CURRICULUM

OF

METALLURGY AND MATERIALS ENGINEERING

For

Bachelor’s & Master’s Program

(Revised 2017)

HIGHER EDUCATION COMMISSION
ISLAMABAD
CURRICULUM DIVISION, HEC

Prof. Dr. Mukhtar Ahmed  Chairman, HEC
Prof. Dr. Arshad Ali  Executive Director, HEC
Mr. Muhammad Raza Chohan  Director General (Academics)
Dr. Muhammad Idrees  Director (Curriculum)
Syeda Sanabor Rizvi  Deputy Director (Curriculum)
Mr. Riaz-ul-Haque  Assistant Director (Curriculum)
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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

STAGE-I  STAGE-II  STAGE-III  STAGE-IV

CURRI. UNDER CONSIDERATION  CURRI. IN DRAFT STAGE  FINAL STAGE  FOLLOW UP

COLLECTION OF EXP.NOMINATION UNI, R&D, INDUSTRY & COUNCILS  APPLRAISAL OF 1ST DRAFT BY EXP  PREP. OF FINAL CURRI.  QUESTIONNAIRE

CONS. OF NCRC.  FINALIZATION OF DRAFT BY NCRC  PRINTING OF CURRI.  COMMENTS

PREP. OF DRAFT BY NCRC  IMPLE. OF CURRI.  ORIENTATION COURSES BY LI, HEC  BACK TO STAGE-I

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

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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.
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.
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**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.


**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**

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<tr>
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## Scheme of Study
for BE/BSc/BS Metallurgy and Materials Engineering

**First Year**

(1st semester)

<table>
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<th>Course Title</th>
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<td>Applied Chemistry</td>
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**First Year**

(2nd semester)

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Final Year (7th semester)  
(8th semester)
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:
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:

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
INDUSTRIAL SAFETY AND ENVIRONMENTAL ENGINEERING

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

Course Outline:


Recommended Books

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:**

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

**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:

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<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
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<tbody>
<tr>
<td>1.</td>
<td>Explain fundamental laws of Physics and their applications.</td>
<td>Cognitive</td>
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<tr>
<td>2.</td>
<td>Explain general physical properties of materials.</td>
<td>Cognitive</td>
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<tr>
<td>3.</td>
<td>Relate materials structure with general properties</td>
<td>Cognitive</td>
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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.
3. **Solid State Physics**

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

**Recommended Books**


**Journals/Periodicals**

**World Wide Web**
CALCULUS

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
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<tr>
<td>1.</td>
<td>Explain fundamental formulae of calculus</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Apply general solving techniques of the subject</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Illustrate about the relationship of calculus principles with the other related subjects</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

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


Recommended Books

Journals/Periodicals
World Wide Web
DIFFERENTIAL EQUATIONS

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain fundamental solving techniques of ODE’s</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Apply general techniques of differential equations</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Illustrate use of differential equation in engineering problems</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

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

Journals/Periodicals
World Wide Web
PROBABILITY AND STATISTICS

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

<table>
<thead>
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<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain fundamental principles of probability and data arrays</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Apply the general techniques of application of data estimations</td>
<td>Cognitive</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Apply the principles in engineering problems</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

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

Journals/Periodicals/World Wide Web
APPLIED CHEMISTRY

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

<table>
<thead>
<tr>
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<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain the basic knowledge of chemical elements, their classification and bonding.</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Apply fundamental concepts of chemistry to engineering problems</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Analyze and correlate reaction parameters with equilibrium, kinetics</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

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
- 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
   Journals/Periodicals/ World Wide Web

34
**RESEARCH METHODOLOGY**

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

<table>
<thead>
<tr>
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<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Organize research data and appropriate literature</td>
<td>Cognitive</td>
<td>4</td>
<td>5,9</td>
</tr>
<tr>
<td>2.</td>
<td>Analyse, interpret and correlate the data for research/design project</td>
<td>Cognitive</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

**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**


Journals/Periodicals
World Wide Web
INTRODUCTION TO COMPUTING

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

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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain the basics of hardware and software</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Apply the general techniques and software</td>
<td>Cognitive</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Develop simple computer programs</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Course Outline:

Recommended Books

Journals/Periodicals
World Wide Web
NUMERICAL ANALYSIS & COMPUTER PROGRAMMING

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

<table>
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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Apply the basic programming techniques</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Demonstrate the applications of computer language to various problems</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Solve the numerical problems and prepare algorithms</td>
<td>Cognitive</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

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:**

**Recommended Books**

Journals/Periodicals/World Wide Web
COMPUTATIONAL MATERIAL SCIENCE

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

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<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Describe use of various softwares for modeling of Materials Engineeri</td>
<td>Cognitive</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>ng processes.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Analyze and model Materials problems using modern computational tools</td>
<td>Cognitive</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Work as a team member on a relevant project.</td>
<td>Psychomotor</td>
<td>P-3</td>
<td>9</td>
</tr>
</tbody>
</table>

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:

Journals/Periodicals
World Wide Web
ENGINEERING DRAWING AND GRAPHICS / AUTO CAD

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

<table>
<thead>
<tr>
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<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Make drawing of engineering components</td>
<td>Cognitive</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>2.</td>
<td>interpret engineering drawings to real models using CAD</td>
<td>Cognitive</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>work as a team member on a relevant project.</td>
<td>Psychomotor</td>
<td>P-3</td>
<td>9</td>
</tr>
</tbody>
</table>

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:

Journals/Periodicals
World Wide Web
WORKSHOP PRACTICE

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

<table>
<thead>
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<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Demonstrate the basic workshop skills</td>
<td>Cognitive</td>
<td>C-3</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Display and perform various machining operations</td>
<td>Psychomotor</td>
<td>P-4</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Work as a team member on a relevant project.</td>
<td>Psychomotor</td>
<td>P-3</td>
<td>9</td>
</tr>
</tbody>
</table>

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

Journals/Periodicals
World Wide Web
INTRODUCTION TO ENGINEERING MATERIALS

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

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

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**

5. **Phase diagrams**
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:**

**Journals/Periodicals**  
World Wide Web
ENGINEERING MECHANICS

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

<table>
<thead>
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<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain the implications of Newton's laws of motion</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Interpret the equations describing equilibrium, rectilinear motion,</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>rotational motion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Analyse mechanical structures and different materials</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

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
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:

Journals/Periodicals
World Wide Web

44
MATERIALS THERMODYNAMICS

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

<table>
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<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Explain various thermodynamics criteria for a spontaneous process to occur.</td>
<td>Cognitive</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Apply thermodynamic principles to explain possibility of a reaction such as oxidation, reduction and apply these concepts in extraction, refining, corrosion, etc.</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Illustrate the principles of phase equilibrium. He/she will be able to construct phase Diagram from thermodynamic data.</td>
<td>Cognitive</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>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.</td>
<td>Affective</td>
<td>A-4</td>
<td>12</td>
</tr>
</tbody>
</table>

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:**

**Journals/Periodicals**

**World Wide Web**
MECHANICAL BEHAVIOUR OF MATERIALS

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

<table>
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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Predict deformation behaviour of materials in different loading conditions</td>
<td>Cognitive</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Identify and explain mechanisms and techniques correlating the structure and mechanical properties</td>
<td>Cognitive</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>Organize the information and present a report on Failure analysis of an engineering component.</td>
<td>Cognitive</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

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:

Journals/Periodicals
World Wide Web
PHYSICAL METALLURGY - I

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

<table>
<thead>
<tr>
<th>S. No.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain different terms related to crystallography</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Explain the role of crystal structure and defects in behaviour of materials</td>
<td>Cognitive</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Construct phase diagram and interpret phase reactions</td>
<td>Cognitive</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

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:
INSPECTION AND TESTING OF MATERIALS

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

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<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Analyse the stress-strain curve and explain the concepts of various engineering terms</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Select appropriate mechanical testing techniques and analyse data</td>
<td>Cognitive</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>Explain the use and limitations of various NDT techniques</td>
<td>Cognitive</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

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

Journals/Periodicals
World Wide Web
HEAT TREATMENT

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

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

Course outline:

Recommended Books:

Journals/Periodicals
World Wide Web
PHYSICAL METALLURGY-II

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

<table>
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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Interpret phase diagrams in relation to development of microstructure</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Correlate microstructure and properties</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Analyse the nucleation and growth mechanism and distribution of phases</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Course outline:


Recommended Books
MINERAL PROCESSING

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

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<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Comprehend knowledge of minerals in Pakistan, their occurrence, identification</td>
<td>Cognitive</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>2.</td>
<td>Select appropriate processing techniques for the beneficiation of minerals and metallic ores</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Demonstrate ore comminution and sampling techniques</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

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

Comminution
- Introduction to comminution and its objective
- Comminution techniques and their selection
- Comminution 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:
2. M. C. Fuerstenau, & N. Han, Kenneth “Principles of Mineral Processing”. Society for Mining Metallurgy & Exploration, 2003

Journals/Periodicals/World Wide Web
IRON AND STEEL MAKING

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

<table>
<thead>
<tr>
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<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain reactions occurring in blast furnace and thermodynamic reasoning of typical composition of pig iron</td>
<td>Cognitive</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Evaluate processing parameters affecting the quality of steels</td>
<td>Cognitive</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Illustrate measures required to minimize effects of iron and steel making on environment</td>
<td>Cognitive</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

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
8. Peters, D. "Ferrous Production Metallurgy" Willey

Journals/Periodicals
World Wide Web
NON-FERROUS METALLURGY

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

<table>
<thead>
<tr>
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<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Demonstrate basic knowledge of nonferrous extractive metallurgy and its significance in national economy</td>
<td>Cognitive</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Select appropriate extraction process for specified nonferrous metal</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Illustrate chemical reactions and thermodynamics involved in an extraction process</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

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
ENGINEERING CERAMICS & GLASSES

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

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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1. Identify different parameters and raw materials used in the processing of ceramics &amp; glasses</td>
<td>Cognitive</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>2. Design the appropriate processing techniques for production of ceramic materials for specific application</td>
<td>Cognitive</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>3. Select a ceramic for specific applications</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>4. Correlate structure and properties of ceramics and glasses</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

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**


**Journals/Periodicals**
World Wide Web
MANUFACTURING PROCESSES

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

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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Explain the manufacturing process</td>
<td>Cognitive</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Select tool(s) required to produce</td>
<td>Cognitive</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>component of required shape</td>
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<td></td>
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</tr>
<tr>
<td>3</td>
<td>Design post manufacturing process</td>
<td>Cognitive</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

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:

Journals/Periodicals
World Wide Web
POLYMERIC MATERIALS

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

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain various types of polymers and their applications</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Compare and contrast various processing techniques for polymers</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Analyse different physical and mechanical properties of polymers using characterisation techniques</td>
<td>Cognitive</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4.</td>
<td>Illustrate the impact of polymers on the environment and remedies</td>
<td>Cognitive</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

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: Injaction molding, Blow Molding, Compression Molding, Film Insert Molding, Gas Assist Molding, Rotational Molding, Structural Foam Molding, Thermoforming, extrusion, spinning, etc.,
- Polymer testing and characterisation; 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
7. Linda C. Sawyer, David T. Grubb, Gregory Frederick Meyers / 2008/ Springer, Polymer microscopy

Journals/Periodicals
World Wide Web
COMPOSITE MATERIALS

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

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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Comprehend the basic knowledge of natural and synthetic composites</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Relate the processing, structure and properties of composites</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Solve material selection problems in terms of adopting alternative approach to materials</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

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:
2. Ever J. Barero, "Introduction to Composite Materials Design", 2nd ed, July 2010

Journals/Periodicals

World Wide Web
ADVANCED MATERIALS AND NANOTECHNOLOGY

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

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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Explain properties &amp; applications of advanced materials</td>
<td>Cognitive</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Illustrate processing and characterization on different types of advanced materials</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Describe the characteristics and use of various types of nanomaterials and devices</td>
<td>Cognitive</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Comprehend the environmental and safety issues associated with new materials</td>
<td>Cognitive</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

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:

5. Scott A Guelcher and Hollinger, Jeffrey O., "An Introduction to Biomaterials", Taylor and Francis, 2005
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

Journals/Periodicals
World Wide Web
FOUNDRY ENGINEERING

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

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<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain the process of melting, casting and cast iron making</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Compare and contrast casting technique for specified metal</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Summarize the casting defects and their remedies</td>
<td>Cognitive</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

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
- CO₂ 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:

Journals/Periodicals
World Wide Web
JOINING OF MATERIALS

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

<table>
<thead>
<tr>
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<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Compare and contrast various joining techniques</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Analyse metallurgical changes occurring in joining of materials</td>
<td>Cognitive</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>Select a joining process for a given situation</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

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**

5. Robert W. Messler Jr. “Joining of Advanced Materials”, Butterworth Heinemann, USA

**Journals/Periodicals**

World Wide Web
CORROSION ENGINEERING

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

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

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:**

4. I.H.Khan, *Corrosion Technology*, Vol.1,2, Institute of Chemical Engineering, University of Punjab, Lahore, Pakistan

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

<table>
<thead>
<tr>
<th>S. No.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain use of various resources available for the design and selection of materials.</td>
<td>Cognitive</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>Design or select Material using modern tools</td>
<td>Cognitive</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>3.</td>
<td>Design or select a product with multiple constraints and conflicting requirements</td>
<td>Cognitive</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>4.</td>
<td>Work as a team member on a relevant project and present the findings</td>
<td>Affective</td>
<td>A-4</td>
<td>9</td>
</tr>
</tbody>
</table>

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:

Journals/Periodicals
World Wide Web
INSTRUMENTATION AND CONTROLS

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Explain the working principles of various techniques and sensors</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Compare various measuring techniques and their limitations and select appropriate instrument for given task</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Comprehend process automation</td>
<td>Cognitive</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

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, tachometer 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:


Journals/Periodicals
World Wide Web

Elective Courses in Major Based Core Depth
See Annex - B
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

<table>
<thead>
<tr>
<th>#</th>
<th>Lab #</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First Year (1\textsuperscript{st} and 2\textsuperscript{nd} Semester)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>I</td>
<td>Identification of Engineering Materials</td>
</tr>
<tr>
<td>2</td>
<td>I</td>
<td>Materials for Electronic and Engineering Applications</td>
</tr>
<tr>
<td>3</td>
<td>I</td>
<td>Atomic Packing in Crystals</td>
</tr>
<tr>
<td>4</td>
<td>I</td>
<td>Crystallography - Work Sheet</td>
</tr>
<tr>
<td>5</td>
<td>I</td>
<td>Solidification and Casting of Metals</td>
</tr>
<tr>
<td>6</td>
<td>I</td>
<td>Preparation of Metallographic Specimens for Microscopy</td>
</tr>
<tr>
<td>7</td>
<td>I</td>
<td>Determination of Young's Modulus of wood and steel.</td>
</tr>
<tr>
<td>8</td>
<td>I</td>
<td>Hardness of Engineering Materials</td>
</tr>
<tr>
<td>9</td>
<td>I</td>
<td>Impact Tests for Engineering Materials</td>
</tr>
<tr>
<td>10</td>
<td>I</td>
<td>Tensile testing of metals.</td>
</tr>
<tr>
<td>11</td>
<td>I</td>
<td>Mechanical Properties - Work Sheet</td>
</tr>
<tr>
<td>12</td>
<td>I</td>
<td>Creep in Materials</td>
</tr>
<tr>
<td>13</td>
<td>I</td>
<td>Oxidation of Metals</td>
</tr>
<tr>
<td>14</td>
<td>I</td>
<td>SEM – A Demonstration</td>
</tr>
<tr>
<td>15</td>
<td>I</td>
<td>Processing of Ceramics</td>
</tr>
<tr>
<td></td>
<td>Second Year (3\textsuperscript{rd} and 4\textsuperscript{th} Semester)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>II</td>
<td>International standards for evaluation of the engineering. Materials(exercise/worksheet)</td>
</tr>
<tr>
<td>17</td>
<td>II</td>
<td>Tensile test of engineering materials</td>
</tr>
<tr>
<td>18</td>
<td>II</td>
<td>Hardness test of engineering materials</td>
</tr>
<tr>
<td>19</td>
<td>II</td>
<td>Compression test of metals/alloys</td>
</tr>
<tr>
<td>20</td>
<td>II</td>
<td>Notched bar impact test of the engineering materials</td>
</tr>
<tr>
<td>21</td>
<td>II</td>
<td>Creep test of the engineering materials</td>
</tr>
<tr>
<td>22</td>
<td>II</td>
<td>Torsion test of engineering materials</td>
</tr>
<tr>
<td>23</td>
<td>II</td>
<td>Liquid penetrant testing</td>
</tr>
<tr>
<td>24</td>
<td>II</td>
<td>Magnetic particle testing -1</td>
</tr>
<tr>
<td>25</td>
<td>II</td>
<td>Magnetic particle testing -2</td>
</tr>
<tr>
<td>26</td>
<td>II</td>
<td>Ultrasonic testing-1</td>
</tr>
<tr>
<td>27</td>
<td>II</td>
<td>Ultrasonic testing-2</td>
</tr>
<tr>
<td>28</td>
<td>II</td>
<td>X-ray radiography of the materials</td>
</tr>
<tr>
<td>Page</td>
<td>III</td>
<td>Specimen Preparation for Metallography (brass, MS, Aluminium)</td>
</tr>
<tr>
<td>------</td>
<td>-----</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>30</td>
<td>III</td>
<td>Specimen Preparation &amp; Observation of Microstructures (cast iron, quenched, annealed and normalized structures of MS)</td>
</tr>
<tr>
<td>31</td>
<td>III</td>
<td>Atomic Packing of Planes and Miller Indices</td>
</tr>
<tr>
<td>32</td>
<td>III</td>
<td>Symmetry Contents of Letters, Motifs and common Objects</td>
</tr>
<tr>
<td>33</td>
<td>III</td>
<td>Metallography (Quantitative Analysis)</td>
</tr>
<tr>
<td>34</td>
<td>III</td>
<td>Stereographic Projections (geometric exercises)</td>
</tr>
<tr>
<td>35</td>
<td>III</td>
<td>Introduction to XRD Technique &amp; Equipment + Rolling Video</td>
</tr>
<tr>
<td>36</td>
<td>III</td>
<td>Carbonizing (diffusion of carbon into the surface of MS)</td>
</tr>
<tr>
<td>37</td>
<td>III</td>
<td>Obtaining Diffraction Pattern from a known Material &amp; Interpretation of Results</td>
</tr>
<tr>
<td>38</td>
<td>III</td>
<td>X-Ray Diffractometry &amp; Determination of Crystal Structure</td>
</tr>
<tr>
<td>39</td>
<td>III</td>
<td>Structure Factor Calculations for Simple Cubic, FCC, BCC</td>
</tr>
<tr>
<td>40</td>
<td>III</td>
<td>Obtaining Diffraction Pattern from a Known Mixture of Two Materials</td>
</tr>
<tr>
<td>41</td>
<td>III</td>
<td>Identification of an Unknown Material by X-Ray Powder Diffraction Film</td>
</tr>
</tbody>
</table>

**Third Year (5th and 6th Semester)**

<table>
<thead>
<tr>
<th>Page</th>
<th>IV</th>
<th>Size distribution of foundry sand.</th>
</tr>
</thead>
<tbody>
<tr>
<td>42</td>
<td>IV</td>
<td>Annealing, normalizing and quenching and tempering of steel.</td>
</tr>
<tr>
<td>43</td>
<td>IV</td>
<td>Identification of polymers using various chemicals and physical methods.</td>
</tr>
<tr>
<td>44</td>
<td>IV</td>
<td>Injection moulding of polymers.</td>
</tr>
<tr>
<td>45</td>
<td>IV</td>
<td>To study the atomic arrangement, lattice defects and deformation behaviour using a bubble raft model.</td>
</tr>
<tr>
<td>46</td>
<td>IV</td>
<td>Testing of moulding sand.</td>
</tr>
<tr>
<td>47</td>
<td>IV</td>
<td>Casting by split and single piece patterns.</td>
</tr>
<tr>
<td>48</td>
<td>IV</td>
<td>To study the effect of annealing, normalizing and quenching and tempering on tensile properties of mild steel.</td>
</tr>
<tr>
<td>49</td>
<td>IV</td>
<td>To study the effect of cooling media on the structure and hardness of steel.</td>
</tr>
<tr>
<td>50</td>
<td>IV</td>
<td>Anisotropy in tensile properties of deformed materials.</td>
</tr>
<tr>
<td>52</td>
<td>IV</td>
<td>Recovery, recrystallisation and grain growth</td>
</tr>
<tr>
<td>----</td>
<td>----</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>53</td>
<td>IV</td>
<td>Tensile test of polymeric materials.</td>
</tr>
<tr>
<td>54</td>
<td>IV</td>
<td>Casting of a metal / alloy using centrifugal casting process.</td>
</tr>
<tr>
<td>55</td>
<td>IV</td>
<td>To study the effect of strain rate on tensile strength of different polymers.</td>
</tr>
<tr>
<td>56</td>
<td>IV</td>
<td>Age hardening behavior of alloys.</td>
</tr>
<tr>
<td>57</td>
<td>IV</td>
<td>Strain aging behavior of mild steel.</td>
</tr>
<tr>
<td>58</td>
<td>IV</td>
<td>Intercritical heat treatment of mild steel.</td>
</tr>
<tr>
<td>59</td>
<td>IV</td>
<td>To study the effect of embrittlement in steel and cast iron by notched bar impact test.</td>
</tr>
<tr>
<td>60</td>
<td>IV</td>
<td>Determination of Tg and Tm of polymers.</td>
</tr>
<tr>
<td>61</td>
<td>IV</td>
<td>Casting of metals using carbon dioxide-sodium silicate process for mold making.</td>
</tr>
<tr>
<td>62</td>
<td>IV</td>
<td>Autempering of steel.</td>
</tr>
<tr>
<td>63</td>
<td>IV</td>
<td>Analysis of polymers using Fourier Transformed Infra-red Spectroscopy.</td>
</tr>
<tr>
<td>64</td>
<td>IV</td>
<td>Jominy end quench hardenability test.</td>
</tr>
<tr>
<td>65</td>
<td>IV</td>
<td>Fatigue test of mild steel.</td>
</tr>
<tr>
<td>66</td>
<td>IV</td>
<td>Study of Investment casting process and casting a metal / alloy.</td>
</tr>
<tr>
<td>67</td>
<td>V</td>
<td>Casting and Microstructural examination of lead-tin alloys.</td>
</tr>
<tr>
<td>68</td>
<td>V</td>
<td>Electrowining of Copper From CuSO solution.</td>
</tr>
<tr>
<td>69</td>
<td>V</td>
<td>Cast and Rheocast Aluminum alloys, properties and microstructures</td>
</tr>
<tr>
<td>70</td>
<td>V</td>
<td>Cold rolling of Aluminium strips and study of properties and microstructures of cold rolled and annealed samples.</td>
</tr>
<tr>
<td>71</td>
<td>V</td>
<td>Hot and cold rolling of copper plate, study of properties and microstructures of rolled plate.</td>
</tr>
<tr>
<td>72</td>
<td>V</td>
<td>Introduction to CNC machining</td>
</tr>
<tr>
<td>73</td>
<td>V</td>
<td>Demonstration of gas Welding and gas welding of mild steel.</td>
</tr>
<tr>
<td>74</td>
<td>V</td>
<td>Gas Welding of Aluminium.</td>
</tr>
<tr>
<td>75</td>
<td>V</td>
<td>Soldering and brazing of copper.</td>
</tr>
<tr>
<td>76</td>
<td>V</td>
<td>Shielded metal electric arc welding of mild steel, its microstructural examination and properties.</td>
</tr>
<tr>
<td>77</td>
<td>V</td>
<td>Welding of stainless steels, study of microstructures</td>
</tr>
</tbody>
</table>
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)**

<p>| 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 | Hand Lay Up Process of Polymer Matrix Composite Materials |
| 88 | VI | Potentiodynamic study of mild steel in 3.5% NaCl solution using Research Potentiostat and Sweep Generator |
| 89 | VI | Diodes: Materials Use, Application and Forward Biased and Reverse Biased Characteristics of Silicon and Germanium Diodes |
| 90 | VI | Mixing and cold pressing of Aluminium and Aluminium - Silicon Carbide (e.g. Al - SiC) powder. |
| 91 | VI | Selective Leaching of Brass and Microstructural Examination Vibrating Sample Magnetometer (VSM) for Magnetic Properties. |
| 92 | VI | Part A: Sintering of Aluminium and Aluminium - Silicon Carbide composite Material. |
| 93 | VI | Part B: Tensile Testing of Polymer Matrix Composite Materials. |
| 94 | VI | Electrochemical studies of mild steel using Gamry Instruments. Measurement of dissolved oxygen using dissolved oxygen (DO) meter |
| 95 | VII | Part (A): Examination and Testing of Copper Powder. |</p>
<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>VII</td>
<td>Part (B): Production of Metallic Powders by Using Different Techniques.</td>
</tr>
<tr>
<td>100</td>
<td>VII</td>
<td>Part A: Particle Size Analysis of Copper Powder by Using Particle Size Analyser</td>
</tr>
<tr>
<td>101</td>
<td>VII</td>
<td>Part B: Liquid Phase Sintering of Copper-Aluminium System.</td>
</tr>
<tr>
<td>102</td>
<td>VII</td>
<td>Part A: Effect of different Environments on Sintered Properties of aluminium compacts.</td>
</tr>
<tr>
<td>103</td>
<td>VII</td>
<td>Part B: Microstructural Examination of Solid/Liquid Phase copper/copper-aluminium compacts.</td>
</tr>
<tr>
<td>104</td>
<td>VII</td>
<td>Production of metallic foam using powder metallurgy methods.</td>
</tr>
<tr>
<td>105</td>
<td>VII</td>
<td>Sintering of SiC using high temperature furnace.</td>
</tr>
<tr>
<td>106</td>
<td>VII</td>
<td>An Introduction to Automobile Materials.</td>
</tr>
<tr>
<td>108</td>
<td>VII</td>
<td>Materials, components and working of optical fibres</td>
</tr>
<tr>
<td>110</td>
<td>VII</td>
<td>Part B: Determination of resistance characteristics of thermistors with temperature, its materials and applications.</td>
</tr>
<tr>
<td>111</td>
<td>VII</td>
<td>Use of software for application and selection of engineering materials.</td>
</tr>
<tr>
<td>112</td>
<td>VII</td>
<td>Measurement of electrical conductivity at low temperatures.</td>
</tr>
<tr>
<td>113</td>
<td>VII</td>
<td>Characterization of materials using TGA.</td>
</tr>
<tr>
<td>114</td>
<td>VII</td>
<td>Characterization of materials using UV-Vis.</td>
</tr>
<tr>
<td>115</td>
<td>VII</td>
<td>Hall effect in P-Germanium</td>
</tr>
<tr>
<td>116</td>
<td>VII</td>
<td>Use of Thermocouples: Comparison of Temperatures in a Tube Furnace with and without Shielding</td>
</tr>
<tr>
<td>117</td>
<td>VII</td>
<td>Part A: Transistors: Types, parts, materials use and application of transistors</td>
</tr>
<tr>
<td>118</td>
<td>VII</td>
<td>Part B: Input and output characteristics of NPN bipolar junction transistor in common emitter configuration.</td>
</tr>
</tbody>
</table>
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:

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>Mechanical Behaviour of Materials</td>
<td>3</td>
</tr>
<tr>
<td>Phase Transformations</td>
<td>3</td>
</tr>
<tr>
<td>Open (depending on the choice of the institute/department)</td>
<td>3</td>
</tr>
</tbody>
</table>

Elective Courses:

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

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory of Dislocations</td>
<td>3</td>
<td>Thin Film Technology</td>
<td>3</td>
</tr>
<tr>
<td>Fracture mechanics and Failure Analysis</td>
<td>3</td>
<td>Surface analysis and characterization</td>
<td>3</td>
</tr>
<tr>
<td>Metal Forming</td>
<td>3</td>
<td>Tribology Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Thermo-mechanical Processing</td>
<td>3</td>
<td>Advanced Coating technology</td>
<td>3</td>
</tr>
<tr>
<td>Micro structural Control</td>
<td>3</td>
<td>Carbon Materials</td>
<td>3</td>
</tr>
<tr>
<td>Advanced Manufacturing Systems</td>
<td>3</td>
<td>Polymer Science and Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Course</td>
<td>Credits</td>
<td>Course</td>
<td>Credits</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Advanced Joining Technology</td>
<td>3</td>
<td>Advanced Ceramics Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Nanomaterials</td>
<td>3</td>
<td>Electronic Materials</td>
<td>3</td>
</tr>
<tr>
<td>Smart Materials</td>
<td>3</td>
<td>Magnetic Materials</td>
<td>3</td>
</tr>
<tr>
<td>Nanotechnology</td>
<td>3</td>
<td>Optical Materials</td>
<td>3</td>
</tr>
<tr>
<td>Synthesis and Design of Nano structures and Devices</td>
<td>3</td>
<td>Nanomaterials and Computer Aided Nano-design</td>
<td>3</td>
</tr>
<tr>
<td>Advances in Extractive Metallurgy</td>
<td>3</td>
<td>Advanced Composite Materials</td>
<td>3</td>
</tr>
<tr>
<td>Solidification</td>
<td>3</td>
<td>Electron Microscopy</td>
<td>3</td>
</tr>
<tr>
<td>Advance Characterization Techniques</td>
<td>3</td>
<td>X-Ray Diffraction and Texture Studies</td>
<td>3</td>
</tr>
<tr>
<td>Modern Steels and Processes</td>
<td>3</td>
<td>Powder Metallurgy</td>
<td>3</td>
</tr>
<tr>
<td>Biomaterials</td>
<td>3</td>
<td>Computational Materials Engineering</td>
<td>3</td>
</tr>
<tr>
<td>Corrosion monitoring and prevention</td>
<td>3</td>
<td>Mathematical Methods in Engineering / Computational Methods for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>Surface Science and Engineering</td>
<td>3</td>
<td>Industrial Management</td>
<td>3</td>
</tr>
<tr>
<td>Nuclear Waste Management</td>
<td>3</td>
<td>Radiation shielding materials</td>
<td>3</td>
</tr>
<tr>
<td>Wood and Paper materials</td>
<td>3</td>
<td>Aerospace materials</td>
<td>3</td>
</tr>
<tr>
<td>Advanced mineral processing</td>
<td>3</td>
<td>Satellite Materials and Technology</td>
<td>3</td>
</tr>
<tr>
<td>Rare earth materials</td>
<td>3</td>
<td>Electrochemistry</td>
<td>3</td>
</tr>
<tr>
<td>Research Methodology</td>
<td>3</td>
<td>Quality management systems</td>
<td>3</td>
</tr>
<tr>
<td>Modelling of Material Processing</td>
<td>3</td>
<td>Nano scale characterization</td>
<td>3</td>
</tr>
<tr>
<td>Leather and textile materials</td>
<td>3</td>
<td>Advanced manufacturing Techniques</td>
<td>3</td>
</tr>
<tr>
<td>Solid state chemistry</td>
<td>3</td>
<td>Solid state Physics</td>
<td>3</td>
</tr>
</tbody>
</table>

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:

Recommended Books:
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:
- Elizebeth, M Thomas-Hope “Solid Waste Management” 1998
METALLURGICAL PLANTS AND QUALITY CONTROL

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

Course Outline:

Recommended Books:
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:
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:

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

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

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

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**

ADVANCED STEELS

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Comprehend the characteristics of different types of advanced steels.</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Select advanced steels for various engineering applications</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Evaluate principles of physical metallurgy behind the development of special steels</td>
<td>Cognitive</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

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 (VIM, VAR, ESR, etc.) Processing of steels: thermo-mechanical processing, advantages and 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

Journals/Periodicals/World Wide Web
MATERIALS CHARACTERIZATION TECHNIQUES

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

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

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 microscopy
   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

Journals/Periodicals
World Wide Web
POWDER METALLURGY

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Comprehend the basic knowledge of Powder Metallurgy processing</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Analyse the powder production techniques</td>
<td>Cognitive</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Select the appropriate sintering parameters</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

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,
- Inspection and Quality Control for P/M Materials
- The Economics of P/M Production

Recommended Books
BIOMATERIALS

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Comprehend the basic knowledge of biomaterials</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Illustrate processes for the preparation of biomaterials</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Outline applications of bio-compatible materials for humans</td>
<td>Cognitive</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>4.</td>
<td>Comprehend the ethical issues related to biomaterials</td>
<td>Cognitive</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

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
FRACTURE MECHANICS AND FAILURE ANALYSIS

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Demonstrate the deformation behaviour of materials</td>
<td>Cognitive</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Identify the type of fracture in an engineering component</td>
<td>Cognitive</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>Interpret the significance of fracture toughness of materials</td>
<td>Cognitive</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Course outline:

Recommended Books

Journals/Periodicals
World Wide Web
FUELS AND FURNACES

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Demonstrate basic knowledge of fuels and furnaces used in</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>metallurgical processes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Characterize various types of fuels</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Design a desire type of furnace</td>
<td>Cognitive</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

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

Journals/Periodicals
World Wide Web
NUCLEAR REACTOR MATERIALS

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

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

Course outline:


Recommended Books

5. Materials in Nuclear Engineering, Prof Michael Short, MIT Open Course Ware, Spring 2015

Journals/Periodicals
World Wide Web
VACUUM TECHNOLOGY

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

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

Course Outlines:

Recommended books

Journals/Periodicals/World Wide Web
WOOD AND PAPER MATERIALS

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describe the fundamentals of wood and paper</td>
<td>Cognitive</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Illustrate the structure property relationship in wood</td>
<td>Cognitive</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

Course Outlines:


Recommended Books
NANOTECHNOLOGY

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

<table>
<thead>
<tr>
<th>S.</th>
<th>CLO</th>
<th>Domain</th>
<th>Taxonomy level</th>
<th>PLO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Compare and analyse various routes for synthesis of nanomaterials</td>
<td>Cognitive</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Relate various nanomaterials to their applications</td>
<td>Cognitive</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Search, read and illustrate nanotechnology development literature</td>
<td>Cognitive</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

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
2. Introduction to nanotechnology by Poole and Owens, publ: John Wiley, 2003
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 subordinates 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
   2.2 Role of Culture in Organization
   2.3 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
   7.2 Community Development Programs in Pakistan
   7.3 Community Organization and Related Services
   7.4 Cooperation and Conflict in Community Development

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

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

Recommended Books:
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
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

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

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:
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.
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:
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
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
  o Functionalist perspective
  o Conflict perspective
  o Interactionistic perspective

• Social Control and deviance
  o Agencies of social control

• Social stratification
  o Determinants of social stratification
  o Social mobility, types and definition
  o Dynamics of social mobility

• Concept of social movement
  o Theories of social movement
  o Social and cultural change

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

• Collective behaviour
  o Definition
  o Characteristics
  o Causes
  o Types
  o Social movements
  o Mob and crowd behaviour

Recommended Books:
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
  o Statements and Classes
  o Translations and Standard Form
  o Terms, Quantifiers
  o Diagramming Categorical Statements
  o Sizing up Categorical Syllogisms

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

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

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

Recommended books
INTRODUCTION TO PHILOSOPHY

• Definition and Nature of Philosophy

• Theory of Knowledge
  o Opinion and Knowledge
  o Plato, the Republic Selection
  o Knowledge through Reason
  o Descartes Meditation on First Philosophy
  o Knowledge through Experience
  o Hume an Inquiry concerning Human Understanding (Selection)
  o Experience Structured by the Mind
  o Kant Critique of Pure Reason (Selection)
  o Knowing and Doing
  o James Pragmatism (Selection)
  o Knowledge and Emotion
  o Jaggar Love and Knowledge (Selection)

• Philosophy of Religion
  o Proving that Existence of God
  o Anselm, Aquinas, Paley, Dawkins (Selection)
  o Justifying Religious Beliefs
  o Pascal Pensees (Selection)
  o James The will to Believe Selection
  o Freud the Future of An Illusion (Selection)
  o Confronting the Problems of Evil
  o Mackie Evil and Omnipotence (Complete)
  o Hick Philosophy of Religion (Selection)

• Metaphysics
  o Idealism and Materialism
  o Berkeley Three Dialogues Between Hylas & Pholonous
  o Armstrong Naturalism, Materialism and First Philosophy
  o Descartes Meditations on First Philosophy (Selection)
  o O’Hear Introduction to the Philosophy of Science (Selection)
  o Dennett The Origins of Selves (Complete)
  o Pali Canon (Selection)
  o Penelhum Religion and Rationality (Selection)

• Freedom to Choose
  o Libertarianism
  o James The Dilemma of Determinism (Selection)
  o Determinism
  o Hosper Meaning and Free Will (Selection)
  o Skinner Walden Two (Selection)
  o Compatibilism
  o Stace Religion and the Modern Mind (Selection)

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

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

**Recommended Books**
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

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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
5. Reading and Study Skills by John Langan
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


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
   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

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, Tadab (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

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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 Isliahi,”
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
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

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
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
4. Basic Statistics an Inferential Approach 2nd Ed. (1986) Fran II. Dietrich-II and Thomas J. Kears
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
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
3. Computers, Communications & Information: A user's introduction by Sarah E. Hutchinson, Stacey C. Sawyer