatigue fracture.

Recommended Books:

1. R. W. Hertzberg, R. P. Vinci, Jason L. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, Wiley 2012.
2. J. Roesler, H. Harders, M. Baeker, Mechanical Behavior of Engineering Materials: Metals, Ceramics, Polymers, and Composites, Springer 2010
3. G.E. Dieter, Mechanical Metallurgy SI Edition, McGraw-Hill, 1988
4. Marc André Meyers, Krishan Kumar Chawla, "Mechanical Behaviour of Materials", Cambridge University Press; 2nd Edition , 2008

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PHYSICAL METALLURGY- I

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain different terms related to crystallography	Cognitive	3	2
2.	Explain the role of crystal structure and defects in behaviour of materials	Cognitive	3	2
3.	Construct phase diagram and interpret phase reactions	Cognitive	4	4

Course Outline:

Types of bonding and basic principles of structure of materials, crystalline and amorphous materials. Space lattice, Crystal system, Allotropy, Rotational and Reflection Symmetries, stereo graphic projections. Crystalline defects, Twining, Ordered and Disordered solutions. Crystallization; Solidification, dendrites, Grain boundaries, Grain size. Introduction to material characterization tools such as X-Ray diffraction, optical and electron microscopy. Macro vs. Micro.
Review of Thermodynamics, 2-component: Ideal Solution; Regular Solution; Phase Diagrams (Binary system, Ternary system), construction of phase diagram, Phase rules, phase reactions, Diffusion, self-diffusion, Volume and grain boundary diffusion; Fick's 1st Law; 2nd Law, Random Walk; Arrhenius Eq.; Diffusion Mechanisms in metals, semiconductor, polymer and ionic materials; inter-diffusion; Kirkendall Effect; Boltzmann-Matano, depth profiling techniques.

Recommended Books:

1. Physical Metallurgy, 5th Edition, Editors: D. Laughlin, Kazuhiro Hono, 2014
2. Modern Physical Metallurgy, 8th Edition, R.E. Smallman, A.H.W. Ngan, 2013
3. Treatise on Process Metallurgy,1st ed. Editor-in-Chief: Seshadri Seetharama, 2013
4. Materials Science and Engineering Properties by Charles Gilmore, Call Number: TA403 .G55 2015, ISBN: 9781111988609, 2014
5. Physical Metallurgy Principles, 4th Ed. Reza Abbaschian, Lara Abbaschian and Robert E. Reed-Hill, Cengage Learning 2010

INSPECTION AND TESTING OF MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Analyse the stress-strain curve and explain the concepts of various engineering terms	Cognitive	4	2
2.	Select appropriate mechanical testing techniques and analyse data	Cognitive	4	4
3.	Explain the use and limitations of various NDT techniques	Cognitive	2	4

Course Outline:

1. Introduction
   a. Scope and importance of inspection and mechanical testing of materials
2. Hardness Testing
   a. Hardness tests (Brinell, Vicker, Rockwell, Knoop, Scleroscope, Shore hardness), conversion tables for various scales of hardness
3. Universal Testing Machine
   a. Universal testing machine (UTM) its components, working principle and applications, attachments for various mechanical tests
   b. Environmental chamber
4. Analysis of Stress-strain curves
   a. Modulus of elasticity, elastic limit, Yield stress, proof stress, elastic and plastic deformation mechanisms, yield point phenomenon
   b. Modulus of resilience, Toughness, brittleness and ductility.
   c. True stress and strain and curves, Work hardening coefficient
   d. Design stress
5. Tensile testing
   a. Specimen preparation
   b. Effect of strain rate and environment
6. Compression testing
   a. Calculations, Specimen preparation, Applications and limitations
7. Bend testing
   a. Flexural strength and modulus
   b. Calculations, Specimen preparation, applications and limitations
8. Shear and Torsion testing
   a. Calculations, applications, limitations
   b. Sample preparation

10. Fracture
    a. Types of fractures
    b. Basics of Fracture mechanics
    c. Fracture toughness
11. Impact testing
    a. Ductile-brittle transitions
    b. Charpy and Izod impact tests
    c. Drop weight test
12. Fatigue testing
    a. The fatigue test (equipment, specimen and S-N curves),
    b. Different types of fatigue fractures
    c. Goodman diagram
    d. Endurance limit-ultimate tensile strength
13. Creep phenomenon
    a. Stages of Creep
    b. The Creep Test
    c. Stress Rupture Test
14. Non-destructive testing (NDT) of materials
    a. Dye Penetrant
    b. Magnetic particle inspection
    c. Eddy Current
    d. Ultrasonic flaw detector
    e. Radiography
15. Standards
    a. ASTM, ASME, ISO standards for all tests.

Recommended Books

1. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, Inc., 2007.
2. F. Karim, "Testing of Engineering Ceramics and Plastics", Ferozsons (Pvt.) Ltd., 1998.
3. W. F. Smith, "Principles of Materials Science and Engineering", McGraw-Hill, 1995.
4. Courtney,T. "Mechanical Behavior of Materials", McGraw-Hill, 2000.
5. Hertzberg R. W., "Deformation and Fracture Mechanics of Engineering Materials", John Wiley, 2000
6. Collins J.A., "Failure of Materials in Mechanical Design", John-Wiley, 2000
7. Halmshaw R., "Non- Destructive Testing", 2nd ed., Edward Arnold, 2000.
8. Felbeck D.K. and Atkins, A.G., "Strength and Fracture of Engineering Solids", Prentice-Hall, 2000.
9. Hull J.B. and V.B. John, "Non-Destructive Testing", Macmillan, 1988.

Journals/Periodicals

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HEAT TREATMENT

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Select an appropriate heat treatment process to tailor microstructure for a particular application	Cognitive	3	3
2.	Design heat treatment cycle for desired properties	Cognitive	2	3
3.	Explain the construction of transformation diagram and various factors affecting it	Cognitive	2	2

Course outline:

Review of phase diagrams and phase transformations. TTT diagrams, CCT diagrams, Effect of cooling rate, Annealing, normalizing, quenching, quenching media. Oxidation and decarburization during heat treatment. Vacuum and controlled atmosphere heat treatment. Heat treatment furnaces. Martensitic, pearlitic and bainitic transformations. effects of austenizing temperature, grain size and alloying element, Thermo-mechanical treatment, hardenability, Jominy-End-Quench test, Tempering, austempering, martempering. Case hardening; Induction and Flame hardening, carburizing, nitriding, cyaniding, carbonitriding, heat treatment of cast iron, heat treatment of non-ferrous metals and alloys, age hardening/precipitation hardening. Sub-zero treatment. Embrittlement, Secondary hardening. Defects caused during heat treatment and their remedies.

Recommended Books:

1. Eric N. Simpson, “Elements of Heat Treatment”, John Wiley, 2012.
2. Mats Hillert, “Phase Equilibria, Phase Diagrams and Phase Transformation: Their Thermodynamic Basis”, 2nd Ed, 2007
3. L. Dossett and H. E. Boyer, “Practical Heat Treating”, Second Edition, ASM International, 2006.
4. Harry Bhadeshia Robert Honeycombe, “Steels: Microstructure and Properties”, Butterworth-Heinemann; 3rd Edition, 2006.

5. George E. Totten, *Portland State University, Oregon, USA, "*Steel Heat Treatment: Equipment and Process Design*", CRC,* 2006.
6. Totten, G. E., "Steel Heat Treatment", CRC, 2007
7. Krauss, G., "Steels Heat Treatment & Processing", ASM, 2000
8. Martin, J. W., "Precipitation Hardening", IoM, 1998
9. Physical Metallurgy Principles, 4th Ed. Reza Abbaschian, Lara Abbaschian and Robert E. Reed-Hill, Cengage Learning 2010

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PHYSICAL METALLURGY-II

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Interpret phase diagrams in relation to development of microstructure	Cognitive	4	2
2.	Correlate microstructure and properties	Cognitive	4	2
3.	Analyse the nucleation and growth mechanism and distribution of phases	Cognitive	4	2

Course outline:

Phase transformation and control of microstructures, diffusional and diffusionless transformations, interfaces, Interstitial and Substitutional solid solutions, Factors affecting solubility, Hume Rothrey's rules, Intermediate compounds, Iron-carbide Diagram, formation of martensite, bainite, cementite, graphite, pearlite and ledeburite. Microstructure and properties of steels and Cast Irons, Microstructures of Copper based and Aluminum based alloys and their relationship to their properties.

Solidification, cast structure, Segregation, Driving force for phase transformation, Free energy changes, Critical radius. Liquid-solid and solid-solid transformations. Nucleation & growth, homogeneous and heterogeneous nucleation, nucleation on crystalline/non-crystalline defects. Precipitation reactions, GP zones, Intermediate and stable precipitate, Coherency strain, Spinodal decomposition

Recommended Books

1. Physical Metallurgy, 5th Edition, Editors: David Laughlin, Kazuhiro Hono, 2014
2. Modern Physical Metallurgy, 8th Ed. Smallman, A.W. Ngan, 2013
3. Treatise on Process Metallurgy,1st ed**.** Editor-in-Chief: Seshadri Seetharama, 2013
4. Materials Science and Engineering Properties by Charles Gilmore, Call Number: TA403 .G55 2015, ISBN: 9781111988609, 2014
5. Physical Metallurgy Principles, 4th Ed. Reza Abbaschian, Lara Abbaschian and Robert E. Reed-Hill, Cengage Learning 2010

MINERAL PROCESSING

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Comprehend knowledge of minerals in Pakistan, their occurrence, identification	Cognitive	2	12
2.	Select appropriate processing techniques for the beneficiation of minerals and metallic ores	Cognitive	4	3
3.	Demonstrate ore communition and sampling techniques	Cognitive	3	3

Course outline:

Minerals
- Introduction, Classification of minerals
- Physico-chemical properties of minerals
- Identification of minerals
- Mineral resources in Pakistan
- Importance and Significance of Mineral Processing

Mineral deposits and their occurrence
- Igneous process,
- Sedimentary process
- Metamorphic process

Communition
- Introduction to comminution and its objective
- Communition techniques and their selection
- Communition circuit and their importance

Ore Sampling
- Significance of ore sampling
- Estimation of minimum sample size
- Sampling equipment
- Online sampling and its analysis

Particle Size Analysis
- Importance of size analysis
- Size analysis techniques
    - sieve analysis
    - sub-sieve analysis techniques
    - online particle size analysis techniques

Classification
- Principles of classification

- Types of classifiers

Gravity concentration techniques

- Principle of gravity concentration techniques
- Gravity concentrators
- Centrifugal concentrators
- Dense medium concentration and circuit

Magnetic Separation techniques

- Principle of magnetic separation
- Magnetism in minerals
- Types of magnetic separators

Froth Flotation

- Principle of flotation
- Hydrophobic and hydrophilic characteristics of minerals
- Chemical Reagents of flotation
- Collectors, frothers, regulators, flotation machines

Selective flocculation

- Principle of selective flocculation
- Surface potential of mineral particles
- Flocculants
- Mechanism of selective flocculation
- Process and ore variables

Leaching processes

Agglomeration processes

- Sintering
- Briquetting
- Nodulizing
- Pelletizing

Recommended Books:

1. Wills Barry & Napier-Munn Tim, "Mineral Processing Technology", 7th ed**.,** Butterworth-Heinemann, 2006
2. M. C. Fuerstenau, & N. Han, Kenneth "Principles of Mineral Processing". Society for Mining Metallurgy & Exploration, 2003
3. Howard L. Hartman, Jan M. Mutmansky, "Introductory Mining Engineering**",** Wiley; 2nd ed., 2002
4. A. G. Well, " Mineral Processing".
5. Mineral Processing Technology, 8th Edition, Barry A. Wills James Finch, Butterworth-Heinemann, 2015
6. Mineral Processing Plant Design, Practice, and Control, by Andrew L. Mular, Derek J. Barratt and Doug N. Halbe

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IRON AND STEEL MAKING

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain reactions occurring in blast furnace and thermodynamic reasoning of typical composition of pig iron	Cognitive	2	2
2.	Evaluate processing parameters affecting the quality of steels	Cognitive	5	2
3	Illustrate measures required to minimize effects of iron and steel making on environment	Cognitive	4	7

Course outline:

Iron Making

- 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 of the process and charge calculation
- Factors affecting the reducibility and other metallurgical properties of burden
- Environmental considerations
- Wrought Iron and sponge Iron
- Direct reduction processes of iron making

Introduction to steel Making

- Role of steel industry in national economy; CPEC project
- Raw materials for steel making: Hot iron from blast furnace, Pig iron, Direct reduced iron, Steel Scrap, Mills scale, Fluxes, Grain refiners, Ferro alloys
- Types of steel making processes
- Open hearth and Bessemer steel making process
- Electric steel making process (arc and induction)
- Environmental considerations

Modern steel making processes

- Basic oxygen process
- Electric arc steel making process
- Induction and vacuum induction steel making processes

Physical Chemistry of steel making process

- Oxidation, Slag making, Refining

Secondary steel making processes

- Ladle metallurgy
- Removal of gases and nonmetallic inclusions in molten steels
- Vacuum degassing
- Inert gas and synthetic slag treatments for removal of nonmetallic inclusions in molten steel

Solidification of Molten Steel

- Ingot casting, Continuous casting
- Casting defects

Recommended Books

1. C. Bodsworth, “Physical chemistry of iron and steel manufacture”, Prentice Hall, 1972
2. J. G. Peacey, W. G. Daveonport, “ The iron Blast furnace”, Pergamon Press 1979
3. Douglas Alan Fisher’ “Steel Making in America”’ United States Steel Corporation’ 2006
4. Daniel A. Brandt, J. C. Warner, “Metallurgy Fundamentals: Ferrous and Nonferrous”, 5th Edition, 2009
5. Bradley Stoughton, “Metallurgy of Iron and Steel”, McGraw-Hill, 2006
6. James McIntyre Camp, Charles Blaine Francis ”The Making Shaping and Treating of Steels” Carnegie-Illinois steel corporation, 2006
7. Tretyakov, E., “Iron and Steel Production”, Minerva, 2001.
8. Peters, D. “Ferrous Production Metallurgy” Willey
9. Alain Vignes, “Extractive Metallurgy 1: Basic Thermodynamics and Kinetics”, Wiley-ISTE; 1st Edition, 2010.
10. Alain Vignes, “Extractive Metallurgy 2: Metallurgical Reaction Processes”, Wiley-ISTE; 1st Edition, 2011.
11. Alain Vignes, “Extractive Metallurgy 3: Processing Operations and Routes”, Wiley-ISTE; 1st Edition, 2011.
12. Ahindra Ghosh, “Secondary Steel Making”, CRC Press, 2001

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NON-FERROUS METALLURGY

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Demonstrate basic knowledge of nonferrous extractive metallurgy and its significance in national economy	Cognitive	3	1
2.	Select appropriate extraction process for specified nonferrous metal	Cognitive	4	2
3.	Illustrate chemical reactions and thermodynamics involved in an extraction process	Cognitive	4	3

Course outline:

Introduction to Non Ferrous metals

- Nonferrous ore deposits in Pakistan, their occurrence and grade
- Scope & importance of nonferrous extraction activity in Pakistan
- Alloy designations

General extraction processes for nonferrous metallic ores

- Pyrometallurgy
- Hydrometallurgy
- Electrometallurgy

Metallurgy of Aluminum

- Preparation of Alumina and Cryolite
- Production of metallic Aluminum
- Alloys production
- Recovery of other values from Aluminum ores
- Aluminum and its alloys, Properties, Microstructure & applications

Metallurgy of Copper

- Preparation of concentrate
- Production of metallic Copper
    - Roasting
    - Matte smelting
    - Pier Smith converter
    - Top Blown Rotary Converter
    - Fire and Electrolytic refining of Copper
    - Recovery of values such as Gold, Silver, etc.
- Copper and its alloys, Properties, Microstructure and applications

Metallurgy 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 its alloys, Properties, Microstructure and application

Metallurgy of Lead

- Extraction of lead
- Blast roasting of lead concentrate
- Blast furnace smelting of lead bullion
- Recovery of aluminum and other metals from lead concentrate
- Lead and its alloys
- Properties microstructure and applications.

Metallurgy of Magnesium and chromium

- Extraction of magnesium and chromium
- Refining of Magnesium and Chromium and its alloys
- Properties, microstructure and application of Mg and Cr alloys

Metallurgy of Titanium

- Treatment of its ores concentrate
- Production of titanium metal by reduction with Na and Mg
- Titanium and its alloys, properties, microstructure and applications

Extraction, refining and uses of rare earth metals

Extraction, refining and uses of precious metals

Recommended Books

1. M. E. Schlesinger, M. J. King, K. C. Sole and W. G.I. Davenport, “Extractive Metallurgy of Copper”, Fifth Edition , Elsevier, 2011,
2. Daniel A. Brandt, J. C. Warner, “Metallurgy Fundamentals: Ferrous and Nonferrous”, 5th Edition, January 2009
3. Gill, C. B., “ NonFerrous Extractive Metallurgy”, Krieger, 2000
4. Polmear, I. J., “Light Alloys”, Edward Arnold, 2000
5. Balá and Zcaron. P “Extractive Metallurgy of Activated Minerals” Elsevier Science, 2000
6. Mular Andrew L, Barrett, Derek J., and Halbe Doug N., “Mineral Processing Plant Design, Practice, and Control,” Society for Mining Metallurgy & Exploration, 2002.
7. Barry A. Wills, Tim Napier-Munn, “Mineral Processing Technology” Elsevier Science & Technology Books, 2006.
8. T. Rosenqvist. “Principles of Extractive Metallurgy”, Tapir Academic Press, 2004
9. M. C. Fuerstenau and N. H. Kenneth, “Principle of Mineral Processing”, Society for Mining Metallurgy and Exploration, 2003.

ENGINEERING CERAMICS & GLASSES

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Identify different parameters and raw materials used in the processing of ceramics & glasses	Cognitive	1	1
2.	Design the appropriate processing techniques for production of ceramic materials for specific application	Cognitive	2	2
3.	Select a ceramic for specific applications	Cognitive	3	3
4.	Correlate structure and properties of ceramics and glasses	Cognitive	4	2

Course outline:

1. Bonding and structures in ceramics
    a. Structure of ionic and covalent solids (oxides and non-oxides)
    b. Binary compounds and their structures
    c. Ternary compounds and their structures
    d. Important ceramic phase diagrams (alumina, silica, zirconia, magnesia, nitrides, carbides systems etc)
    e. Structure property relationship
2. Raw material and Powder processing
    a. Raw materials selection criteria
    b. Powder production and sizing, wet and dry mixing
    c. selection and effects of various additives
    d. Spray drying, Granulation
    e. Batch calculations
    f. Calcination
3. Shape forming process
    a. Pressing steps, Uniaxial pressing – presses & tools
    b. Iso-static pressing, Casting: slip casting, tape casting, Hydroplastic forming: Extrusion, Injection molding, gel casting, green machining
4. Densification and sintering/firing
    Sintering and its different stages, different mechanisms of sintering, sintering parameters, sintering problems, modified densification processes: over pressure sintering, hot pressing, hot isostatic pressing, microstructure evolution in sintering

5. Finishing
   Machining, Coloring, Glazing
6. Glasses
   a. Structural theories of glasses, Glass melting: Raw materials, compositional nomenclature, batch calculations, mechanisms of batch melting, fining of melts, homogenization of melts
   b. Forming methods: container glasses, flat glasses, tubing and rods, solid & hollow glass spheres, optical fibers, porous glass
7. Refractories
   Types, properties and applications
8. Applications
   a. Tiles, sanitary and insulator, cements
   b. Oxygen sensors, solid oxide fuel cells, Na/S rechargeable batteries
   c. Traditional vs advanced ceramics

Recommended Books

1. David Richerson, "Modern Ceramic Engineering: Properties, Processing, and Use in Design, Third Edition", CRC Press; 3 editions, 2005.
2. W. Rayan, "Properties of ceramic raw materials" 2nd ed, Pregamon Press 1978
3. W.E. Worrall, "Ceramic Raw Materials", Pregamon Press, 1982
4. James F. Shackelford (Editor), Robert H. Doremus, "Ceramic and Glass Materials: Structure, Properties and Processing", Springer; Softcover reprint of hardcover 1st ed. 2008 edition, 2010.
5. Kingery, Bowen, Uhlmann "Introduction to Ceramics" Wiley, 1976
6. Rice, R.W., "Ceramic Fabrication Technology", Marcel Dekker, 2003
7. Bengisu, M., "Engineering Ceramics", Springer, 2001
8. Terpstra, R. A., Pex, P. P. A. C. and de Vries, A. H., "Ceramic Processing", Chapman & Hall, 1995
9. Lee, W.E. and. Rainforth, W.M., "Ceramic Microstructures: Property Control by Processing", Chapman and Hall, 1994
10. Rawson H "Glasses and their Applications", Royal Institute of Metals, London 1991
11. J.E. Shelby "Introduction to glass science and technology" Royal Society of Chemistry, 2nd Edition, 2005

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MANUFACTURING PROCESSES

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain the manufacturing process	Cognitive	2	2
2.	Select tool(s) required to produce component of required shape	Cognitive	3	5
3.	Design post manufacturing process	Cognitive	6	3

Course outline:

Basic concepts of manufacturing and types of manufacturing processes. Materials and process selection: forging and its types, rolling, extrusion, forming methods, shearing, blanking, bending, stretch forming, shear forming, flow turning, deep drawing and incremental forming, upsetting, drawing of rods, wires, machining of materials. Machining operations for special geometries and high-speed machining, cutting tools and coolant selection. Post manufacturing processes to achieve desired properties, Advanced manufacturing processes, Electro-discharge machining (EDM), CNC machining, Rapid prototyping, micro/nano-fabrication and lithography, injection and blow moulding. Iso-static pressing

Recommended Books:

1. M. P. Groover, Introduction to Manufacturing Processes, Wiley, 2011
2. Kalpakjian and Schmid, " Manufacturing Processes for Engineering Materials" Prentice Hall, 5th Edition 2007
3. Creese, R. C., "Introduction to Manufacturing Processes and Materials", Taylor and Francis, 1999
4. Ashby, M. F. and Jones, D. R. H., "Engineering Materials-2", Pergamon, 2005
5. Hwaiyu Geng, "Manufacturing Engineering Handbook", McGraw-Hill, 2004
6. Dieter, G. E., "Mechanical Metallurgy", McGraw-Hill, 2000
7. Paul De Garmo, Mlack, and Kohsar, "Processing Methods in Manufacturing", Prentice Hall, USA, 2000

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POLYMERIC MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain various types of polymers and their applications	Cognitive	2	1
2.	Compare and contrast various processing techniques for polymers	Cognitive	4	3
3.	Analyse different physical and mechanical properties of polymers using characterisation techniques	Cognitive	4	5
4.	Illustrate the impact of polymers on the environment and remedies	Cognitive	4	7

Course Outline:

- Polymer chemistry, polymerisation, co-polymerisation, vulcanisation, kinetics of polymerisation. Polymer blending and compounding
- Structure, properties (mechanical, thermal, chemical) and applications of thermoplastic and thermosetting polymers, elastomers and rubber, additives, adhesive and fillers. Mechanism of polymer deformation. Thermal transition in polymers. Polymer crystallinity.
- Polymer processing: Iinjection molding, Blow Molding, Compression Molding, Film Insert Molding, Gas Assist Molding, Rotational Molding, Structural Foam Molding, Thermoforming, extrusion, spinning, etc.,
- Polymer testing and characterization; molecular weight determination, rheology, DSC, TGA, UTM, Shore hardness, etc.
- Advanced polymers (e.g. conducting, smart and bio degradable polymers).
- Degradation of polymers
- Environmental considerations

Recommended Books

1. McCrum, N. G. and Buckley, C., “Principles of Polymer Engineering”, OUP, 2002
2. Rodriguez, F., “Principles of Polymer Systems”, 5th ed., McGraw-Hill, 2003.

3. Rodger, Brendan, “Rubber Compounding: Chemistry and Applications”, Taylor and Francis, 2004
4. Margolis J. M. “Conductive Polymers and Plastics”, Chapman & Hall, 1989.
5. Mills, N. J., “Plastics: Microstructure, Properties and Applications”, Arnold, 1993
6. John W. Nicholson – 2011/ Royal Society of Chemistry “The Chemistry of Polymers”
7. Linda C. Sawyer, David T. Grubb, Gregory Frederick Meyers / 2008/ Springer, Polymer microscopy
8. “Smart Polymers and their Applications”, Edited by Maria Rosa Aguilar and Julio San Roman, Woodhead Publishing Limited, 2014.

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COMPOSITE MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Comprehend the basic knowledge of natural and synthetic composites	Cognitive	2	1
2.	Relate the processing, structure and properties of composites	Cognitive	4	2
3.	Solve material selection problems in terms of adopting alternative approach to materials	Cognitive	3	3

Course Outline:

- Introduction to Composite materials; Advantages and limitations of composites over monolithic materials
- Natural composites and their applications, mimicking of natural composites. Wood, types of wood, applications of wood, advances in synthetic wood. Termite resistant wood and moisture resistant wood
- Properties, applications and manufacturing of fibers and other reinforcements
- Mechanics of composites, Filler distribution (particulate, laminate, fiber-reinforced etc.), Mechanical, thermal, physical properties and applications.
- Processing of Metal matrix composites MMCs), stir casting, rheo casting, melt infiltration, in-situ synthesis etc.
- Processing of Polymer matrix composites (PMCs), Filament winding, compression moulding, pultrusion etc.
- Processing of Ceramic matrix composites (CMCs) and Carbon-carbon composites, etc.
- Particulate composites
- Structural and hybrid composites
- Testing and characterization of composites
- Nanocomposites

Recommended Books:

1. Ronald F. Gibson, “Principles of Composite Material Mechanics”, 3rd ed, September 2011
2. Ever J. Barero, “Introduction to Composite Materials Design”, 2nd ed, July 2010

3. Mathew and Rowling ‘Composite Materials’ Woodhead Publishing, 1999
4. Deborah D L Chung, “Composite Materials”, Springer, 2003
5. Charles E. Bakis, “Composite Materials”, ASTM International, 2003
6. Hull, D. and Clyne, T. W., “Introduction to Composite Materials”, CUP, 1996
7. K. K. Chawla “Composite Materials Science and Engineering’ Springer 2001

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ADVANCED MATERIALS AND NANOTECHNOLOGY

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain properties & applications of advanced materials	Cognitive	6	3
2.	Illustrate processing and characterization on different types of advanced materials	Cognitive	4	3
3.	Describe the characteristics and use of various types of nanomaterials and devices	Cognitive	5	2
4	Comprehend the environmental and safety issues associated with new materials	Cognitive	2	7

Course outline:

- Introduction: Functionally graded materials, Smart materials, Optical materials, Semiconductors, Superconductors, advance steels and bulk metallic glasses (BMG) etc.
- Biomaterials: Biocompatibility, Basic chemical and physical properties of biomaterials, Advanced dental materials, Metallic implants, Bioceramics, and biopolymers polymers, In-vitro and vivo testing concepts, Role of microstructure properties in the selection of biomaterials and design of artificial organs, implants, and prostheses.
- High Temperature Materials, superalloys, refractory metals and alloys, Intermetallics, ceramics, carbon-carbon composites
- Nanotechnology**:** Nanomaterials, Classification and properties of nanomaterials, synthesis and characterization of nanomaterials, safety and environmental considerations, Nanofabrication, Processing of nanomaterials, application of nanomaterials and nanodevices
- Advanced Alloying: mechanically alloyed metals, ODS alloys
- Energy Materials: Basics of energy materials, Types of energy materials, Fuel cell materials for hydrogen storage

Recommended Books:

1. Dieter Vollath, Nanomaterials: An Introduction to Synthesis, John Wiley & Sons, 2013.
2. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2012.
3. A. K. Haghi, Ajesh K. Zachariah, Nandakumar Kalariakkal, Nanomaterials: Synthesis, Characterization, and Applications, CRC press, 2013
4. Bruce, Dalton, Nelley, Kibbe, Modern Materials and Manufacturing Processes, Prentice Hall 3rd Edition 2003.
5. Scott A Guelcher and Hollinger, Jeffrey O., "An Introduction to Biomaterials", Taylor and Francis, 2005
6. Charles P. Poole Jr. and Frank J. Owens, "Introduction to Nanotechnology", Wiley-Interscience, 2003
7. Van de Voorde, M. H. and Meetham, G. W., "Materials for High Temperature Engineering Applications", Springer, 2000
8. Edelstein, A. S. and Cammarata, R. C., "Nanomaterials: Synthesis, Properties and Applications", IoP, 2001
9. Donachie, M. and Donachie, S., "Superalloys: A Technical Guide**",** IHS , 2002
10. Park, Joon B. and Bronzino, Joseph D., "Biomaterials: Principles and Applications", Taylor and Francis, 2002
11. Nenov, T. G., Yordanov, S. R., "Ceramic Sensors", Technomic, 1996
12. Mechanical Alloying 2nd Edition, (Nanotechnology, Materials Science and Powder Metallurgy). M. Sherif El-Eskandarany, 2015
13. Light Alloys 5th Edition, (Metallurgy of Light Metals), Ian Polmear, David St John, Jian-Feng, Nie Ma Qian, 2017)
14. The Science of Armour Materials, 1st Edition, Ian Crouch, 2015
15. Chemistry and Physics of Modern Materials by A. K. Haghi (Editor); P. M. Sivakumar (Editor); Nazmul Islam (Editor); Jimsher N. Aneli (Editor); Alfonso Jimenez (Editor); Stefan Kubica (Editor) 2013
16. Introduction to Nanofiber Materials by Frank K. Ko; Yuqin Wan, Call Number: Electronic Book, ISBN: 9780521879835, Publication Date: 2014-07-31

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FOUNDRY ENGINEERING

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

Ser	CLO	Domain	Taxonomy level	PLO
1.	Explain the process of melting, casting and cast iron making	Cognitive	2	1
2.	Compare and contrast casting technique for specified metal	Cognitive	4	3
3.	Summarize the casting defects and their remedies	Cognitive	5	4

Course outline:

Introduction to Foundry Engineering and Practice

- Scope and importance of the foundry
- Foundry industry in Pakistan
- Types of foundries

Foundry plant layout

- Tooling, equipment, machines and types of furnaces
- Selection of suitable moulding and core materials
- Properties & testing of moulding and core materials

Pattern

- Types and design of pattern
- Pattern making
- Shrinkage, dragging, contraction and machining allowances
- Pattern materials
- Pattern for machine molding
- Use of computer aided design (CAD) and CAM

Moulding Processes

- Green sand molding and Dry sand molding
- Shell molding
- Core sand molding
- CO_2 molding process
- Molding sand properties and characterization
- Pit and floor molding
- Loam molding
- Cement bonded sand molding
- Molding machines and equipment
- Special additives of molding sand
- Mold cavity coatings

Moulding Cores

- Ingredients and Properties of core sand
- Binders of cores
- Core making, baking and finishing
- Core setting
- Testing of core sands
- Core coatings.

Mould designing

- Elements and Design of gating system
- Essentials of getting system
- Characteristics of gates
- Pouring cups sprue
- Types of runners and gates
- Gating ratio
- Pressurized and un-pressurized gating system
- Riser design and its primary function
- Riser shape and size with reference to casting geometry
- Location of riser

Melting furnaces

- Gas fired Pit furnace
- Cupola furnace
- Rotary furnace
- Induction and Arc melting furnace
- Furnace and ladle Refractories

Foundry Castings

- Ferrous and nonferrous casting techniques
- Selection and control of melting processes
- Control of chemical compositions
- Casting and fettling operation
- Metal gas interaction

Casting defects

- Defect types
- Causes of defects and their remedies
- Inspection and quality assurance

Modern foundry techniques

- Gravity die casting
- Pressure die casting
- Centrifugal casting
- Investment casting
- Application of Solid cast and Magma software for modelling and simulation of solidification behavior of casting.

Solidification

- Introduction
- Freezing of pure metal

- Solidification in a mold
- Nucleation and growth
- Directional and non-directional solidification

Casting Cleaning and Inspection

- Rough cleaning i.e. flogging, mechanical cutoff, gas torch cutting, surface cleaning by tumbling, blasting, etc.
- Visual, radiography inspection
- Dimensional inspection
- Dye penetrant testing
- Identification and characterization of micro cracks

Family of Cast iron

- Types of Cast irons
- Production of various types of cast irons
- Properties and applications of various types of cast irons

Recommended Books:

1. John Campbell, “Complete Casting Handbook - Metal Casting Processes, Techniques and Design”, Butterworth-Heinemann 2011
2. Peter, Beeley “Foundry Technology”, Butterworth-Heinemann; 2nd Edition, 2000
3. Chastain Stephen D, “Metal Casting,” Chastain Publishing, 2003
4. Brooks. Nick, “Mould making and Casting” Crowood Press, 2005
5. Campbell. John, “Castings” Butterworth-Heinemann; 2nd Edition, 2003.
6. Chastain. Stephen D, “Iron Melting Cupola Furnaces for the Small Foundry” Stephen D. Chastain, 2000
7. P. Beeley. “Foundry technology”, Betterworth-Heinemann, 2001
8. J. R. Brown, “The Foseco Non ferrous foundryman’s Hand Book, 11 th edition, 1999
9. J. R. Brown, “The Foseco ferrous foundryman’s Hand Book, 10th edition, 1999

Journals/Periodicals
World Wide Web

JOINING OF MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Compare and contrast various joining techniques	Cognitive	4	2
2.	Analyse metallurgical changes occurring in joining of materials	Cognitive	4	4
3.	Select a joining process for a given situation	Cognitive	3	3

Course outline:

Introduction to Joining

- Classification of joining processes
- Application of welding and joining, Brazing, Soldering, Riveting and fastening processes and other processes in manufacturing
- Safety in Welding and Joining

Welding processes

Introduction, principles, parameters, defects and equipment for

- Arc Welding
- Gas Metal Arc Welding (GMAW)
- Metal Transfer in GMAW
- Gas Tungsten Arc Welding
- Flux Cored Arc Welding
- Submerged Arc Welding(SAW)
- Role of Flux in SAW
- Oxy-Acetylene Welding/cutting
- Under water welding
- Resistance welding
- Friction stir welding
- Electro-slag welding
- laser welding
- electron beam welding
- plasma welding/cutting
- Thermit welding
- Explosive welding

Design of welded joints

- Type of joints
- Types of welds

- Fundamentals of engineering analysis of heat flow, thermal and residual stresses
- fracture and fatigue with applications to design and simulation in welding

Welding Qualifications and Testing

- selection of appropriate welding process,
- welding procedure specification sheets (WPS),
- procedure qualification records(PQR),
- Welding Defects
- Inspection and testing of weldments with reference to international codes and standards (AWS, ASME, etc.)

Welding Metallurgy

- Effect of Heat on Metals, Pre-heating, Stress- Strain and Weldability
- Fundamentals of Welding Metallurgy of Steels
- Welding of Carbon Steels
- Low, Medium and High Alloy Steels
- Aluminum and its alloys
- Magnesium and its alloys
- Titanium and its alloys
- Nickel based alloys
- Joining of dissimilar materials

Joining of Dissimilar Metals

Brazing:

- Scope and limitations.
- Types and processing of brazing alloys
- Brazing of commercially important ferrous and non ferrous metals and alloys

Soldering:

- Process involved in soldering
- Soldering alloy
- Application of soldering techniques

Mechanical Fastening

- Screw Joints
- Riveted Joints
- Joining by Folds and clinching

Friction stir Welding

- Process
- Tools and other parameters

Joining of Polymers and Composites

- Hot tool welding
- Hot gas welding
- Extrusion welding
- Induction welding

- Resistance welding
- Ultrasonic welding
- Vibration welding
- Spin welding
- Infrared/laser welding
- Dielectric welding
- Microwave welding
- Adhesive bonding

Recommended Books

1. CASTI Guidebook to ASME Section IX- Welding Qualification, CASTI guidebook Vol 2, Third Edition(covering 2001 code edition), M. J. Houle, R.D. McGuire, CASTI publishing Inc., (available online at http://www.wes.ir/files/2326318welding%20qualification.pdf)
2. Joining of Plastics: Handbook for Designers and Engineers, Jordan Rotheiser, Hanser Publishers, 2004
3. Easterling, K., "Introduction to the Physical Metallurgy of Welding", Butterworth-Heinemann, 2000
4. Lancaster, J. F., "Metallurgy of Welding", William Andrew, 1999
5. Robert W. Messler Jr. "Joining of Advanced Materials", Butterworth Heinemaan, USA
6. Tiku, G. L., "Manual on Joining Processes by Welding, Brazing and Soldering**"** Minerva Press, 2003
7. Thomas Böllinghaus and Herold. Horst, "Hot Cracking Phenomena in Welds" Springer; 1st ed., 2005
8. Creative Publishing International, "Welding Basics**"** Creative Publishing International, 2003
9. R. W. Messler, "Joining of Materials and Structures: From Pragmatic Process to Enabling Technology", Butterworth-Heinemann; 1st Edition, 2004.
10. Sindo Kou, "Welding Metallurgy", Wiley-Interscience; 2nd ed. 2002
11. Rajiv S. Mishra, Murray W. Mahoney, " Friction Stir Welding and Processing" , ASM International, 2007

Journals/Periodicals
World Wide Web

CORROSION ENGINEERING

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Determine corrosion type and estimate corrosion rate under various circumstances using standard corrosion equations	Cognitive	4	4
2.	Analyse effects of passivity and polarization on corrosion behavior of metals using their polarization curves and data.	Cognitive	4	2
3.	Suggest and apply the most suitable corrosion protection technique like cathodic protection, anodic protection, type of coating, inhibitors and alteration in environment	Cognitive	5	7
4	Propose the correct combination of alloys, design and operation conditions in order to minimize the corrosion rate in new installations	Cognitive	4	3

Course Outline:

Introduction and basic definitions, Economic impact and cost of corrosion damage, EMF series and Free energy concepts, Galvanic series, Nernst Equation & its applications, Reference electrodes, Electrochemical Cells and their types, Corrosion rate expression and its units, Atmospheric corrosion, Types of corrosion such as uniform corrosion, Galvanic corrosion, Intergranular corrosion and sensitization, Crevice corrosion, Pitting, Erosion corrosion, Cavitation damage, Fretting, Hydrogen embrittlement, Stress corrosion cracking, selective leaching, Corrosion fatigue, Passivation, Pourbaix diagrams, Polarization and its types, Exchange current density, Kinetics of Electrochemical reactions, Evans diagrams and "E-log i" plots, Tafel equations, Mixed potential theory. Corrosion control by appropriate materials selection, Corrosion control by design, corrosion control by Inhibitors, their types and protection mechanism, Cathodic protection & design of CP system, Anodic Protection, Basic introduction to protective coatings. Corrosion testing (weight loss method, salt spray tests, electrochemical methods,

corrosion testing in soils, galvanic corrosion test, intergranular corrosion test, crevice corrosion test. High temperature corrosion.

Recommended Books:

1. Pierre Roberge, Handbook of Corrosion Engineering 2/E, McGraw-Hill Professional 2012
2. Revie and Uhlig “Corrosion and Corrosion Control” Wiley 4th Ed. 2008
3. Fontana, M. G., “Corrosion Engineering”, McGraw-Hill, 2005
4. I.H.Khan, Corrosion Technology, Vol.1,2, Institute of Chemical Engineering, University of Punjab, Lahore, Pakistan
5. Einar Bardal, Einar Bargal, “Corrosion and Protection”, Springer, 2004
6. Helmut Kaesche, “Corrosion of Metals”, Springer, 2003
7. Mansfeld., Florian, “Analytical Methods in Corrosion Science and Engineering”, CRC, 2005
8. Jones D.A., “Principles and Prevention of Corrosion”, Macmillan, 1996

Journals/Periodicals
World Wide Web

DESIGN AND SELECTION OF MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain use of various resources available for the design and selection of materials.	Cognitive	3	3
2.	Design or select Material using modern tools	Cognitive	3	5
3.	Design or select a product with multiple constraints and conflicting requirements	Cognitive	5	7
4.	Work as a team member on a relevant project and present the findings	Affective	A-4	9

Course outline:

1. Introduction – Materials and design
   Materials design, the design process, types of design, design tools and materials data. Function, material, shape and process

2. Elements of materials selection
   Materials information for design, material property charts, selection strategy, attribute limits and material index, the selection procedure, computer-aided selection, Material selector, materials data resources (ASM, ASME standards and codes references, websites) the structural index. Effect of process on properties and cost

3. Constraints and conflicting objectives
   Selection and multiple constraints, conflicting objectives. Material life-cycle and its assessment, sustainability. Case studies

Recommended Books:

1. Michael F. Ashby, "Materials Selection in Mechanical Design, 4th Edition", Butterworth-Heinemann; 2010.
2. Michael F. Ashby, Hugh Shercliff and David Cebon, "Materials 3e North American Edition w/Online Testing: Materials - North American Edition, Second Edition: engineering, science, processing and design, Butterworth-Heinemann; 2nd ed. 2009.
3. Michael F. Ashby, "Materials and the Environment: Eco-informed Material Choice", Butterworth-Heinemann; 1st Edition, 2009.

4. Lawrence W. Fisher, P. E, “Selection of Engineering Materials and Adhesives”, Volume: 186, CRC Press, 2005,
5. Hummel, Rolf E. “Understanding Materials Science: History, Properties, Applications”, 2nd Edition, Springer, 2005, Joseph Datsko, “Materials Selection for Design and Manufacturing: Theory and Practice”, CRC Press, 1997,
6. M. F. Ashby, Kara Johnson, “Materials and Design: The Art and Science of Material Selection in Product Design”, Elsevier Science, 2002, CES 2011 EduPack Software.
7. National Research Council (USA) “Computer Aided Materials Selection” National Academies Press 1995

Journals/Periodicals
World Wide Web

INSTRUMENTATION AND CONTROLS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Explain the working principles of various techniques and sensors	Cognitive	2	1
2.	Compare various measuring techniques and their limitations and select appropriate instrument for given task	Cognitive	4	3
3.	Comprehend process automation	Cognitive	2	2

Course outline:

1. Introduction
    - Importance of IPC in Science and Engineering fields.
    - Basic Concepts about instrumentation and process control
2. Basic measuring instruments and their principles
    - Design and working of instruments especially for Indicating and Recording Length, Weight, Volume, Temperature, Pressure, Vacuum, Flow, Levels etc.
    - Conductivity meter, pH meter, multimeter, pyrometer, tacometer and clampmeter
    - Coordinate measuring machine
    - Errors, and factors affecting their precision and accuracy
    - Calibration and calibration standards
3. Various sensors, gauges and their materials
    - For the measurement of temperature, pressure, vacuum, flow, displacement, depth, position, etc.
4. Various process systems
    - Introduction to Principles of Automatic Control Systems Encountered in Engineering
    - Open-loop and Closed Loop System
    - Feedback control
    - Mode of Operations of Hydraulic, Pneumatic, Electrical Components
    - Amplifier Servomotors
    - Process Controller
    - Regulating Valves
    - Response and Transfer Functions of First-Order Systems along with Physical Examples of First-Order Systems

- Systems in Series
- Cascade systems
- Block Diagram of Control System Control Element
- Time Constant of Different Physical Systems
- Control Values On-Off Control Pneumatic and Solenoid Value of Control System.

Recommended Books:

1. D. R. Coughanowr, "Process Systems Analysis and Control", McGraw-Hill, 1991.
2. J. M. Coulson and J. F. Richardson, "Coulson & Richardson's Chemical Engineering", Butterworth-Heinemann, 2007.
3. J. Park, S. Mackay, “Instrumentation and Control System”, Newness, 2003.
4. W. Boyes, “Instrumentation Reference Book”, Elsevier, 2003

Journals/Periodicals
World Wide Web

Elective Courses in Major Based Core Depth
See Annex - B

SENIOR DESIGN PROJECT PART-I
SENIOR DESIGN PROJECT PART-II

Specific Objectives of Course:

To provide students learning of research techniques used in the industry.

Course Outline:

Selected problems from the industry and current materials research issues regarding selection processing, designing, manufacturing and development. Fabrication of prototype/models and laboratory experimentation shall be assigned to individual students/ Grading shall be the reports produced by individual students and their evaluation through an oral examination

Experimental work will be carried out in the relevant laboratories/industry according to the nature of the project.

List of Experiments

#	Lab #	Experiment
First Year (1st and 2nd Semester)		
1	I	Identification of Engineering Materials
2	I	Materials for Electronic and Engineering Applications
3	I	Atomic Packing in Crystals
4	I	Crystallography - Work Sheet
5	I	Solidification and Casting of Metals
6	I	Preparation of Metallographic Specimens for Microscopy
7	I	Determination of Young's Modulus of wood and steel.
8	I	Hardness of Engineering Materials
9	I	Impact Tests for Engineering Materials
10	I	Tensile testing of metals.
11	I	Mechanical Properties - Work Sheet
12	I	Creep in Materials
13	I	Oxidation of Metals
14	I	SEM –A Demonstration
15	I	Processing of Ceramics
Second Year (3rd and 4th Semester)		
16	II	International standards for evaluation of the engineering. Materials(exercise/worksheet)
17	II	Tensile test of engineering materials
18	II	Hardness test of engineering materials
19	II	Compression test of metals/alloys
20	II	Notched bar impact test of the engineering materials
21	II	Creep test of the engineering materials
22	II	Torsion test of engineering materials
23	II	Liquid penetrant testing
24	II	Magnetic particle testing -1
25	II	Magnetic particle testing -2
26	II	Ultrasonic testing-1
27	II	Ultrasonic testing-2
28	II	X-ray radiography of the materials

29	III	Specimen Preparation for Metallography (brass, MS, Aluminium)
30	III	Specimen Preparation & Observation of Microstructures (cast iron, quenched, annealed and normalized structures of MS)
31	III	Atomic Packing of Planes and Miller Indices
32	III	Symmetry Contents of Letters, Motifs and common Objects
33	III	Metallography (Quantitative Analysis)
34	III	Stereographic Projections (geometric exercises)
35	III	Introduction to XRD Technique & Equipment * + Rolling Video
36	III	Carburizing (diffusion of carbon into the surface of MS)
37	III	Obtaining Diffraction Pattern from a known Material & Interpretation of Results
38	III	X-Ray Diffractometery & Determination of Crystal Structure
39	III	Structure Factor Calculations for Simple Cubic, FCC, BCC
40	III	Obtaining Diffraction Pattern from a Known Mixture of Two Materials
41	III	Identification of an Unknown Material by X-Ray Powder Diffraction Film
Third Year (5^{th} and 6^{th} Semester)		
42	IV	Size distribution of foundry sand.
43	IV	Annealing, normalizing and quenching and tempering of steel.
44	IV	Identification of polymers using various chemicals and physical methods.
45	IV	Injection moulding of polymers.
46	IV	To study the atomic arrangement, lattice defects and deformation behaviour using a bubble raft model.
47	IV	Testing of moulding sand.
48	IV	Casting by split and single piece patterns.
49	IV	To study the effect of annealing, normalizing and quenching and tempering on tensile properties of mild steel.
50	IV	To study the effect of cooling media on the structure and hardness of steel.
51	IV	Anisotropy in tensile properties of deformed materials.

52	IV	Recovery, recrystallisation and grain growth
53	IV	Tensile test of polymeric materials.
54	IV	Casting of a metal / alloy using centrifugal casting process.
55	IV	To study the effect of strain rate on tensile strength of different polymers.
56	IV	Age hardening behavior of alloys.
57	IV	Strain aging behavior of mild steel.
58	IV	Intercritical heat treatment of mild steel.
59	IV	To study the effect of embrittlement in steel and cast iron by notched bar impact test.
60	IV	Determination of Tg and Tm of polymers.
61	IV	Casting of metals using carbon dioxide-sodium silicate process for mold making.
62	IV	Autempering of steel.
63	IV	Analysis of polymers using Fourier Transformed Infra-red Spectroscopy.
64	IV	Jominy end quench hardenability test.
65	IV	Fatigue test of mild steel.
66	IV	Study of Investment casting process and casting a metal / alloy.
67	V	Casting and Microstructural examination of lead-tin alloys.
68	V	Electrowining of Copper From CuSO solution.
69	V	Cast and Rheocast Aluminum alloys, properties and microstructures
70	V	Cold rolling of Aluminium strips and study of properties and microstructures of cold rolled and annealed samples.
71	V	Hot and cold rolling of copper plate, study of properties and microstructures of rolled plate.
72	V	Introduction to CNC machining
73	V	Demonstration of gas Welding and gas welding of mild steel.
74	V	Gas Welding of Aluminium.
75	V	Soldering and brazing of copper.
76	V	Shielded metal electric arc welding of mild steel, its microstructural examination and properties.
77	V	Welding of stainless steels, study of microstructures

		and X-ray radiography of the weldments.
78	V	Milling and Characterization of alumina powder.
79	V	Demonstration of high temperature furnace and sintering of alumina compacts
4th Year (7th and 8th Semester)		
80	VI	Part A: Determination of corrosion rate through weight loss method.
81	VI	Part B: Cathodic Protection of Mild Steel using Zinc as Sacrificial Anode
82	VI	Applications of Thermistors and Determination of Temperature – Resistance characteristics of thermistors
83	VI	Hand Lay Up Process of Polymer Matrix Composite Materials
84	VI	Part A: Compiling galvanic series of different metals and alloys using Zero Resistance Ammeter (ZRA).
85	VI	Part B: Measurement of pH of different electrolytes using pH Meter
86	VI	Use of Thermocouples: Comparison of Temperatures in a Tube Furnace with and without Shielding
87	VI	and with Temperatures Indicated by the Controller.
88	VI	3 Point Bend Test of Polymer Matrix Composite Materials
89	VI	Potentiodynamic study of mild steel in 3.5% NaCl solution using Research Potentiostat and Sweep Generator
90	VI	Diodes: Materials Use, Application and Forward Biased and Reverse Biased Characteristics of Silicon and
91	VI	Germanium Diodes
92	VI	Mixing and cold pressing of Aluminium and Aluminium - Silicon Carbide (e.g. Al - SiC) powder.
93	VI	Selective Leaching of Brass and Microstructural Examination
94	VI	Vibrating Sample Magnetometer (VSM) for Magnetic Properties.
95	VI	Part A: Sintering of Aluminium and Aluminium - Silicon Carbide composite Material.
96	VI	Part B: Tensile Testing of Polymer Matrix Composite Materials.
97	VI	Electrochemical studies of mild steel using Gamry Instruments. Measurement of dissolved oxygen using dissolved oxygen (DO) meter
98	VII	Part (A): Examination and Testing of Copper Powder.

99	VII	Part (B): Production of Metallic Powders by Using Different Techniques.
100	VII	Part A: Particle Size Analysis of Copper Powder by Using Particle Size Analyser
101	VII	Part B: Liquid Phase Sintering of Copper-Aluminium System.
102	VII	Part A: Effect of different Environments on Sintered Properties of aluminium compacts.
103	VII	Part B: Microstructural Examination of Solid/Liquid Phase copper/copper-aluminium compacts.
104	VII	Production of metallic foam using powder metallurgy methods.
105	VII	Sintering of SiC using high temperature furnace.
106	VII	An Introduction to Automobile Materials.
107	VII	Power Cables: Applications, Types and Material Selection.
108	VII	Materials, components and working of optical fibres
109	VII	Part A: Electric Motors: Working Principle, Types, Different Parts, and Materials used.
110	VII	Part B: Determination of resistance characteristics of thermistors with temperature, its materials and applications.
111	VII	Use of software for application and selection of engineering materials.
112	VII	Measurement of electrical conductivity at low temperatures.
113	VII	Characterization of materials using TGA.
114	VII	Characterization of materials using UV-Vis.
115	VII	Hall effect in P-Germanium
116	VII	Use of Thermocouples: Comparison of Temperatures in a Tube Furnace with and without Shielding
117	VII	Part A: Transistors: Types, parts, materials use and application of transistors
118	VII	Part B: Input and output characteristics of NPN bipolar junction transistor in common emitter configuration.

Graduate Programme

MS Degree Programme in Metallurgy and Materials Engineering

The MS Program in Materials Engineering is diverse enough to cover the wide range of areas of active research and field of specialization such as advanced materials, manufacturing, metallurgical processes, structural properties, new materials, biomaterials and nanomaterials. The criteria and outline of courses are described for adoption as per HEC guidelines.

MS Degree Programme 4-Semester Duration (02 Years)

Option 1:
Course Work: 24 CH
MS Thesis: 6 CH
Total CH: 30

Option 2:
MS Course work: 30 CH

Core courses are mandatory for MS degree in Materials Engineering.

Minimum 3 of the Core Courses are required:

Course Name	Credit Hours
Materials Thermodynamics	3
Mechanical Behaviour of Materials	3
Phase Transformations	3
Open (depending on the choice of the institute/ department)	3

Elective Courses:

Minimum Four (4) Courses may be selected from the list given below:

Course Title	Credit Hours	Course Title	Credit Hours
Theory of Dislocations	3	Thin Film Technology	3
Fracture mechanics and Failure Analysis	3	Surface analysis and characterization	3
Metal Forming	3	Tribology Engineering	3
Thermo-mechanical Processing	3	Advanced Coating technology	3
Micro structural Control	3	Carbon Materials	3
Advanced Manufacturing Systems	3	Polymer Science and Engineering	3

Advanced Joining Technology	3	Advanced Ceramics Engineering	3
Nanomaterials	3	Electronic Materials	3
Smart Materials	3	Magnetic Materials	3
Nanotechnology	3	Optical Materials	3
Synthesis and Design of Nano structures and Devices	3	Nanomaterials and Computer Aided Nano-design	3
Advances in Extractive Metallurgy	3	Advanced Composite Materials	3
Solidification	3	Electron Microscopy	3
Advance Characterization Techniques	3	X-Ray Diffraction and Texture Studies	3
Modern Steels and Processes	3	Powder Metallurgy	3
Biomaterials	3	Computational Materials Engineering	3
Corrosion monitoring and prevention	3	Mathematical Methods in Engineering / Computational Methods for Engineers	3
Surface Science and Engineering	3	Industrial Management	3
Nuclear Waste Management	3	Radiation shielding materials	3
Wood and Paper materials	3	Aerospace materials	3
Advanced mineral processing	3	Satellite Materials and Technology	3
Rare earth materials	3	Electrochemistry	3
Research Methodology	3	Quality management systems	3
Modelling of Material Processing	3	Nano scale characterization	3
Leather and textile materials	3	Advanced manufacturing Techniques	3
Solid state chemistry	3	Solid state Physics	3

Interfaculty Electives:

- Student may have option to register one Interfaculty course.

RECOMMENDATIONS

The committee is of the view that the field of Metallurgy and Materials Science and Engineering largely contributes to the socio-economic development of the nation and supports the industry and R&D institutions. In this regard, following recommendations are made:

1. The Universities should be facilitated to impart quality education and produce engineers who are capable to undertake research and industrial assignments and pursue higher studies.

2. The curriculum designed should guide the universities and relevant departments offering this program to meet the minimum benchmark for the Bachelor and Master degree programmes in Metallurgy and Materials Engineering.

3. Keeping in view the mineral resources of the country, the higher education institutions should be encouraged and supported by the Government to initiate research programmes to facilitate mineral upgradations and value additions including extraction of metals.

4. Universities should have plan for providing opportunities to students for preferable internship programme and offer final year projects relevant to industrial needs.

5. HEC must facilitate availability of e-books/pdf editions with print copy of internationally acclaimed text books for the program, availability of lab equipment and software relevant to the program.

6. HEC should arrange resources for video-conferencing and lectures sharing amongst the departments offering this programme.

7. All the universities/institutions offering this programme must focus on developing industrial linkages and international collaborations with foreign universities.

HEC should review the faculty development programme to allocate more funding to increase scholarships in the field of Material Science and Engineering.

Annex "A"

ELECTIVE COURSES

Management Sciences

ENVIRONMENTAL MANAGEMENT AND CONTROL

Course Objectives:

To provide thorough understanding of environmental management and its control.

Course Outline:

Environmental Organization, Legislation, Standards, Monitoring and Compliance assurance, Environmental Economies, Regional Development Planning, Environmental Decision-Making for industries. NEQA, ISO-14000 and Occupational Safety and Hazards Regulations. Risk Analysis. Atmospheric Dispersion of Pollutants. Analysis of Control Systems for Gaseous and Particulate Emissions. Discussion of Source Control and Air Quality Standards, Environmental Quality Objectives, Environmental Legislation, Standards, and Technologies. Interrelations of Air, Water Pollutions Environmental Pollution Control.

Recommended Books:

1. Christopher J. Barrow, "Environmental Management & Control" Rutledge, 2006
2. Stephen. Tinsley, "Environment Management", Taylor & Francis, 2001, ISBN 0415246636
3. Bhaskar Nath, "Environment Management in Practice", Rutledge, 1999, ISBN 041514907X
4. Frank B. Friedman, "Practical Guide to Environmental Management", Environmental Law Institute, 2003, ISBN 1585760471

SOLID WASTE MANAGEMENT

Course Objectives:

To provide knowledge of solid waste management produced by materials industry.

Course Outline:

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.

Recommended Books:

- Johan Post “Solid Waste Management”, Springer, 2004, ISBN 1402019750
- Elizabeth M. Thomas-Hope, “Solid Waste Management”, Canoe Press University of the West Indies, 1998, ISBN 9768125438
- Elizebeth, M Thomas-Hope “Solid Waste Management” 1998
- Forbes, R. McDougall, “Integrated Solid Waste Management” Black Well Publishing, 2001, ISBN 9780632058891

METALLURGICAL PLANTS AND QUALITY CONTROL

Course Objectives:

To provide knowledge of metallurgical plants and the quality control procedures used.

Course Outline:

Metallurgical plant location, Factors affecting location; Multiplant location; Plant layout; product and process layout analysis; Layout comparison. Type of Pollutants and their treatment, Overview of Environmental impacts of Iron and Steel making, Hot rolling, Forging, Cold rolling, Annealing and Tempering, Coating and Plating plants. Environmentally friendly metallurgical plants. Occupational Health and Safety Impacts of Metallurgical plants. Basic procedures and remedies. Applications of computers for environmental and Pollution Control and Waste management in metallurgical plants. Fundamentals of statistics and analysis techniques. Probability distributions. AQL, AOQL, L TPD, attributes sampling, variable sampling, selection of proper sampling plan. Reliability and maintainability, inspection of different types of materials and products for evaluation of quality reliability of flaw detection by non-destructive inspection, quality control applications of non-destructive inspection. 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.

Recommended Books:

- Tim Jones, "Steel Industry and the Environment: Technical and Management issues", International Iron, Steel Institute, ISBN: 9280716514, 2000.
- Mular Andrew L, Barrett, Derek J., and Halbe Doug N., **"**Mineral Processing Plant Design, Practice, and Control**,"** Society for Mining Metallurgy & Exploration, 2002.
- Kasatkin, N. L, **"**Erection and Operation of Metallurgical Plant**"** Mir, 1975.
- Nurse M. C, Brown Sharon, **"**Metallurgical Plant Makers of the World**",** Metal Bulletin Books; 4th ed., 1997.
- Coppa & Avery Consultants, **"**Metallurgical Plant Design**",** Vance Bibliographies 1985.
- Metals Handbook Vol. 17th, "Non-destructive Testing and Quality Control", American Society for Metals USA, 2005.

PRODUCTION OPERATIONS MANAGEMENT

Course Objectives:

To provide insight in the management skills to the engineers working in the production industry.

Course Outline:

Production /operation functions and the organization. Basic concepts of five Ps. Production strategies, guides and unities. Decision making in operations. Planning and controlling operations. Operational budget making and controlling. Variety management. Quality control and quality management. TQM.
Location, design and layout of plant and equipment. Maintenance of equipment.
Methods study and work measurement. The importance of forecasting in production and operations control. Project management techniques. Personnel management. Health and safety management in industry

Recommended Books:

1. Keith Lockyer, “Production and Operations Management”, Pitman, ELBS ed., 2000.
2. Lockyer, K. G., “Production Control in Practice”, Pitman, 2007
3. Norman Gaither, “Production and Operation Management”, Dryden Press, 2007
4. William Gavett Harcourt, “Production and Operation Management”, Brace & World, 2006
5. John F. and Muth, Gene K. Groff, “Operation Management”, Irwin, 2007
6. Buffa, Elwood Spencer, “Modern Production Management” Wiley, 2006, ISBN 0471118230
7. Nicholas J. Aquilano, Richard B. Chase, “Production and Operation Management” , Irwin, 2007,

ENGINEERING MANAGEMENT

Industrial networks, fundamentals of product and process development, business community and new generations of managers, practical skills, knowledge and experience in commercialization of new technological inventions, use of multidisciplinary science based knowledge, problem-solving, teamwork, outreach activity, major steps in proof of concept to intellectual property protection, prototype development, fabrication and assembly routes, materials procurement, identification and creation of new markets, development of business plan, appropriate technology and marketing, distribution and financing, routes and strategies for specific technology under development.

Recommended Books:
R. A. Bulgelman, Strategic Management of Technology and innovation, 4th Edition McGraw Hill, 2009.

PRINCIPLES OF MANAGEMENT

Course Objectives:
The focus will be on the learning fundamental principles of management and of managing people and organization. Students are expected to develop analytical and conceptual framework of how people are managed in small, medium and large public and private national and international organizations.

Course Contents:

- Introduction, overview and scope of discipline
- The evolution and emergence of management thought
- Management functions
- Planning concepts, objectives, strategies and policies
- Decision making
- Organizing; departmentalization, line/staff authority, commitments and group decision making
- Staffing: principles of selection, performance, career planning
- Leading: Motivation, leadership, communication
- Controlling: the system, process and techniques of controlling
- Management and Society: future perspective

Recommended Books

1. Stephen P. Robins, Mary Coulter: Management
2. H. Koontz Odonnel and H. Weihrich: Management
3. Mc Farland: Management: Foundation and Practice
4. Robert M. Fulmer: The New Management

Annex-B

ELECTIVE COURSES

Major Based Core Depth

TRIBOLOGY AND SURFACE ENGINEERING

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COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Describe tribological properties and different surface engineering techniques	Cognitive	2	1
2.	Apply knowledge of surface engineering to suggest suitable technique for wear resistant application.	Cognitive	4	3
3.	Evaluate merits and demerits of various coating processes keeping in view the environmental concerns	Cognitive	5	7

Course Outline:

Introduction to surface engineering and Tribology, Tribological Properties of Solid Surfaces, Friction and wear, Types of friction, wear losses, Lubrication modes and lubricants for metal fabrication processes, Surface interaction with environment, surface roughness and profilometer, microstructural effects on wear and friction, Case hardening, cladding, electron beam hardening, Ion beam implantation.

Surface preparation techniques such as, pickling, ultrasonic cleaning, Plasma cleaning, buffing etc., Anodic coatings, Cathodic Coatings, Electroplating of Cu, Ni and Cr, Hard chrome plating, Silver Plating, Gold Plating, Electroless Plating, Electrophoretic deposition, Hot dip Galvanized coating, Zn rich organic coatings, Aluminizing. HVOF process, Chromate conversion coatings, Phosphating, Anodizing of aluminum and its alloys, High Temperature coatings, Plasma Spraying, Thin Film Deposition Processes**,** sputtering, Physical Vapor Deposition, Chemical Vapor deposition, Pulsed Laser Deposition, Hybrid Deposition Process, Coatings for surgical and cutting tools, pistons, rings and bearings.

Recommended Books

1. S. Kalpakjian and S.R.Schmid, Manufacturing processes for engineering materials, Pearson Education, Inc, 2003
2. Peter Martin, Introduction to Surface Engineering and Functionally Engineered Materials, ISBN: 978-0-470-63927-6, October 2011
3. John B Hudson, “Surface Engineering: An Introduction”, Butterworth Heinemann, 2000
4. Bose “High Temperature Coatings” Butterworth Heinemann 2007
5. Lang E., “Coatings for High Temperature Applications”, Applied Science, 2000
6. Heinz Dimigen, “Surface Engineering”, Wiley-VCH, 2000
7. Smith, D. L. “Thin Film Deposition, Principles and Practice”, McGraw-Hill, 2000.
8. Grainger, S. and Blunt, J., “Engineering Coatings”, Woodhead, 1998.
9. Lang E., “Coatings for High Temperature Applications”, Applied Science, 2000
10. Donald Mattox, Handbook of Physical Vapour Deposition (PVD) Processing, 2nd Edition, William Andrew 2010

ADVANCED STEELS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Comprehend the characteristics of different types of advanced steels.	Cognitive	2	1
2.	Select advanced steels for various engineering applications	Cognitive	4	3
3.	Evaluate principles of physical metallurgy behind the development of special steels	Cognitive	5	3

Course outline:

Review of microstructure-property relationships in steels. Types of steels and their classification: High strength low Alloy (HSLA), micro alloyed, stainless steels, duplex, super duplex, high yield steels, IF (interstitial-free), maraging, TRIP steels and super alloys etc. Production routes for advanced steels (V I M , V A R , E S R , e t c .) Processing of steels: thermo-mechanical p r o c e s s i n g , advantages a n d limitations, TMT steels, dual phase steels, IF (interstitial-free) and ultra-low carbon steels for structural, automotive and power generation applications, ultra-low-carbon bainitic steels (ULCB), Special Steels: Stainless steels, nitrogen containing fine grained steels, orthopaedic steels, superduplex corrosion resistant stainless steels, special steels, TRIP steels, maraging steels, tool steels, die steels, Quenched and partitioned steels (QPS). Steels for low and high temperature applications.

Recommended Books

1. Honeycombe, R. W. K., “Steels: Microstructure & Properties”, Edward Arnold, London, 2005
2. Pickering, F. B., “Physical Metallurgy and Design of Steels”, Applied Science Publishers, 2000.
3. Marshall, P., “Austenitic Stainless Steels: Microstructure and Mechanical Properties”, Elsevier Applied Science Publishers, 2000
4. Harry Bhadeshia , Robert Honeycombe, “Steels: Microstructure and Properties”, Butterworth-Heinemann; 3rd Edition, 2006.

Journals/Periodicals/World Wide Web

MATERIALS CHARACTERIZATION TECHNIQUES

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Know about various characterisation techniques and their usage	Cognitive	1	12
2.	Analyse data obtained by various characterization techniques	Cognitive	4	3
3.	Explain working of various equipment with their accuracy and limitations	Cognitive	2	5
4.	Select a technique for the required characterization	Cognitive	4	5

Course outline:

1. Introduction
   a. Introduction of material characterization techniques
   b. Importance of material characterization
2. Compositional analysis
   a. Micro analysis (EDX and WDS)
   b. Bulk analysis (XRF, wet analysis, etc.,)
3. X-ray diffraction
   a. Properties and production of x-ray
   b. X-ray Diffraction methods (Debye-Scherrer technique, Laue method and rotating crystal, Powder diffraction)
   c. Structure factors of cubic system
   d. Indexing of diffraction pattern
   e. application of software for analysis of diffraction patterns
   f. phase identification
   g. size and strain measurement in crystal using Scherrer equation
4. Optical Microscopy
   a. optical microscopy
   b. interference contrast microscopy
   c. polarization microscopy
5. Electron microcopy
   a. interaction of electrons with matter

b. scanning electron microscopy (working principle, resolution, ray diagram, components, imaging techniques, various detectors, sample preparation)
c. transmission electron microscopy (working principle, resolution, ray diagram, components, imaging techniques, various detectors, electron diffraction, sample preparation)

6. Scanning probe microscopy
   a. AFM
   b. STM
7. Spectroscopic techniques
   a. FTIR, UV spectroscopy
   b. Emission spectroscopy
8. Thermal characterization of materials
   a. TGA, DSC
   b. DTA
   c. DMA
   d. Dilatometry
9. Transport properties measurement
   a. Electrical conductivity
   b. thermal conductivity
10. Electrical and Magnetic Properties of Materials
    a. dielectric properties measurement
    b. magnetic properties measurement (VSM, etc.)

Recommended Books

1. Cullity, B.D, Elements of X-ray diffraction, 3rd Ed, Prentice Hall, 2002.
2. Brandon, D. and Kaplan, W.D., "Microstructural Characterisation of Materials", Wiley, 2nd Ed. 2008.
3. Edigton, J.W, Practical electron microscopy in materials science, Van Nostrand Reinhold Co., 1976.
4. Williams, D.B. and Carter, C. B., "Transmission electron Microscopy", Plenum, 1996
5. .Magonov, S. N. and Myung-Hwan Whangbo, "Surface Analysis with STM and AFM. Experimental and Theoretical Aspects of Image Analysis", VCH, 1996
6. Goodhew, P.J., Humphreys F.J, "Electron Microscopy and Analysis", 2nd ed., Taylor & Francis, 1988
7. Brown, M.E, Introduction to thermal analysis, Techniques and Applications, Kulwer Academic Publishers, 2001.
8. Goldstein, J.I. et. al., "Practical Scanning Electron Microscopy", Plenum, 1975

Journals/Periodicals
World Wide Web

POWDER METALLURGY

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Comprehend the basic knowledge of Powder Metallurgy processing	Cognitive	2	1
2.	Analyse the powder production techniques	Cognitive	4	1
3.	Select the appropriate sintering parameters	Cognitive	4	3

Course outline:

Introduction

Metal powder products and Applications

Powder Production

Atomization of liquid metals (gas, water, oil, soluble gas, rotating electrode, rotating disk),
Chemical reaction methods, Reduction, Precipitation,
Electrolytic deposition,
Mechanical processing

Powder Characterization I

Particle size, shape and distribution,
Specific surface area,
characterization methods (sieving, microscopic examination, Stoke's Law, light obscuration/scattering, permeametry, etc.)

Powder Characterization II

sampling, chemical composition,
apparent density and flow, tap density,
compressibility, green strength,
pyrophoricity, toxicity

Compacting I

mixing, lubrication, pressure application, density distribution,
compacting tools,
presses (mechanical, hydraulic, rotary)

Compacting II

cold isostatic pressing, high energy rate and triaxial compaction,
injection molding, extrusion of powder, roll compacting, slip casting

Applied and Fundamental Aspects of Sintering

effects on geometry, microstructure and mechanical properties,

material transport, diffusion

Sintering Furnaces and Atmospheres
continuous, batch, and vacuum furnaces,
temperature control, types of atmosphere, reactions

Liquid-Phase Sintering
contact and dihedral angles, hot densification,
controlled porosity, super-solidus sintering,
infiltration, activated sintering, cemented carbides,

Structural Powder Metallurgy Parts
Design and design tolerances,
mechanical properties of Power Metallurgy parts,
Powder metallurgy of steel, copper, stainless steel, aluminum

Recent developments in Powder Metallurgy
powder forging, hot pressing, hot isostatic pressing (HIP),
"CAP" process, Ceracon process,
rapid omnidirectional compaction (ROC),
STAMP process, hot extrusion

Rapidly-Solidified and Dispersion-Strengthened Alloys
melt spinning, dispersion strengthening, mechanical alloying,
P/M aluminum alloys, tool steels

Other Applications of Powder Metallurgy
Refractory metals, Metal-bonded diamond tool materials
Electric contact materials, Switch materials, electrodes,
Friction materials, Magnetic applications,
Secondary Operation Performed on P/M parts and products
Inspection and Quality Control for P/M Materials
The Economics of P/M Production

Recommended Books

1. Anish Upadhyaya, Gopal Shankar Upadhyaya, Powder Metallurgy: Science, Technology, and Materials, Universities Press 2011
2. German. Randall, “A - Z of Powder Metallurgy”, Elsevier Science, 2006
3. West, William G, F. Leander, Pease, “Fundamentals of Powder Metallurgy”, Metal Powder Industries Federation 2002
4. German, R. M., “Sintering Theory and Practice”, Metal Powder Industries Federation, 1996
5. Yule, A.J., and Dunkley, J. D., “Atomization of Melts for Powder Production and Spray Deposition” Clarendon Press, 1994
6. German, R. M., “Powder Metallurgy Science”, Metal Powder Industries Federation, 1984
7. Gessinger, G. H., “Powder Metallurgy of Super alloys”, Butterworths, 1984

BIOMATERIALS

COURSE LEARNING OUTCOMES:

Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Comprehend the basic knowledge of biomaterials	Cognitive	2	1
2.	Illustrate processes for the preparation of biomaterials	Cognitive	4	2
3.	Outline applications of bio-compatible materials for humans	Cognitive	4	6
4.	Comprehend the ethical issues related to biomaterials	Cognitive	2	8

Course Outline:

- Properties and applications of biomaterials, biocompatibility, osteointegration, surface properties and cells interaction.
- Biomaterials: metallic, ceramic & glasses, polymer & composites.
- Classification: Bio-inert, bioactive and bio-resorbable materials
- Orthopedic and cardiovascular implants, dental materials, dental composites, amalgams, bone cements, enamels, dental implants and prosthesis
- Manufacturing and Processing of biomaterials: chemical synthesis, coatings (e.g. hydroxyapatite (HA) coatings etc.), Total Hip Joint and Knee Joint Replacement implants
- Surface (corrosion and degradation) and bulk mechanical properties
- Introduction and applications of Tissue Engineering.

Recommended Books

1. JS Temenoff and AG Mikos, Biomaterials: Intersection of Biology and Material Science, Pearson/prentice Hall, 2008.
2. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons, Biomaterials Science, 3rd Edition: An Introduction to Materaisl in Medicine, Academic Press, 2012.
3. Jeffrey O. Hollinger, An Introduction to Biomaterials, 2nd Edition (Biomedical Engineering, CRC Press 2011.
4. Buddy D. Ratner,2004 Elsevier, “Biomaterials Science”
5. Joyce Y. Wong, Joseph D. Bronzino, 2007, CRC Press, “*Biomaterials*”
6. Jeffrey O. Hollinger, 2011, CRC Press,” An Introduction to *Biomaterials*”
7. Krishnendu Roy – 2010, Springer, “Biomaterials”
8. Lucian A. Lucia, Orlando Rojas – 2009, Wiley.com, “The Nano-science and Technology of Renewable *Biomaterials*”

FRACTURE MECHANICS AND FAILURE ANALYSIS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Demonstrate the deformation behaviour of materials	Cognitive	3	1
2.	Identify the type of fracture in an engineering component	Cognitive	2	4
3.	Interpret the significance of facture toughness of materials	Cognitive	4	4

Course outline:

Fracture and its types, ductile, brittle and cleavage and cleavage planes, Plane stress and plane strain conditions, Griffith's and Orowon theory of fracture, Linear elastic and elastoplastic fracture mechanics. Fracture Toughness Testing, stress intensity factor and its range (ΔK), Paris Law. Determination of K_{1c}, Compact Tension, J-integral and Crack Opening Displacement (COD) methods. Tensile, Creep, Fatigue and environmental fractures. Ductile to Brittle Transition Temperature and its determination. Fracture toughness testing of composites materials. Fracture toughness testing of re-inforced/composite materials. Fractography and Case studies of fractured components. Failure analysis procedures

Recommended Books

1. Hertzberg, "Deformation and fracture mechanics of engineering materials " 5th Edition, 2012
2. Anderson, Ted, Anderson, T. L., "Fracture Mechanics Fundamentals", 3rd Edition, Taylor & Francis Group, 2005.
3. Knott, J. F. and Withey, P., "Fracture Mechanics - Worked examples", IoM, Latest edition.
4. Lancaster, J. F., "Engineering Catastrophes", Woodhead, 2005
5. G. Powell, "A Fractography Atlas of Casting Alloys", Battelle, 1992
6. ASM, "Fractography", Metals Handbook 12, 9th Edn, 1987

Journals/Periodicals
World Wide Web

FUELS AND FURNACES

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Demonstrate basic knowledge of fuels and furnaces used in metallurgical processes	Cognitive	2	1
2.	Characterize various types of fuels	Cognitive	4	2
3.	Design a desire type of furnace	Cognitive	6	3

Course outline:

Introduction to Fuels
- Classification, Preparation, Storage, handling and transportation.
- Combustion of Fuels
    - low and high temperature carbonisation of coal

Types of fuels
- Liquid fuels; petroleum, Light and heavy oils, furnace oil
- Gaseous fuels; producer/water/coke oven gas, LPG, Natural gas

Fuel Analysis
- Calorific value, viscosity, Octane and Cetane number
- Analysis of fuel economy

Introduction and Types of furnaces
- Oil/gas/coal fired furnaces, Electric Furnaces
- Heat treatment, vacuum, and controlled atmosphere furnaces
- Zone furnaces

Design and construction of furnaces
- Power calculations
- Heat transfer and insulation
- Temperature measurement procedures and instruments
- Energy management and cost effectiveness

Recommended Books

1. Connel “Energy Efficiency,Principles and Practices” Pennwell, 2009
2. Gilchrist. J. D., “Fuels”, Edward Arnold, 2000
3. Dame and King, “Fuels Technology” Edward Arnold, 2000

Journals/Periodicals
World Wide Web

NUCLEAR REACTOR MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Propose materials for a given nuclear reactor component	Cognitive	3	3
2.	Describe various types of nuclear reactors	Cognitive	5	1
3.	Illustrate health/safety issues related to nuclear materials	Cognitive	2	12

Course outline:

Fission and Fusion reactions. Nuclear cross sections, Einstein's equation: $E = mc^2$. Binding energy of nucleons, Nuclear energy calculations. Types of nuclear reactors and their components. Requirements of materials for core and outer core components, Types of nuclear fuels, Fuel cladding materials, Fissium alloys. Reflectors and moderators, control rod materials
Shielding materials, Structural materials, Nuclear Power Plants, LWR, PWR, Heavy Water Reactors and Liquid Metal Fast Breeder Reactors. Radiation effects on materials. Radiation hazards and safety, health physics. Radioactive waste management .

Recommended Books

1. Nuclear Engineering Materials, V. Gerasimov, A. Monokhov, Mir Publishers, Moscow, Transl. Peter Zabolotny
2. The Elements of Nuclear Power, D. J. Bennet, Longman, London
3. Nuclear Engg. Handbook, Ed. Keneth D. Kok, CRC Press, 2009
4. Nuclear Materials Science, K. Whittle, IOP Science 2016
5. Materials in Nuclear Engineering, Prof Michael Short, MIT Open Course Ware, Spring 2015
6. Hemsworth "Nuclear Materials" Nova Science5 Inc. 2011
   Materials Science and Technology, Volume 10, Nuclear Materials, Parts I & II, Vol. Editor: Frost, B. R. T, VCH, 1994.
7. The American Society of Mechanical Engineers, "Performance and Evaluation of Light Water Reactor Pressure Vessels", 1987

Journals/Periodicals
World Wide Web

VACUUM TECHNOLOGY

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Relate measuring units to the description of a vacuum system	Cognitive	3	1
2.	Explain the practical significance of vacuum production and cite examples of its application	Cognitive	2	3
3.	Evaluate vacuum pumps, gauges, valves for particular applications	Cognitive	5	4
5	Analyse problems in vacuum production and suggest remedies	Cognitive	4	2

Course Outlines:

Vacuum technology: 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 principle 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.

Recommended books

1. Vacuum Technology, Alexander Roth. North-Holland, (2007)
2. The Foundations of Vacuum Coating Technology by Mattox, D. M. Noyes Data Corporation/Noyes Publications, (2003)
3. Vacuum Metallurgy, Choudhury, A. ASM Intl, (2000)
4. Vacuum Metallurgy, Inker. O.W. Elsevier, (2001)
5. Vacuum Technology by Alexander Roth. North-Holland, (2007)
6. Vacuum technology: practice for scientific instruments by Nagamitsu Yoshimura. Springer, (2008).

Journals/Periodicals/World Wide Web

WOOD AND PAPER MATERIALS

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Describe the fundamentals of wood and paper	Cognitive	2	1
2.	Illustrate the structure property relationship in wood	Cognitive	3	7

Course Outlines:

Introduction to forest products, types of woods, annual wood consumption worldwide. Identification of wood. The Structure of Wood and the Wood Cell Wall: Gross Structure of Wood, Cellular Composition, Wood Rays, Planes of Wood, Sapwood and Heartwood, Growth Increments, Axial Parenchyma, Intercellular Canals and Other Gross Features etc. Defects and Abnormalities of Wood. Biological Deterioration of Wood. Wood preservation. Physics of wood. Mechanics and Rheology of Wood. Steaming and Seasoning of Wood. Wood machining. Properties of wood: Includes: moisture relations, density, mechanical properties, thermal properties, electrical properties, and acoustical properties. Concepts of paper, types of papers, production, characterisation of papers and applications of papers.

Recommended Books

1. Terry Porter, Wood Identification and Use , GMC Publications; Compacted edition 2012
2. R.Bruce Hoadley, Understanding Wood: A Craftsman's Guide to Wood Technology, Taunton Press Inc; 2nd Revised edition edition Dec 2000
3. Nick Gibbs, The Real Wood Bible: The Complete Illustrated Guide to Choosing and Using 100 Decorative Woods, Firefly Books Ltd; Revised edition, 2016
4. Franz F. P. Kollmann Wilfred A. Cote, Principles of Wood Science and Technology -I Solid Wood, springer, 1968
5. Michael Dresdner, The New Wood finishing book, Taunton Press Inc; 2nd Revised edition, 1999

NANOTECHNOLOGY

COURSE LEARNING OUTCOMES:
Upon successful completion of the course, the student will be able to:

S.	CLO	Domain	Taxonomy level	PLO
1.	Compare and analyse various routes for synthesis of nanomaterials	Cognitive	4	2
2.	Relate various nanomaterials to their applications	Cognitive	4	3
3	Search, read and illustrate nanotechnology development literature	Cognitive	6	12

Course Outline

One, two and three dimensional materials, nanoscale synthesis (bottom-up), production of nanoparticles and clusters, quantum wells and dots, nanowires, nano-rods, and nano-multilayered structures, CNTs, self-assembly and catalysts, bulk nanomaterials, nanomaterials handling, safety and precautions, special characterization methods for nanomaterials and advanced surfaces, unique physical, chemical and mechanical properties, nano-bio-info-materials, nano-devices, nanotechnology and its prospects for industry.

Recommended Books

1. Nanoscale Science and Technology by Kelsall, Hamely & Geoghegan Wiley (2005)
2. Introduction to nanotechnology by Poole and Owens, publ: John Wiley, 2003
3. Handbook of nanotechnology by Bhushan, Springer, 2003
4. Nanoscale Science & Technology, Robert Kelsall (editor), Wiley, 2005

Annex "C"

COURSES FOR SOCIAL SCIENCE

Sociology and Development

Objectives:
The main objective of this course is to apprise potential engineers about social factors that contribute towards enhancing their professional performance for the good of society and the country. This course is culture specific and has to be taught within the context of local and national socio-economic environment. The engineers are expected to supervise several people in different capacities and their understanding about human behaviour is critical for their optimum performance. Modification of human behaviour or getting work done from sub-ordinates and seniors remain a major challenge for all the professional engineers. This course will enhance understanding about the determinants of human behaviour, which ultimately will result in improved individual efficiency.

1. Introduction to Sociology
    - 1.1 Nature, Scope, and Importance of Sociology
    - 1.2 Social Interactions, Social Groups, Social Institutions
2. Culture and Related Concepts
    - 2.1 Culture, Types of Culture, Elements of Culture
    - 2.4 Role of Culture in Organization
    - 2.5 Socialization and Personality
3. Interpersonal Relations
    - 3.1 Interpersonal Behaviour
    - 3.2 Formation of Personal Attitudes
    - 3.3 Language and Communication
    - 3.4 Motivations and Emotions
    - 3.5 Public Opinion
4. Social Stratification
    - 4.1 Factors of Social Stratification
    - 4.2 Caste and class
    - 4.3 Power, Prestige, and Authority
    - 4.4 Social Mobility, Migration
5. Human Ecology
    - 5.1 Ecological Processes
    - 5.2 Ecosystem and energy
    - 5.3 Ecosystem and Physical Environment
    - 5.4 Pollution, Waste Disposal

6. Population Dynamics
    - 6.1 World Population Growth and Distribution
    - 6.2 Population Dynamics in Pakistan
    - 6.3 Causes and Consequences of Urbanization
    - 6.4 Population Policy in Pakistan

7. Community Development
    - 7.1 Scope and processes Community Development
    - 7.3 Community Development Programs in Pakistan
    - 7.4 Community Organization and Related Services
    - 7.5 Cooperation and Conflict in Community Development

8. Deviance and Crime
    - 8.1 Crime as a Social and Cultural Phenomenon
    - 8.3 Organized Crime
    - 8.5 Economics of Crime

9. Sociology of Change and Development
    - 9.1 Dynamics of Social Change and its effects on Development
    - 9.3 Role of NGOs in Development
    - 9.4 World System and Development
    - 9.5 Gender and Development

Recommended Books:

1. Allport, G. W. (1985). The Historical Background of Modern Social Psychology. New York, Random House.
2. A.Bernard and T.Burgess (2004), Sociology, Cambridge Univ. Press.
3. DuBrin, A. J. (2007). Human Relations: Interpersonal Job Oriented Skills. New York, Prentice Hall.
4. Gardezi, H. N., Ed. (1991). Understanding Pakistan: The Colonial Factor in Societal Development. Lahore, Maktaba Fikr-o-Danish.
5. Hafeez, S. (1991). Changing Pakistan Society. Karachi, Royal Book Company. Gardezi, H. N., Ed. (1991).
6. Jones, G. W. (2005). "Why are Population and Development Issues not Given Priority?" Asia-Pacific Population Journal **20** (1).
7. J. J. Macionis (1999). Sociology 7th Ed. National Book Foundation, Islamabad
8. Maser, C. (1997). Sustainable Community Development: Principles and Concepts. Plorida St. Lucie Press.
9. N.Nelson and S.Wright(1995).Power and Participatory Development: Theory and Practice. London, Intermediate Technology Publications.
10. Syed, S. H. (2003). The State of Migration and Multiculturalism in Pakistan:The Need for Policy and Strategy,Islamabad,UNESCO.
11. Utton, A. E. (1976). Human Ecology, West View Press.
12. Webster, A. (1990). Introduction to Sociology of Development. London, Macmillan Education Ltd.
13. A.M.Weiss (2001). Power and civil society in Pakistan, Oxford Univ. Press.

SOCIAL ANTHROPOLOGY

Objectives:
The students are expected to learn anthropological skills for application by professional engineers. Societal growth needs are to be understood within our own cultural environment. As culture and society play important role towards all human activities, this course will help students relate technical skills to the societal needs and requirements.

I. Introduction
   1. Anthropology and Social Anthropology
   2. Fields of Anthropology
   3. Anthropological Research Methods
   4. Social Anthropology and other Social Sciences

II. Culture
   1. Definition, Properties and Taxonomy
   2. Evolution of Growth and Culture
   3. Evolution of Man: Religious and Modern Perspectives
   4. Culture and Personality

III. Evolution and Growth of Culture
   1. Evolution of Man
   2. Schools of Thought in Cultural Anthropology
   3. Acculturation and Enculturation
   4. Ethnocentrism and Xenocentrism

IV. Language and Culture
   1. Communication
   2. Structural Linguistics
   3. Historical Linguistics
   4. Relationship between Language and Culture
   5. Ethnography

V. Economic System
   1. Global Economic System
   2. The Allocation of Resources
   3. The Conversion of Resources
   4. The Distribution of Goods and Services
   5. Poverty and Inequality

VI. Marriage and Family
   1. Marriage and Mate Selection
   2. The Family: Types, structure and Functions
   3. Kinship System
   4. Gender Relations

VII. Political Organization

1. Political Sociology
2. Origin of Political Organization and Organizational System
3. Types of Political Organizations
4. Power Politics and Factionalism in Pakistan
5. Resolution of Conflict

VIII. Religion and Magic
1. The Universality of Religion
2. Comparative Religions
3. Religion and Society
4. Religious Beliefs and Practices
5. Witchcraft and Sorcery

IX. Culture Change
1. Forms of Art
2. Expressive Culture
3. Process of Cultural Change
4. Cultural Change in the Modern World
5. Cultural Change in Pakistani society

Recommended Books

1. Ahmad, Akbar S. 1990. Pakistani Society, Karachi, Royal Books Co.
2. Bernard, H. Russel. 1994. Research Methods in Anthropology, Qualitative and Quantitative Approaches. London: Sage Publications
3. Bodley, John H. 1994. Cultural Anthropology, California: Mayfield Publishing Co.
4. Brogger, Jan. 1993. Social Anthropology and the Lonely Crowd. New Delhi: Reliance Publishing
5. Ember, Carol R. & Ember Melvin. 2005. Anthropology, 11th ed. Englewood Cliffs: Prentice Hall, Ince. Harper and Row
6. Harris Marvin. 1987. Cultural Anthropology. New York: Harper and Row
7. Harris Marvin. 1985. Culture, People, nature; An Introduction to General Anthropology London: Harper and Row
8. Haviland, W. A. (2005). Anthropology: The Human Challenge. New York, Thomson Learning Inc.
9. Hertzler J. O. 1981. The Social Structure of Islam. Cambridge: Cambridge University Press.
10. Keesing, Roger m. 1998. Cultural Anthropology: A contemporary perspective. 3rd ed. New York: Harcourt Brace College Publishers.
11. Kottak, Conard Phillip. 2002. Anthropology: The Exploration of Human Diversity. 9th ed. Boston: McGraw-Hill Higher Education.
12. Kennedy, Charles H. 1992. Pakistan London: Westview Press,.
13. Marron, Stanley. 1057. Pakistani Society and Culture. New Heaven
14. Wilson, Richard A. 1996. Human Rights, Culture and Context: Anthropological Perspective. London: Pluto Press.

UNDERSTANDING PSYCHOLOGY AND HUMAN BEHAVIOUR

- What is Psychology?
- Nature, Scope and Application with Special Reference to Pakistan
- Different Schools of Psychology
- Methods of Psychology Learning
- Intelligence and Artificial Intelligence
- Personality and its Assessment
- Understanding Maladjustive Behaviour
- Positive Emotional States and Processes
- Stress Management and Anger Management

Recommended Books

1. Atkinson R. C., & Smith E. E. (2000), Introduction to Psychology (13th ed.), Harcourt Brace College Publishers.
2. Fernald, L. D., & Fernald, P. S. (2005), Introduction to Psychology, USA: WMC Brown Publishers.
3. Hergenhahn, B. R. (2001). An Introduction to the History of Psychology, New York: Wadsworth.
4. Goodwin, C. J, (2000) Research in Psychology: Methods and Design, (3rd ed.), New York: John Wiley & Sons.
5. Synder, C. R., & Lopez, S. J. (2007) Positive Psychology, USA, Sage Publications.
6. Allen, B. P. (1997), Personality Theories: Development, Growth and Diversity, (2nd Ed.), Boston: Allyn & Bacon.
7. Cohen, R. J., & Swerdlik, M. E. (2005) Psychological Testing & Assessment (6th ed.), New York: McGraw-Hill.
8. Corcini, R., (2000). Current Psychotherapies. London: Thompson & Co Publishers.
9. Comer, R. J. (2004). Abnormal Psychology, USA: Freeman & Company.
10. Schwartz, B., Wassernman, E., & Robbins, S. (2002), Psychology of Learning and Behaviour, 5th Ed. Norton and Company.

PROFESSIONAL PSYCHOLOGY

- Introduction to Professional Psychology
- Psychological Testing
- Educational Psychology
- Industrial/Organizational Psychology
- Social Psychology
- Health Psychology
- Clinical Psychology
- Positive Psychology
- Legal, Ethical, and Professional Issues

Books Recommended

1. Crow, L., & Crow, A. (2000) Educational Psychology, New Delhi: Eurosia Publishing House Ltd.
2. Spiegel, P. K., & Koocher, G. P. (1998), Ethics in Psychology, New York: Oxford University Press
3. Snyder, C. R., & Lopes, S. J. (2000), Handbook of Positive Psychology, New York: Oxford University Press.
4. Compton, W. C. (2005), Introduction to Positive Psychology, USA, Thomson Wadsworth.
5. Debra, L. N. & James Compbell Quick, (2000) Organizational Behaviour (3rd ed), Cincinnat: South Western.
6. Fred Luthans, Alexander, D.S. & Edwin, A. Locke (2000) (Eds), Handbook of Principles of Organizational Behaviour, London: Blackwell.
7. Brannon, L. & Reist, J. (2000), Health Psychology: An Introduction to Behaviour and Health (4th ed.), USA Wadsworth.
8. Donohue, W. & Ferguson, K. (Eds), (2003), Handbook of Professional Ethics for Psychologists; Issues, Questions and Controversies, London: Sage Publications.
9. Meyers, D. (2005), Social Psychology, 8th Ed. McGraw Hill Inc.
10. Cooper, J. & Hogg, M. (2003) Handbook of Social Psychology, Sage Publications
11. Halgin, R. P., Whitbourne, S. K., & Halgin, R. (2004), Abnormal Psychology: Clinical Perspectives on Psychological Disorders, New York: McGraw-Hill.
12. Thorndike R. L., & Hage, E. P. (1995), Measurement and Evaluation in Psychology and Education (4th Ed), New York, MacMillan.

PROFESSIONAL ETHICS

Course Objectives:

This course introduces contemporary and controversial ethical issues facing the business community. At the completion of the course requirements, the student will be able to:

a. Understand and apply ethical decision-making framework
b. Understand social responsibility from several dimensions
c. Understand how the organization influences ethical decision-making
d. Examine how significant others influence ethical decision-making
e. Develop an effective ethics programme
f. Understand international business ethics

Course Outline:

An Overview of Business Ethics: Business Ethics Defined, Social Responsibility, and Business Ethics, Development of Business Ethics, Why study Business Ethics?, Framework for Studying Business Ethics.
Ethical issues in Business: Foundation of Ethical Conflict, Classifications of Ethical Issues, Ethical Issues Related to Participants and Functional Areas of Business, Recognizing an Ethical Issue.
Applying Moral Philosophies to Business Ethics**:** Moral Philosophy Defined, Moral Philosophy Perspectives.
Social Responsibility**:** The Economic Dimension, The legal Dimension, The Ethical Dimension, the Philanthropic Dimension.
An Ethical Decision-Making Framework**:** Ethical Issue Intensity, Individual Factors: Stages of Cognitive Moral Development, Corporate Culture, Opportunity, Business Ethics Evaluations and Intentions, Using Ethical Decision-Making Framework to Improve Ethical Decisions.
How the Organization Influences Ethical Decision Making: Organizational Structure and Business Ethics, Role of Corporate Culture in Ethical Decision Making, Dimensions of Organizational Structure and Culture, Implications of Organizational Relationships for Ethical Decisions.
The Role of Opportunity and Conflict**:** Opportunity, Conflict.
Development of Effective Ethics Programme**:** Effective Ethical Compliance, Programme, Codes of Ethics and Compliance Standards, High-Level Manager's Responsibility, Effective Communication of Ethical Standards, Establishing Systems to Monitor, Audit, and Enforce Ethical Standards, Continuous Improvement of the Programme, Influence of Personal Values, The Ethical Compliance Audit.
International Business Ethics**:** Ethical Perceptions and International Business, Culture As a Factor, Adapting Ethical Systems to a Global Framework: Cultural Relativism, the Multinational Corporation, A universal Set of Ethics, Ethical Issues Around the Globe.

Recommended Book:

1. Ferrell, O.C., and Fraedrich, John, Ethical Decision Making and Cases, New York: Houghton Mifflin.

ORGANIZATIONAL BEHAVIOUR

- Introduction to Organizational Behaviour
  - Organizational Disciplines and topics
  - Psychological Perspective
  - Social-Psychological Perspectives

- Structure and Control in Organization
  - Introduction
  - Bureaucracy
  - Managerial Work
  - Contingency theory
  - Organizational Design

- Individual and Work Learning
  - Learning Theories
  - Learning and Work

- Stress
  - Types of Stress and Work
  - Occupational Stress Management

- Individual Differences
  - Personality and its factors
  - Personality dimensions and social learning
  - Intelligence

- Motivation and Job Satisfaction
  - Needs at Work
  - Theories of Motivation and job satisfaction
  - Correlates of Job satisfaction
  - Correlates of Job satisfaction

- Group and Work
  - Social Interaction
  - Dramaturgy and impression Management
  - Social Skill

- Group and Inter group Behaviour
  - Group Structure & Norms
  - Group Processes
  - How throne Studies

- Leadership
  - Leadership as an attribute

- Leadership Style

- Patterns of Work
  - Work-the classical approach
  - Marx, Weber, & The critique of labor
  - Foucault & Disciplinary Power

- Conflict and Consent in Work
  - The labor Process debate
  - Work place control and resistance
  - Industrial conflict and industrial relations

- Organizational culture
  - Organizational culture and strategic management
  - Exploring organizational culture
  - Evaluating concept of culture

Recommended Books

1. Finchan, R., & Rhodes, P. (2003), Principles of Organizational Behaviour, 3rd Oxford.
2. Noe, R., Hollenbeck, J. Gerhart, B., & Wright, P. (2006), Human Resource Management, 5th ed., McGraw Hill.
3. Newstrom John W. (2007), Organizational Behaviour, (12th Ed), McGraw Hill.
4. Luthan Fred, (2005), Organizational Behaviour, McGraw Hill Inc.
5. Robins, Stephen, (2005), Organizational Behaviour, McGraw Hill Inc.

INTRODUCTION TO SOCIOLOGY

- The Nature of Sociology
  - The study of social life
  - Exploring the global village
  - Sociology as a science
  - The Sociological imagination
  - The development of Sociology
  - Pioneers of Sociology
  - Nature, scope and subject matter of Sociology
  - Brief historical development of Sociology
  - Society and community
  - Relationship with other social sciences
  - Social Interaction Processes

- Social groups
  - Definition and functions
  - Types of social groups

- Social institutions
  - Definition
  - Structure and function of social institutions
  - Inter-relationships among various social institutions

- Culture and related concepts
  - Definition and aspects of culture
  - Elements of culture
  - Organization of culture
  - Other concepts, cultural relativism, sub cultures, ethnocentrism, culture lag

- Socialization and personality
  - Role and status
  - Socialization
  - Culture and personality

- Deviance and social control
  - Definition and types of deviance
  - Juvenile delinquency
  - Formal and information methods of social control

- Social stratification
  - Approach to study social stratification
  - Caste class and race as basics of social stratification

- Major perspectives in Sociology
  - Functionalist perspective
  - Conflict perspective
  - Interactionstic perspective

- Social Control and deviance
  - Agencies of social control

- Social stratification
  - Determinants of social stratification
  - Social mobility, types and definition
  - Dynamics of social mobility

- Concept of social movement
  - Theories of social movement
  - Social and cultural change

- Social and cultural change
  - Definition of social change
  - Dynamics of social change
  - Impact of globalization on society and culture
  - Resistance to change

- Collective behaviour
  - Definition
  - Characteristics
  - Causes
  - Types
  - Social movements
  - Mob and crowd behaviour

Recommended Books:

1. Neulreck, Kenneth, J. 2005, Sociology: Diversity, Conflict and Change, Boston
2. Barnard, Andy. 2004. Sociology, Cambridge University Press
3. Giddens, Anthony, 2004, Sociology 4th edition, Cambridge Polity Press
4. Albrow, Martin, 2003, Sociology, London Routledge.
5. Richard, T. Schaefer, 2003, Sociology5th edition, McGraw Hill College
6. Kendall, Diana, 2004. Sociology in our Times, 4th ed, Wadsworth
7. Tyler Melissa, Wallace Claire & Abbott Pamela, 2005, An Introduction to Sociology, 3rd ed. Routledge.

CRITICAL THINKING

- The Power of Critical Thinking
  - Claims and Reasons
  - Reasons and Arguments
  - Arguments in the Rough

- The Environment of Critical Thinking
  - Perils of Haunted Mind
  - Self and the Power of the Group
  - Subjective and Social Relativism
  - Skepticism

- Making Sense of Arguments
  - Arguments Basics
  - Patterns
  - Diagramming Arguments
  - Assessing Long Arguments

- Reasons for Belief and Doubt
  - Conflict Experts and Evidence
  - Personal Experience
  - Fooling Ourselves
  - Claims in the News

- Faulty Reasoning
  - Irrelevant Premises
  - Genetic Fallacy, Composition, Division
  - Appeal to the Person, Equivocation, Appeal to Popularity
  - Appeal to Tradition, Appeal to Ignorance, Appeal to Emotion
  - Red Herring, Straw Man

- Unacceptable Premises
  - Begging the Question, False Dilemma
  - Slippery Slope, Hasty Generalization
  - Faulty Analogy

- Deductive Reasoning: Propositional Logic
  - Connectives and Truth Values
  - Conjunction, Disjunction, Negation
  - Conditional, Checking for Validity
  - Simple Arguments, Tricky Arguments
  - Streamlined Evaluation

- Deductive Reasoning: Categorical Logic
  - Statements and Classes
  - Translations and Standard Form
  - Terms, Quantifiers
  - Diagramming Categorical Statements
  - Sizing up Categorical Syllogisms

- Inductive Reasons
  - Enumerative Induction
  - Sample Size, Representativeness, Opinion Polls
  - Analogical Induction
  - Casual Arguments, Testing for Causes
  - Casual Confusions

- Inference to the Best Explanation
  - Explanations and Inference
  - Theories and Consistency
  - Theories and Criteria
  - Testability, Fruitfulness, Scope, Simplicity
  - Conservatism

- Judging Scientific Theories
  - Science and Not Science
  - The Scientific method, Testing Scientific Theories
  - Judging Scientific Theories
  - Copernicus versus Ptolemy, Evolution Versus Creationism
  - Science and Weird Theories
  - Making Weird Mistakes
  - Leaping to the Weirdest Theory, Mixing What Seems with What is
  - Misunderstanding the Possibilities
  - Judging Weird Theories
  - Crop Circles, Talking with the Dead

Recommended books

1. Vaughn Lewis, 2005, The Power of Critical Thinking, Oxford University Press.
2. Paulsen David W., Cederblom Jerry: 2000, Critical Reasoning, Wadsworth
3. Restall Greg. 2005, Logic: An Introduction, Routledge

INTRODUCTION TO PHILOSOPY

- Definition and Nature of Philosophy
- Theory of Knowledge
  - Opinion and Knowledge
  - Plato, the Republic Selection
  - Knowledge through Reason
  - Descartes Meditation on First Philosophy
  - Knowledge through Experience
  - Hume an Inquiry concerning Human Understanding (Selection)
  - Experience Structured by the Mind
  - Kant Critique of Pure Reason (Selection
  - Knowing and Doing
  - James Pragmatism (Selection)
  - Knowledge and Emotion
  - Jaggar Love and Knowledge (Selection)
- Philosophy of Religion
  - Proving that Existence of God
  - Anselm, Aquinas, Paley, Dawkins (Selection)
  - Justifying Religious Beliefs
  - Pascal Pensees (Selection)
  - James The will to Believe Selection
  - Freud the Future of An Illusion (Selection)
  - Confronting the Problems of Evil
  - Mackie Evil and Omnipotence (Complete)
  - Hick Philosophy of Religion (Selection)
- Metaphysics
  - Idealism and Materialism
  - Berkeley Three Dialogues Between Hylas & Pholonous
  - Armstrong Naturalism, Materialism and First Philosophy
  - Descartes Meditations on First Philosophy (Selection)
  - O'Hear Introduction to the Philosophy of Science (Selection)
  - Dennett The Origins of Selves (Complete)
  - Pali Canon (Selection)
  - Penelhum Religion and Rationality (Selection)
- Freedom to Choose
  - Libertarianism
  - James The Dilemma of Determinism (Selection)
  - Determinism
  - Hospers Meaning and Free Will (Selection)
  - Skinner Walden Two (Selection)
  - Compatibilism
  - Stace Religion and the Modern Mind (Selection)
- Ethics
  - Fulfilling Human Nature

- Aristotle Nicomachean Ethics (selection)
- Loving God
- Augustine The Morals of Catholic Church and the City of God
- Following Natural Law
- Aquinas Summa Theologiae (Selection)
- Kant Fundamental Principles of the Metaphysics of Morals
- Maximizing Utility
- Mill Utilitarianism (Selection)
- Nietzsche Human, All too Human and Beyond Good and Evil
- Creating Ourselves
- Sartre Existentialism is a Humanism (Selection)
- Hearing the Feminine Voice
- Gilligan In a Different Voice (Selection)
- Baier What do Women Want in a Moral Theory (Selection)

- Political and Social Philosophy
  - The State as Natural
  - Plato the Republic (Selection)
  - Aristotle Politics (Selection)
  - The State as a Social Contract
  - Hobbes Philosophical Rudiments Concerning Government and Society
  - Locke the Second Treatise of Government (Selection)
  - Liberty of the Individual
  - Mill On Liberty (Selection)
  - Alienation in Capitalism
  - Marx Economic and Philosophic Manuscripts of 1844
  - Justice and Social Trust
  - Rawls A Theory of Justice (Selection)
  - Nozick Anarchy, State, and Utopia (Selection)
  - Held Rights and Goods (Selection)
  - Women in Society
  - Wollstonecraft A Vindication of the Rights of Women
  - De Behaviour The Second Sex (Selection)
  - Russel The Problems of Philosophy (Selection)
  - Midgley Philosophical Plumbing (Selection)

Recommended Books

1. Abel Donald C., Stump Samuel Enoch, 2002. Elements of Philosophy: An Introduction, 4th Ed. McGraw-Hill.
2. Scruton Roger, 2001. A short History of Modern Philosophy, 2nd Edition Routledge.

ANNEXURE - D

English I (Functional English)

Objectives:

Enhance language skills and develop critical thinking.

Course Contents

Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

General topics and every-day conversation

Listening

To be improved by showing documentaries/films selected by teacher

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Note: Extensive reading is required for vocabulary building

Recommended Books

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506
3. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

4. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.

English II (Communication Skills)

Objectives:

Enable students to meet their real life communication needs.

Course Contents:

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

CV and job application

Translation skills

Urdu to English

Study skills

Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills

Letter/memo writing, minutes of meetings, use of library and internet

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
2. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
3. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0194354065 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
4. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
5. Reading and Study Skills by John Langan
6. Study Skills by Richard York.

English III (Technical Writing and Presentation Skills)

Objectives: Enhance language skills and develop critical thinking

Course Contents

Presentation skills

Essay writing

Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
4. The Mercury Reader. A Custom Publication. Compiled by Northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton.

ANNEXURE - E

ISLAMIC STUDIES AND PAKISTAN STUDIES

PAKISTAN STUDIES

Introduction/Objectives

- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline

1. Historical Perspective

a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.

b. Factors leading to Muslim separatism

c. People and Land
   i. Indus Civilization
   ii. Muslim advent
   iii. Location and geo-physical features.

2. Government and Politics in Pakistan

Political and constitutional phases:

a. 1947-58
b. 1958-71
c. 1971-77
d. 1977-88
e. 1988-99
f. 1999 onward

3. **Contemporary Pakistan**

a. Economic institutions and issues
b. Society and social structure
c. Ethnicity
d. Foreign policy of Pakistan and challenges
e. Futuristic outlook of Pakistan

Recommended Books

1. Burki, Shahid Javed. *State & Society in Pakistan,* The MacMillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S. M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Bangladesh,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: Wm Dawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K. K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

ISLAMIC STUDIES

Objectives

This course is aimed at:

1 To provide basic information about Islamic Studies
2 To enhance understanding of Islamic Civilization
3 To improve Students skill to perform prayers and other worships
4 To enhance understanding of issues related to faith and religious life.

Course outline

Introduction to Quranic Studies

1. Basic Concepts of Quran
2. History of Quran
3. Uloom-ul-Quran

Study of Selected Text of Holly Quran

1. Verses of Surah Al-Baqara Related to Faith(Verse No-284-286)
2. Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3. Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4. Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
5. Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

Study of Selected Text of Holly Quran

1. Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6, 21, 40, 56, 57, 58.)
2. Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3. Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I

1. Life of Muhammad Bin Abdullah (Before Prophet Hood)
2. Life of Holy Prophet (S.A.W) in Makkah
3. Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

1. Life of Holy Prophet (S.A.W) in Madina
2. Important Events of Life Holy Prophet in Madina
3. Important Lessons Derived from the life of Holy Prophet in Madina

Introduction to Sunnah

1. Basic Concepts of Hadith
2. History of Hadith
3. Kinds of Hadith
4. Uloom –ul-Hadith
5. Sunnah & Hadith
6. Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

1. Basic Concepts of Islamic Law & Jurisprudence
2. History & Importance of Islamic Law & Jurisprudence
3. Sources of Islamic Law & Jurisprudence
4. Nature of Differences in Islamic Law
5. Islam and Sectarianism

Islamic Culture & Civilization

1. Basic Concepts of Islamic Culture & Civilization
2. Historical Development of Islamic Culture & Civilization
3. Characteristics of Islamic Culture & Civilization
4. Islamic Culture & Civilization and Contemporary Issues

Islam & Science

1. Basic Concepts of Islam & Science
2. Contributions of Muslims in the Development of Science
3. Quran & Science

Islamic Economic System

1. Basic Concepts of Islamic Economic System
2. Means of Distribution of wealth in Islamic Economics
3. Islamic Concept of Riba
4. Islamic Ways of Trade & Commerce

Political System of Islam

1. Basic Concepts of Islamic Political System
2. Islamic Concept of Sovereignty
3. Basic Institutions of Govt. in Islam

Islamic History

1. Period of Khilaft-E-Rashida
2. Period of Ummayyads
3. Period of Abbasids

Social System of Islam

1. Basic Concepts of Social System of Islam
2. Elements of Family
3. Ethical Values of Islam

Reference Books

1. Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
2 Hameed ullah Muhammad, "Muslim Conduct of State"
3 Hameed ullah Muhammad, 'Introduction to Islam
4. Mulana Muhammad Yousaf Islahi,"
5 Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6 Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
7 Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
8 H. S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
9 Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

ANNEXURE – F

Mathematics and Statistics

MATHEMATICS I (ALGEBRA)

Course Objectives: To prepare the students with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Outline:

Preliminaries*:* Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.
Quadratic Equations*:* Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.
Sequences and Series*:* Arithmetic progression, geometric progression, harmonic progression.
Binomial Theorem*:* Introduction to mathematical induction, binomial theorem with rational and irrational indices.
Trigonometry*:* Fundamentals of trigonometry, trigonometric identities.

Recommended Books

1. Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin, Boston (suggested text)
2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

MATHEMATICS II (CALCULUS)

Course Objectives: To prepare the students with the essential tools of calculus to apply the concepts and the techniques in their respective disciplines.

Course Outline

Preliminaries*:* Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities.
Limits and Continuity*:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions.

Derivatives and their Applications*:* Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives.
Integration and Definite Integrals*:* Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals.

Recommended Books

1. Anton H, Bevens I, Davis S, *Calculus: A New Horizon* (8th edition), 2005, John Wiley, New York
2. Stewart J, *Calculus* (3rd ed.), 1995, Brooks/Cole (suggested text)
3. Swokowski EW, *Calculus and Analytic Geometry*, 1983, PWS-Kent Company, Boston
4. Thomas GB, Finney AR, *Calculus* (11th edition), 2005, Addison-Wesley, Reading, Ma, USA

MATHEMATICS III (GEOMETRY)

Course Objectives: To prepare the students, not majoring in mathematics, with the essential tools of geometry to apply the concepts and the techniques in their respective disciplines.

Course Outline

Geometry in Two Dimensions*:* Cartesian-coördinate mesh, slope of a line, equation of a line, parallel and perpendicular lines, various forms of equation of a line, intersection of two lines, angle between two lines, distance between two points, distance between a point and a line.

Circle: Equation of a circle, circles determined by various conditions, intersection of lines and circles, locus of a point in various conditions.

Conic Sections*:* Parabola, ellipse, hyperbola, the general-second-degree equation

Recommended Books

1. Abraham S, Analytic Geometry, Scott, Freshman and Co. 1969
2. Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6^{th} edition), 1986, PWS-Kent Company, Boston

STATISTICS-I

Definition and importance of Statistics, Data Different types of data and variables

Classification and Tabulation of data, Frequency distribution, stem-and-Leaf diagram, Graphical representation of data Histogram, frequency polygon, frequency curve.

Measure of Central tendency, Definition and calculation of Arithmetic mean, Geometric mean, Harmonic mean, Median quartiles and Mode in grouped and un-grouped data.

Measure of Dispersion, Definition and Calculation of Range, quartile deviation, Mean deviation, Standard deviation and variance, coefficient of variation.

Practical

a. Frequency Distribution
b. Stem-and-Leaf diagram
c. Various types of Graphs
d. Mean, Geometric mean Harmonic Mean,
e. Median, Quartiles Deviation, mean Deviation.
f. Standard Deviation, Variance, Coefficient of variation,
g. Skewness and kenosis

Recommended Books

1. Introduction to Statistical Theory Part- I by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. A. Concise Course in A. Level Statistic with world examples by J. Crashaw and J. Chambers (1994)
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomas J. Keans

STATISTICS-II

Sampling Probability and non-Probability Sampling, Simple random sampling stratified random sampling Systematic sampling error, Sampling distribution of mean and difference between two means. Interference Theory: Estimation and testing of hypothesis, Type—I and type-II error, Testing of hypothesis about mean and difference between two means using Z-test and t-test, Paired t-test, Test of association of attributes using X2 (chi-square) Testing hypothesis about variance.

Practical

a. Sampling random sampling
b. Stratified random sampling.
c. Sampling distribution of mean
d. Testing of hypotheses regarding population mean
e. Testing of hypotheses about the difference between population means
f. Chi-square test
g. Testing of Correlation Coefficient
h. Fitting of simple linear regression
i. One-way ANOVA
j. Two-way ANOVA

Recommended Books

1. Introduction to Statistical Theory Part-II by Sher Muhammad and Dr. Shahid Kamal (Latest Edition)
2. Statistical Methods and Data Analysis by Dr. Faquir Muhammad
3. Principles and Procedures of Statistics A Bio-material approach, 2nd Edition, 1980 by R. G. D Steal and James H. Tarric
4. Statistical Procedures for Agricultural Research 2nd Edition (1980) by K. A. Gomez and A. A. Gomez

ANNEXURE - G

Introduction to Information and Communication Technologies

Course Description

This is an introductory course on Information and Communication Technologies. Topics include ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications. After completing this course, a student will be able to:

- Understand different terms associated with ICT
- Identify various components of a computer system and networking
- Identify various categories of software and their usage
- Understand different terms associated with Internet and www
- Use various web tools including Web Browsers, E-mail clients and search utilities.
- Use text processing, spreadsheets and presentation tools
- Understand the enabling/pervasive features of ICT

Course Contents

Basic Definitions & Concepts
Hardware: Computer Systems & Components
Storage Devices, Number Systems
Software: Operating Systems, Programming and Application Software
Introduction to Programming, Databases and Information Systems
Networks, Data Communication
The Internet, Browsers and Search Engines
The Internet: Email, Collaborative Computing and Social Networking
The Internet: E-Commerce
IT Security and other issues

Text Books/Reference Books

1. Introduction to Computers by Peter Norton, 6th International Edition, McGraw-Hill
2. Using Information Technology: A Practical Introduction to Computer & Communications by W. Sawyer, 6th Ed. McGraw-Hill
3. Computers, Communications & information: A user's introduction by Sarah E. Hutchinson, Stacey C. Swayer

4. Fundamentals of Information Technology by Alexis Leon, Mathews Leon, Leon Press.