

**CURRICULUM**  
**OF**  
**INDUSTRIAL ENGINEERING**  
**BS/BE**  
**&**  
**MS/ME**

(Revised 2012)



**HIGHER EDUCATION COMMISSION**  
**ISLAMABAD**

**CURRICULUM DIVISION, HEC**

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# PREFACE

The curriculum of subject is described as a throbbing pulse of a nation. By viewing curriculum one can judge the stage of development and its pace of socio-economic development of a nation. With the advent of new technology, the world has turned into a global village. In view of tremendous research taking place world over new ideas and information pours in like of a stream of fresh water, making it imperative to update the curricula after regular intervals, for introducing latest development and innovation in the relevant field of knowledge.

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

In compliance with the above provisions, the HEC undertakes revamping and refurbishing of curricula after regular intervals in a democratic manner involving universities/DAIs, research and development institutions and local Chamber of Commerce and Industry. The intellectual inputs by expatriate Pakistanis working in universities and R&D institutions of technically advanced countries are also invited to contribute and their views are incorporated where considered appropriate by the National Curriculum Revision Committee (NCRC).

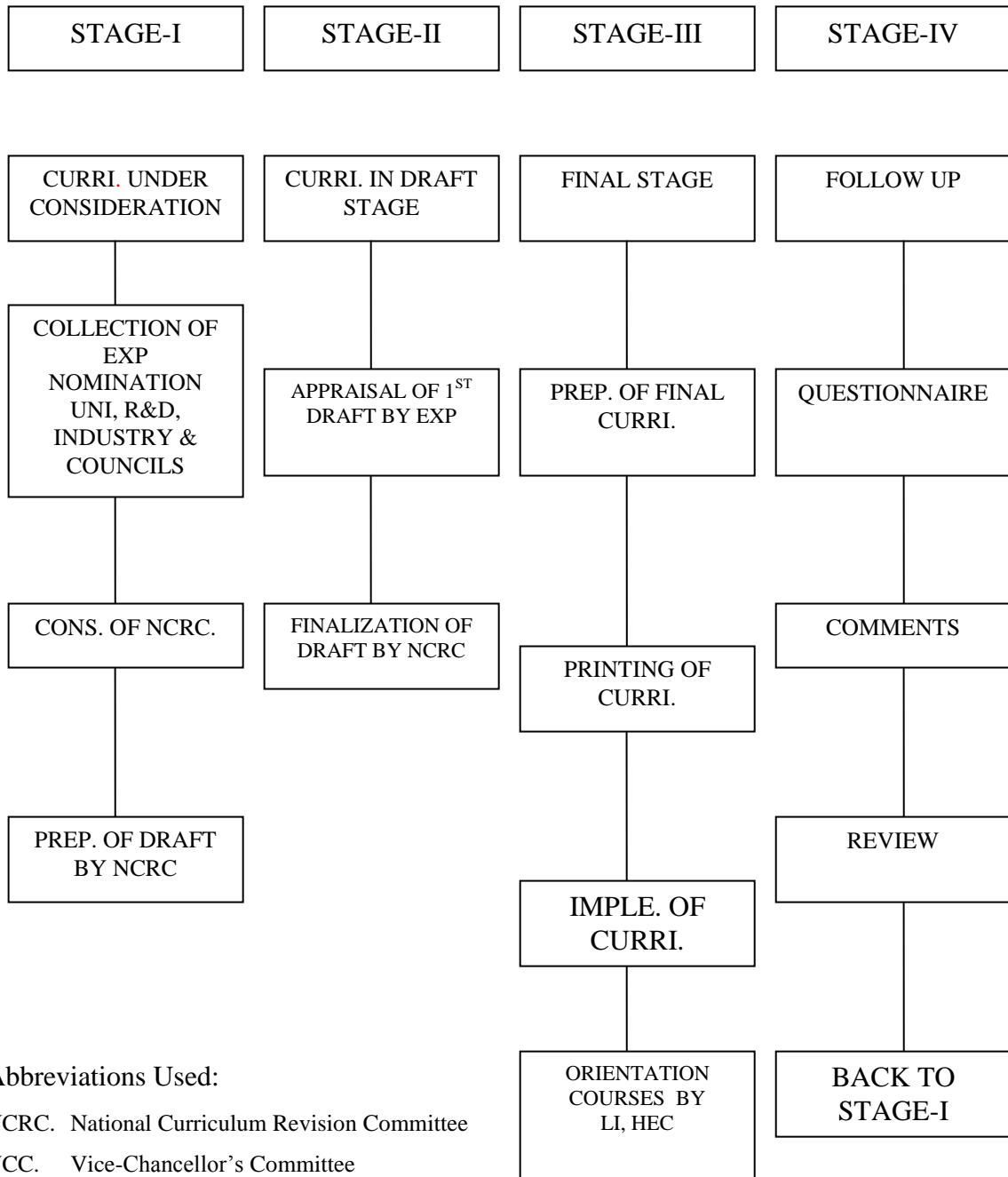
A committee of experts comprising of conveners from the National Curriculum Revision Committees of HEC in the disciplines of Basic, Applied, Social Sciences, Agriculture and Engineering met in 2007 & 2009 and developed the unified templates to standardize degree programmes in the country so as to bring the national curriculum at par with international standards, and to fulfill the national needs. It also aimed to give a basic, broad based knowledge to the students to ensure the quality of education.

In line with above, NCRC comprising senior university faculty and experts from various stakeholders and the respective accreditation councils has finalized the curriculum for Industrial Engineering. The same is being recommended for adoption by the universities/DAIs channelizing through relevant statutory bodies of the universities.

**MUHAMMAD JAVED KHAN**  
**Adviser (Academics)**

**April, 2012**

# CURRICULUM DEVELOPMENT



**Abbreviations Used:**

- NCRC. National Curriculum Revision Committee
- VCC. Vice-Chancellor's Committee
- EXP. Experts
- COL. Colleges
- UNI. Universities
- PREP. Preparation
- REC. Recommendations
- LI Learning Innovation
- R&D Research & Development Organization
- HEC Higher Education Commission

# INTRODUCTION

The final meeting of National Curriculum Revision Committee in Industrial Engineering was held at HEC, Regional Centre, Karachi, from 29<sup>th</sup> February to 2<sup>nd</sup> March, 2012 to finalize the curriculum of Industrial Engineering at Bachelors and Masters level, drafted in preliminary meeting held on October 24-26, 2011. The following members attended the preliminary and final meetings of NCRC:-

1.	Prof. Dr. Iftikhar Hussain Chairman, Department of Industrial Engineering, University of Engineering & Technology, Peshawar.	Convener
2.	Prof. Dr. Salim ur Rehman Vice Chancellor, Sarhad University, 36-B, Chinar Road, University Town, Peshawar.	Secretary
3.	Prof. Dr. Hussain Bux Mari Chairman, Department of Industrial Engineering & Management, Mehran University of Engineering & Technology, Jamshoro.	Member
4.	Prof. Dr. Sahar Noor Department of Industrial Engineering, University of Engineering & Technology, Peshawar.	Member
5.	Prof. Dr. Syed Amir Iqbal Chairman, Department of Industrial & Manufacturing Engineering, NED University of Engineering & Technology, University Road, Karachi.	Member
6.	Engr. Shahab Afroz Khan Chairman, Department of Industrial Engineering & Management, Dawood College of Engineering and Technology, Karachi.	Member
7.	Prof. Dr. Riaz Ahmed Sohag Department of Industrial Engineering and Management, Mehran University of Engineering and Technology, Jamshoro.	Member
8.	Engr. Nishat Ahmed Manager, AMI Department, AERO Central Registry, Lub Thatto, Hazara Road, Hassan Abdal, Distt. Attock.	Member
9.	Dr Usama Umer Assistant Professor, Institute of Manufacturing Engineering and Management (IMEM),	Member

	Pakistan Navy Engineering College (PNEC), National University of Sciences and Technology, Karachi	
10.	Dr. Maqsood Ahmed Khan Associate Professor, Department of Industrial & Manufacturing Engineering, NED University of Engineering & Technology, University Road, Karachi.	Member
11.	Dr. Muhammad Irshad Khan Senior Fellow, Head of Department, Department of Industrial Engg. & Management, Institute of Business Management, Korangi Creek, Karachi	Member
12.	Dr. Muhammad Qaiser Saleem Assistant Professor, Department of Industrial and Manufacturing Engineering, University of Engineering and Technology, Lahore.	Member
13	Prof. Dr. Mohammad Pervez Mughal Department of Industrial and Manufacturing Engineering, University of Engineering and Technology, Lahore.	Member
14	Mr. Badar-ud-Din Ahmed Manager, NESCOM, L-7 Gilani Hospital, Street Mosazai Colony, Mirpur, Abbottabad.	Member
15	Prof. Dr. Nadeem Ahmad Mufti Chairman, Department of Industrial & Manufacturing Engineering, University of Engineering & Technology, Lahore.	Member
16	Dr. Nadeem Ishaq Kureshi Asst. Professor, Institute of Manufacturing Engineering & Management (IMEM), PNEC, National University of Science & Technology, Karachi.	Member

The meeting started with recitation of Holy Quran by the Dr. Muhammad Tahir Ali Shah, Dy. Director (Curriculum) HEC. Muhammad Javed Khan, Adviser (Academics) welcomed the committee members on behalf of the Chairman, Executive Director and himself. He elaborated the main purpose of this committee and highlighted the importance of the curriculum that was being reviewed by this committee. He also mentioned that the initial draft of revised curriculum was sent to the foreign experts for their comments. Thereafter, the proceedings of the meeting started.

1. The committee discussed the first draft in detail and made certain modifications. Some of the courses were strengthened by incorporating current knowledge and practices. The idea of global employability has

also been taken into consideration. It was also checked against all parameters defined by the HEC and was found in conformity.

- a) As desired by HEC the total credit hours of the bachelors programme are in the specified limits of 133-136.
  - b) Three credits hours have been left for any course to be decided by the individual institution.
2. In the final year, four elective courses have been included for which 20 courses have been identified. Individual university may add more courses in the list therein.
  3. For Masters programme four areas of specialization have been defined;
    - a. Manufacturing
    - b. Operations Research
    - c. Quality Management
    - d. Engineering Management
  4. The details of undergraduate courses are placed as Annexure-A
  5. The details of postgraduate courses are placed as Annexure-B

The Committee acknowledged the hospitality extended and facilities provided by HEC Regional Centre Karachi, and particularly thanked Dr. Muhammad Tahir Ali Shah, Dy. Director (Curriculum), HEC and Ms. Khalida Yakoob, Computer Operator for their continuous cooperation and help provided in completion of the assigned task within stipulated time.

### **Legend:**

The following notation is used to define credit and contact hours.

x (a,b,) where

x Total Credit Hours

a) Theory Credit Hours (one contact hour equal to one credit hour)

b Lab /tutorial Credit Hours (three contact hours equal one credit hour)

## **Role of Industrial Engineers**

Industrial Engineers are equipped with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from the integrated systems of people, materials, information, equipment, and energy. Industrial Engineers having a diversified knowledge and skills in the field of manufacturing systems, operation management/research, total quality management, enterprise resource planning, ergonomics and computers are most suitable for the optimum operation of any organization including manufacturing industry, banking sector, agricultural, shipping and transportation etc.

Throughout the globe, there is an increasing trend of recruitment of industrial engineers with high pays and salaries which shows the realization about the importance and key role of Industrial Engineers in the cost effective operations of organizations but unfortunately there is less awareness among our employers and government functionaries about the role of industrial engineers.

Any organization can run effectively and efficiently if all of its subsystems work in an integrated manner for its main objective. Operations management of any industry/organization plays a very important role in the improvement of productivity which leads to improved living standard. However, there is no significant improvement in the productivity of Pakistan's organizations which can



be attributed to various factors and reasons. Our organizations can increase their productivity, competitiveness and reduce their wastes by incorporating right methodologies/ techniques at right time by right management teams in all functional areas.

The main areas of improvements in our industries are related to risk assessment, product development, Material Requirement Planning (MRP), capacity planning, work in process management and inventory management, operations management, quality control, process control, facility planning and design, manufacturing techniques, human factors engineering and working within multi-echelon environments. These problems necessitate integrated solutions which can only be catered through Industrial Engineers because they are especially trained for it. They engineer the processes and systems that improve quality and productivity, eliminate wastes in terms of time, money, materials, energy and other commodities. They examine and analyze the production systems to find better ways to solve problems. They use mathematical techniques, expert computer systems, cost analysis, quality control, financial planning and complex distribution plans to solve problems.

***Industrial engineers, equipped with knowledge and skills for the Knowledge-Based Economy can be a competitive edge for any organization.***

# UNIFIED FRAMEWORK BE/BS

## Non-Engineering Domain

Knowledge Area	Subject Area	Name of Course	Lec CH	Lab CH	CR	Total Courses	Total Credits	% Area	% overall
<b>Humanities</b>	English	Functional English	3	0	3	3	9	20.5	6.7
		Communication Skills	3	0	3				
		Technical Report Writing & Presentation Skills	3	0	3				
	Culture	Pakistan Studies	2	0	2	2	4	9.1	3.0
		Islamic Studies/Ethics	2	0	2				
	Social Sciences	Social Sciences-I (Logic & Critical Thinking )	3	0	3	2	6	13.6	4.4
Social Sciences-II (Engg. Economics)		3	0	3					
<b>Management sciences</b>		Intro to Engg. Management	3	0	3	2	7	15.9	5.2
		Project Management	3	3	4				
<b>Natural Sciences</b>	Physics	Applied Physics	2	3	3	1	3	6.8	2.2
	Mathematics	Calculus	3	0	3	3	9	20.5	6.7
		Differential Equations	3	0	3				
		Applied Linear Algebra	3	0	3				
	Electives	Elective-I (Numerical Analysis)	3	0	3	2	6	13.6	4.4
	Elective-II (Probability & Statistics)	3	0	3					
<b>TOTAL</b>						<b>15</b>	<b>44</b>	<b>100.0</b>	<b>32.6</b>

Engineering Domain									
Knowledge Area	Subject Area	Name of Course	Lec CH	Lab CH	CR	Total Courses	Total Credits	% Area	% overall
Computing	Fundamentals	Introduction to Computing	2	3	3	3	10	11.0	7.4
	Programming	Computer Simulation	2	3	3				
	Design	CAD/CAM	3	3	4				
Engineering Foundation	Engineering Foundation	Operations Research	3	3	4	10	30	33.0	22.2
		Metrology & Statistical Quality Control	3	3	4				
		Mechanics of Materials	3	3	4				
		Basic Industrial Engg	2	0	2				
		Engineering Drawing-I	0	3	1				
		Engineering Drawing-II	1	3	2				
		Workshop Practice	0	6	2				
		Material Engineering	3	3	4				
		Industrial Facilities Design	2	3	3				
		Manufacturing Systems	3	3	4				
Major Based Core (Breadth)	Major Based Core (Breadth)	Operations of Manufacturing Systems	3	3	4	7	24	26.4	17.8
		Manufacturing Processes	3	3	4				
		Production Planning & Control	2	3	3				
		Industrial Maintenance & Safety	3	0	3				
		Work Study & Method Engineering	2	3	3				
		Instrumentation and Control	3	3	4				
		Human Factor Engg.	2	3	3				
		Electives							
Major Based Core (Depth)	Major Based Core (Depth)	Elective-I	3	3	4	4	14	15.4	10.4
		Elective-II	3	3	4				
		Elective-III	3	0	3				
		Elective-IV	3	0	3				
		IDEE-I Introduction to Thermo-Fluids	3	3	4	2	7	7.7	5.2
		IDEE-II Design of experiments	3	0	3				

<b>Senior Design Project</b>	Senior Design Project -I	0	9	3	2	6	6.6	4.4
	Senior Design Project -II	0	9	3				
<b>TOTAL</b>					<b>28</b>	<b>91</b>	<b>100.0</b>	<b>67.4</b>
<b>Industrial Training</b>								
<b>Grand Total</b>					<b>43</b>	<b>135</b>		

**Note:** 1 Cr Hr lab would be for 3 Contact Hours

<b>Domain</b>	<b>Knowledge Area</b>	<b>Total Courses</b>	<b>Total Credits</b>	<b>% Overall</b>
<b>Non-Engineering</b>	Humanities	7	19	32.6
	Management Sciences	2	7	
	Natural Sciences	6	18	
	<b>Sub Total</b>	<b>15</b>	<b>44</b>	
<b>Engineering</b>	Computing	3	10	67.4
	Engineering Foundation	10	30	
	Major Based Core (Breadth)	7	24	
	Major Based Core (Depth)	4	14	
	Inter-Disciplinary Engineering Breadth (Electives)	2	7	
	Senior Design Project	2	6	
	Industrial Training	0	0	
	<b>Sub Total</b>	<b>28</b>	<b>91</b>	
<b>Grand Total</b>		<b>43</b>	<b>135</b>	<b>100</b>





# DETAIL OF COURSES

## A) ENGINEERING DOMAIN

### COMPUTING

#### Introduction to Computing

3 (2, 1)

##### **Objective:**

To give working knowledge & skills of coding (C++ / Fortran/ VB / Matlab etc), how to avoid common coding pitfalls, to use and create own functions and classes. The course will enable students recognize the advantages of using pointers and references & to understand the fundamental ideas of object oriented (OO) design.

##### **Contents:**

Introduction to computer hardware and software, Word processing programs, Spread sheets programmes, Equation solvers and procedural computations, Communication and networking. Constants and variables, Arithmetic operations, Intrinsic functions, Algorithm design, Flowcharts, and Pseudo codes, IF statements, Do loop, While loop, Data files, Formatted Input and Output, Logical and character data type, Arrays: one-dimensional, two-dimensional, Subprograms: Functions and subroutines, Numerical Applications, Introduction to programming language.

##### **Recommended Books:**

1. Programming with C++ by Dietel
2. Visual basic by Mathew McDonald,
3. Microsoft Visual Basic 2010 Step by Step by Michael Halvorson, Microsoft Press
4. Fortran 90/95 for Scientists & Engineers by Stephan J. Chapman
5. MATLAB for Engineers by Holly Moore, Prentice Hall
6. An Engineers guide to MATLAB by Edward B. Magrab, Pearson Education.

##### **Suggested Lab:**

Hands on Experience using software.

#### Computer Simulations

3 (2,1)

**Prerequisites:** Introduction to Computing, Probability and Statistics

##### **Objective:**

The course enables the students to become proficient in simulation model building and use of computer simulation as problem solving technique. Hands-on experience on computer simulation using any suitable software.

##### **Contents:**

Introduction to simulation concepts, Random number generation, Simulation model building, Simulation languages, Model validation and output, Development of various simulation models of practical nature using ARENA or any other simulation software.

### **Recommended Books:**

1. Simulation with ARENA
2. Discrete System Simulation by Jerry Banks, Prentice Hall.

### **Suggested Lab:**

Hands on Experience using software.

### **CAD/CAM**

**4 (3,1)**

**Prerequisites:** Engineering Drawing, Manufacturing Processes

### **Objective:**

To expose the students to the computer geometric modelling & transformation, CAD/CAM database, NC & CNC machines coding, configuration & motion etc.

### **Contents:**

Computer methods in design, Computer geometric modelling, Transformations, Projection, Process planning, Types of tool path generation methods for sculptured surfaces, CAD/CAM databases, Introduction to automated machine tools and cutting tools, Numerical control, motion control, CNC machine tools programming, Robotics, Configuration and motions.

### **Recommended Books:**

1. Mastering CAD/CAM by Ibrahim Zaid, McGrall-Hill
2. Principles of CAD/CAM/CAE Systems by Knunwoo Lee, Addison Wesley

### **Suggested Labs:**

Solid & Assembly Modelling using any CAD modelling software, Introduction to CNC (background and advantages), linear/circular interpolation (CNC lathe/mill), linear/circular steps turning, operating of CNC mill, sub programming, offsetting (CNC mill).

## **B) ENGINEERING FOUNDATION**

### **Operations Research**

**4(3,1)**

**Prerequisites:** Applied Linear Algebra

### **Objectives:**

The primary emphasis is on linear programming and its applications, covering modeling, fairly complex problems & solving those using computers, understand transportation and assignment problems, determining optimum solution of constrained resource allocation problems.

### **Contents:**

Application of Linear Algebra to Industrial Problems, Introduction to Linear Programming, Graphical method of solving L.P. problems, Simplex method, Duality and Sensitivity, Solving large scale problems using computer, Transportation and Assignment Problems, Network problems, shortest path, minimum spanning tree, maximum flow problems, Queuing theory.



### **Recommended Books:**

1. Operations Research by H. A. Taha, Prentice Hall
2. Operation Management-Strategy and analysis by Krajewsky and Ritzman
3. Operations Research by S. Kalavathy, Vikas Publishing House.
4. Operations Research: Applications and Algorithms by Wayne L. Winston

### **Suggested Labs:**

1. Familiarization with software like LINDO, TORA , LPEra, etc.
2. Mathematical modeling of real life problems.
3. Solving an LP problem using graphical method.
4. Solving a given LP problem and finding the relationship between solutions of Primal and Dual formulations.
5. Performing sensitivity analysis.
6. Solving assignment and transportation problems using Simplex Method.
7. Studying the effect of problem formulation on the number of iterations.
8. Comparison of actual number of iterations with the maximum possible iterations for a given formulation.

## **Metrology & Statistical Quality Control**

4 (3,1)

**Prerequisites:** *Probability and Statistics*

### **Objective:**

The course exposes the students to the principles of measurement, gauges and modern quality concepts and their practical use, the basic statistical & probability techniques and their usages in quality applications.

### **Contents:**

General principles of measurement, Geometric dimensioning and tolerances, Gauges and comparators, Interferometers and associated devices, Surface texture measurement, Study of frequency distributions and probability models in quality control, Sources of variation, Preparation and use of various control charts, Process Capability Indices, Construction of different sampling plans, Methods to quality improvement and analysis of quality costs, Computer applications in SQC.

### **Recommended Books:**

1. Quality Control by D. H. Besterfield, Pearson Education
2. Introduction to Statistical Quality Control by Douglas C. Montgomery
3. Engineering Metrology by J. F. W. Galyer and C. R. Shotbolt, Cassell Publishers Ltd
4. Statistical Methods for quality improvement by Hitoshi Kume, Association for overseas technical scholarships (A. O. T. S.) Japan

### **Suggested Labs:**

Use of gauges and measuring instruments such as vernier callipers, micro meters, gauge blocks, slip gauges, Go-Not gauges etc.  
Applications of comparators and surface measuring instruments.  
Data collection, tally sheets, pareto analysis, fishbone diagrams.  
Control charts for variables and attributes using mini tab.

## Mechanics of Materials

4 (3,1)

**Prerequisites:** *Materials Engineering*

### Objective:

This course allows engineers to predict failures and understand the physical and mechanical properties of materials. Students are exposed to basic engineering design concepts.

### Contents:

Mechanics of Deformable Bodies, Deformation, Strain, General stress-strain relationships, Elastic load-deformation behaviour of materials, Lateral strain, Thermal strain, Bending: Pure bending, Moment-curvature Relationship, Beam Deflection; Torsion and Twisting, Energy Methods, Stress and strain transformations, Mohr's stress/strain circle, Stress and strain transformation in composites, Yield and failure criteria of materials.

### Recommended Books:

1. Mechanics of Material. Beer, Johnson and Dewolf

### Reference Books:

2. Hibbeler, R. C. *Mechanics of Materials*. 6<sup>th</sup> Ed. East Rutherford, NJ: Pearson Prentice Hall
3. Lardner, T. J., R. R. Archer, S. H. Crandall, and N. C. Dahl. *An Introduction to the Mechanics of Solids*. 2<sup>nd</sup> Ed. New York: McGraw-Hill Primis Custom Publishing
4. Dowling, N. E. *Mechanical Behavior of Materials*. 2<sup>nd</sup> Ed. Upper Saddle River, NJ: Prentice-Hall

### Suggested Labs:

1. To study the Universal testing machine.
2. To determine the shear strength (single and double) of a metallic and non metallic (wood etc.) specimen.
3. To determine the hardness of different metallic specimens using a) Brinell b) Rockwell c) any other testing equipment.
4. To determine Modulus of Elasticity of a) rectangular section b) I-section beam using bending test.
5. To determine the Modulus Of Elasticity of a metallic specimen using tensile test.
6. To determine the stiffness of a) leaf b) helical coil spring by plotting load vs deflection graph.

## Basic Industrial Engineering

2 (2,0)

### Objective:

This course will provide an overview of basic industrial engineering principles.

### Contents:

Introduction to Industrial Engineering topics including, Project Management, Strategic IE decisions (product, process, location, layout), and tactical IE decisions (production, inventory, scheduling, and quality). Works and methods study. Awareness related to International Standards related to quality and environment, Environmental balance – Types of pollution (air, water and soil

pollution), Environmental impact of Engineering and Industrial activities, introduction to CBAs (collective bargaining agents).

### **Recommended Books:**

1. Introduction to Industrial & Systems Engineering by Turner, Mize, Case and Nazemetz, Prentice Hall
2. Environmental Science: Towards a sustainable future by Wright and Boorse
3. Environmental Science: Science, Principles and Practices by Das and Behera.

## **Engineering Drawing-I**

**1 (0,1)**

### **Objective:**

To familiarize the students with the basic concepts of engineering drawing and graphics.

### **Contents:**

Introduction. Types of lines, lettering, dimensioning, drawing instruments, planning of drawing sheet. Orthographic projections, plane of projections, projection of straight lines, traces of a line, true length of a line, inclination to both the planes, projection of oblique and auxiliary planes. Loci of Points and Generated Curves. Development of Solids. Intersection of Surfaces. Intersection of solids. Axonometric Projections. Types, Isometric projections of solids, planes, typical examples. Projection in Auxiliary Planes. Auxiliary planes and views, projection of points, line, plane. Projection of Solids, development of surfaces.

### **Recommended Books:**

1. Engineering Drawing and Graphics by T. E. French, C. J. Vierck, R. J. Foster
2. Practical Geometry & Engineering Graphics by Abbot.
3. Engineering Graphics by Craft, Meyers & Boyer

## **Engineering Drawing-II**

**2 (1,1)**

**Pre requisites: Engineering Drawing-I**

### **Objective:**

Introduction to modern tolerance interpretation of drawings and dimensions. Exposure to machine elements' and assembly drawing.

### **Contents:**

Introduction to geometric dimensioning and tolerances on engineering drawings for manufacturing and assembly operation, assembly and layout drawings. Introduction to tolerances for geometric features like straightness, flatness, circularity, cylindricity, parallelism, symmetry, rivets and riveted joints, screws, threads, bolts and nuts, couplings, bearings, keys and cotters, pulleys, and computer aided drafting.

### **Recommended Books:**

1. Engineering Drawing and Graphics by T. E. French, C. J. Vierck, R. J. Foster
2. Practical Geometry & Engineering Graphics by Abbot.
3. Engineering Graphics by Craft, Meyers & Boyer

### **Suggested Lab:**

Use of AutoCad

## **Manufacturing Systems**

**4 (3,1)**

**Prerequisites:** *Manufacturing processes*

### **Objectives:**

To familiarize the students with the analysis and design of manufacturing systems.

### **Contents:**

Introduction to Lean Manufacturing, Manufacturing automation fundamentals and strategies, High volume manufacturing systems, Flow lines, Assembly lines, Automated material handling and storage systems, Process planning, Group technology, Cellular manufacturing systems, Computer networks of manufacturing, Computer integrated manufacturing systems, Flexible manufacturing systems, Modeling of manufacturing systems.

### **Recommended Books:**

1. Automation, Production Systems and Computer Integrated Manufacturing by M. P. Groover, Prentice Hall
2. Modelling and Analysis of Manufacturing Systems by Askin and Standridge, John Wiley and Sons

### **Suggested Lab:**

1. Working applications of switches, sensors, encoders, servo and stepper motors, speed controller and PID controller
2. Use of Manufacturing System Simulation Software.

## **MATERIALS ENGINEERING**

**4 (3,1)**

### **Objective:**

To familiarize the students with various industrial materials, their properties and structural changes during manufacturing processes.

### **Contents:**

Types of materials, crystalline & amorphous materials, Solid solutions and phase diagrams, application of materials. Ferrous and Non-Ferrous Metals and alloys, their major properties and their heat treatment. Ceramics, Glasses, Rubbers & Refractory Materials, Polymers, Composites, Environmental Degradation, corrosion. Indigenous materials.

### **Recommended Books:**

1. Basic principles of material engineering by William F. Smith.
2. Fundamentals of material science and engineering: An integrated approach by W. D. Callister and D. G. Rethwisch.

### **Suggested Labs:**

Lab work to expose students to micro and macro examination of materials including sample cutting, grinding, polishing, mountings, heat treatment, study of micro structure, determination of grain size and phase analysis.

## **Industrial Facilities Design**

**3 (2,1)**

**Prerequisites:** *Work Study and Methods Engineering, Production Planning and Control*

### **Objective:**

To enable the students to understand facility design, Material handling equipment analysis, warehousing, layout and location and flow of material, Exposure to relevant computer software.

### **Contents:**

Location and Site selection, Facility design stages, processes, material handling equipment and analysis, Area allocation and space requirements, Flow analysis, fabrication of individual parts, total plant flow, Plant layout, Utilities Layout, Computerized facility layout and location, Strategies for storages.

### **Recommended Books:**

1. Manufacturing Facilities: Location, Planning & Design by D. Sule, B.W.S.- Kent Publishing Company
2. Facilities Planning by Tomkins & White, John Wiley

### **Suggested Lab:**

Hands on experience using relevant computer software

## **Workshop Practice**

**2 (0,2)**

### **Objective:**

The main focus to be on hand training of Workshop practice namely Machine shop including CNC, Wood working, fitting shop, fabrication & foundry etc.

### **Contents:**

Basic Processes in Fitter Shop, Bench-fitting practice; Exercise in marking and fittings, Basic Processes in Wood Work Shop, Use of carpenter's tools; Exercises in preparing simple joints; Use of measuring instruments.

Basics of Electric Shop, Functions of Forge & Foundry Shop, Machine Shop, Soldering, Brazing and Welding. Smith's forge; Exercise in bending, upsetting and swage. Heat treatment, Moulding and casting. Simple machine shop processes, such as turning, shaping, milling, Introduction to CNC Machines.

### **Recommended Books:**

1. Workshop Technology Part-1 by W. A. J. Chapman, McGraw-Hill  
Metal Work by LUDWIG
2. Manufacturing Processes by Ostwald

## **C. MAJOR BASED CORE (BREADTH)**

### **Operations of Manufacturing Systems**

4 (3,1)

**Prerequisites:** *Introduction to Engineering Management*

#### **Objective:**

The course aims at material requirements, resource planning and inventory management. The course enables the students to apply the acquired knowledge in real situations.

#### **Contents:**

Inventory Control, Material requirement planning, Manufacturing resource planning, Enterprise resource planning, Just in time, Total quality manufacturing, Factory dynamics, Push, Pull and hybrid systems, Inventory control in supply chain.

### **Recommended Books:**

1. Factory Physics by Hopp & Spearman, McGraw-Hill
2. Production and Operations Analysis by Steven Nahmias, McGraw-Hill

### **Suggested Labs:**

Tutorials & Case Studies on Inventory Control, MRP, Just in Time, Internal bench marking, CONWIP production lines and supply chain.

### **Instrumentation and Control**

4 (3,1)

#### **Objectives:**

Through problem solving and laboratory practice, this course provides a foundation in continuous-time linear control system theory. Further to that it provides a basic understanding of various gauges and transducers and a rational for their selection.

#### **Contents:**

Basic concepts, characteristics, functions of instruments especially for indicating and recording, length, weight, volume, temperature, pressure, flow level, etc. Measuring errors and calibration.

Introduction to the principles of automatic control systems encountered in Mechanical Engineering; Open-loop and closed loops systems. Control Modelling: Block diagrams, transfer functions, Laplace transforms, root locus, Bode diagram Frequency response.

Design parameters: Response Time, relative stability, Overshoot, settling time etc. Classical control systems modelling Temperature, speed, level, flow,

proportional, integral and derivative controls, mode of operation of hydraulic, pneumatic, and electrical components, amplifiers servomotors, process controllers, regulating valves, position transducers.

### **Recommended Books:**

1. Feedback Control of Dynamic Systems by Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, Pearson
2. Modern Control Systems (12<sup>th</sup> Edition) by Richard C. Dorf and Robert H. Bishop, Pearson
3. Instrumentation by Franklyn W. Kirk, Thomas A. Weedon and Phillip Kirk, ATP Publishers.

### **Suggested Lab:**

1. To draw the characteristics of temp measuring sensor (RTD, IC, TC, STT)
2. To draw the characteristics of light intensity measuring device (Photovoltaic, Photodiode, Photocell, Phototransistor)
3. To draw the characteristics of position sensing device (potentiometer)
4. To control the Position of a system (open loop, closed loop)
5. To control the Speed of a system (open loop, closed loop)
6. To Study the effects of Proportional, Integrative and Derivative Components on the Automatic Level Control System
7. PID control of Flow rate: Familiarization with the plant
8. Familiarization with Analogue Servo Trainer and Preliminary Procedures for Operation.
9. Parameter Determination of the Modular Servo System: Gain verification and summarization
10. Use of MATLAB/SIMULINK software for Modelling of open and close loop systems.

## **Manufacturing Processes**

**4 (3,1)**

**Prerequisites:** *Workshop Practice*

### **Objective:**

Enable the students to recognize the strong interrelationships between material properties and manufacturing processes.

### **Contents:**

Basic concepts of manufacturing processes, Casting processes, Furnaces, Forming and Joining processes, Welding, Brazing and soldering, Adhesive bonding, Traditional and non-traditional machining operations, capabilities and limitations, Rapid prototyping operations, Manufacturing of parts using polymer, composite and powder metallurgy, Process selection.

### **Recommended Books:**

1. Manufacturing Engineering Processes by L. Alting, Marcel Dekker
2. Material & Processes in Manufacturing by Paul De Garmo, Black and Kohser, Prentice Hall
3. Materials and Designs: The art and science of material selection in product design by M. F. Ashby and K. Johnson, Butterworth and Hienmann.
4. Fundamentals of Modern Manufacturing: Materials, processes and systems by M. P. Groover, John Wiley.

### **Suggested Labs:**

1. To Study various Safety Rules for Machining Shop.
2. To Study the Different Materials, their properties and uses in Metal Cutting.
3. To Study various parts and cutting tools used for a Lathe Machine.
4. To Study Various Operations that can be performed on a Lathe Machine.
5. To Make a Screw Jack (or some other component) according to given dimensions using different machining operations such as Turning, Facing, Threading, Knurling etc.
6. To Study and perform various welding processes such as Oxyacetylene gas welding and cutting , Electric Arc welding, Spot welding etc.
7. To Study and perform Non Traditional Machining (NTM) operations such as Electrical discharge machining (EDM) and Wire EDM etc.
8. Make a check list of the findings related to manufacturing of parts from given drawing
9. Develop a process plan for the given parts (machined, sheet metals, casting etc.)
10. Calculate the blank size of the given sheet metal part.

## **Production Planning and Control**

**3(2,1)**

**Prerequisites:** *Operations of Manufacturing Systems*

### **Objective:**

The course enables the students to use various forecasting methods & their applications, different production planning models & capacity requirement planning.

### **Contents:**

Study of different forecasting methods and their applications to various industrial and management problems, Analysis and design of production and scheduling control systems, machine sequencing, Flow shop, Job shop, Open shop, Algorithms for production planning and re-planning, Stochastic inventory models, Aggregate planning, Capacity requirements planning, Introduction to mixed production models.

### **Recommended Books:**

1. Operations Management by Heizer and Render, Prentice Hall
2. Elements of production planning and control by Samuel Eilon.
3. Principle of production control by J. L. Burbige.
4. Manufacturing Planning & Control by Vollmann, William Berry & Whybark, McGraw-Hill.
5. Factory Physics by Hopp & Spearman, McGraw-Hill.

### **Suggested Labs:**

Hands on work using any relevant software.



## **Industrial Maintenance and Safety**

3(3,0)

***Prerequisites: Human Factors Engineering, Operations of Manufacturing Systems***

### **Objectives:**

To up keep the plant and machines by removing every type of trouble and providing safe atmosphere in the organization to improve productivity and to enhance the efficiency and economy of the organization

### **Contents:**

Importance of plant maintenance, factors influencing the maintenance, Considerations in designing plant maintenance, Economic aspects of maintenance, care and maintenance of common industrial equipment (like bearings, piping, filters, pumps, compressors, and lubricating systems), maintenance linkage to safety, Different systems/types of maintenance, Laws of Accident Proneness, Accidents preventions. Legal, humanitarian & economic reasons to Prevent Accidents, Safety Measures, Analysis & Procedures, Safety equipment, OHSAS 18000.

### **Recommended Books:**

1. Maintenance Manager's Standard Manual by Thomas A. Wester-Kamp, Prentice-Hall
2. A Guide to Effective Industrial Safety by Jack W. Boley, Gulf Publishing Company

## **Work Study and Methods Engineering**

3 (2,1)

***Prerequisites: Manufacturing Processes***

### **Objective:**

Course gives fundamental concepts and techniques to analyze the work and find ways to improve the methods used.

### **Contents:**

Introduction to work analysis and design, Methods engineering: study of the basic work measurement techniques, applications and limitations of the stop-watch time study, learning curve, Development and use of process flow charts, pre-determined motion time studies (PMTS), micro motion analysis, Human factors underlying the design of specific human-machine systems, Techniques of work optimization, energy expenditure and bodily functions.

### **Recommended Books:**

1. Motion and Time Study by Benjamin W. Niebel, McGraw-Hill
2. Time and Motion study by I. L. O.

### **Suggested Labs:**

1. Study through videos
2. Study of simple assembly operations
3. Estimation of process duration through PMTS
4. Development and use of process flow charts
5. Any other lab on discretion of the instructor.

## Human Factors Engineering

3 (2,1)

**Prerequisites:** *Work Study and Methods Engineering*

### **Objective:**

The course enables the students to understand and analyze man-machine interaction, including an introduction to the relevant underlying human sciences.

### **Contents:**

Introduction to Human Factors Engineering, Human Characteristics relevant to ergonomics. Information on Human Role in artificial Intelligence, information by text, graphics and symbols. Anthropometry, Anthropology, Principles of workplace design, Equipment and work space, Failure of design, Climatic Factors, Noise and Vibration, Effects of noise on various organs and its prevention, visibility (Illumination, contrast, quality, colour etc.) and its effects, Basic concepts of Human Error detection and reduction. The role of controls in advanced technology, Control devices.

### **Recommended Books:**

1. An Introduction to Human Factors Engineering by Wickens, Gordon, Liu.
2. Hand-Book of Industrial Engineering: Technology and Operations, by Salvendy G., McGraw-Hill,
3. Human Factors Engineering & Design by Sanders & Mc Cormick.

### **Suggested Labs:**

1. Study of various types of workplaces
2. Noise measurement at different places
3. Illumination measurement at different places
4. Any other lab on discretion of the instructor.

## **D. MAJOR BASED CORE (DEPTH)**

### **Computer Integrated Manufacturing (CIM)**

4 (3,1)

**Prerequisites:** CAD/CAM, Industrial Facilities Design

### **Objective:**

To expose the students to CIM in general and SME in Specific. The course would make students apply CIM to the local environment and establish strategic alliance in top management support.

### **Contents:**

Introduction to Computer Integrated Manufacturing, components of CIM system, CIM modelling, data flow diagrams and IDEF models, Integration of interconnected networks, computer network protocols, integrated approach to CIM justification and optimization, assessing the impact of investment in CIM, a decision support system for CIM investment, guidelines for implementing CIM, Application of CIM System in small & medium enterprises (SMEs),

### **Recommended Books:**

1. CIM justification and optimization by Lin and Nagalingan, Taylor and Francis Taylor and Francis.

2. Computer Integrated Design and Manufacturing by Nanua Singh, John Wiley & Sons.
3. Computer Networks for World Class CIM systems by Paul G. Ranky, CIMware Ltd.

### **Suggested Lab:**

- 1) Part programming on CNC machines
- 2) Part storage/retrieval programs and applications
- 3) Automated part identification
- 4) Part handling by robots and AGV
- 5) Use of CMM
- 6) Simulation of CIM
- 7) IDEF models development
- 8) Study of a decision support system

## **Virtual Reality**

**4 (3,1)**

***Prerequisites: Computer Simulation, Manufacturing Systems***

### **Objectives:**

To familiarize the students with the world of virtual manufacturing and enable them to apply the knowledge where real manufacturing facilities are not available (academic level).

### **Contents:**

Virtual reality applications in manufacturing systems design, manufacturing applications of networked virtual reality, virtual reality modelling of occupational safety engineering. Manufacturing systems design optimization using virtual environments, optimization of manufacturing decision support using virtual reality interfaces, analysis and evaluation of virtual environments.

### **Recommended Books:**

1. Virtual and Augmented Reality applications in manufacturing by Ong, S. K. and Nee, A. Y. C, Springer
2. Introductory Techniques for 3D computer vision by Trucco, E. and Verri, A., Prentice Hall.

### **Suggested Lab:**

1. The working of manufacturing and automation modeling using CAD/CAM and computer-integrated manufacturing methods
2. Working of Virtual CIM Laboratory
3. Working of industrial robots in virtual environment
4. Working of highly automated manufacturing system/factory in virtual environment
5. Study the operation of automated manufacturing systems in virtual environment
6. Virtual reality modeling of occupational safety engineering

## **Metal Forming and Cutting Analysis**

**4 (3,1)**

***Prerequisites: Manufacturing Processes***

### **Objective:**

The course aims to give the students the basic understanding of forming and machining processes. Students will learn how to classify the processes, effect of tool material and tool geometry. Exposure to design of jigs and fixtures.

### **Contents:**

Objectives of Metal Forming Processes, Classification of processes, Sheet metal formability, Analysis of bending, Drawing; Rolling, Extrusion and Forging Processes, Evaluation of machining performance and its optimization, Objectives of metal cutting processes, Cutting mechanisms, Material removal operations, Cutting tool materials and geometry, Effects of different cutting parameters on tool life and cutting forces, Tool design, Jigs and fixtures design.

### **Recommended Books:**

1. Manufacturing Engineering & Technology by Kalpakjian & Schmid, Prentice Hall
2. Metal forming: Mechanics and Metallurgy, W. F. Hosford, R. M. Caddell, Cambridge University Press.
3. Fundamentals of Metal Machining and Machine Tools by G. Boothroyd, McGraw-Hill Inc.

### **Suggested Labs:**

1. To Study various Safety Rules for a Machining Shop.
2. Transformation of given Specimen into the Shape through Machine as per given Specification using different material removal processes.
3. To analyse wear patterns on different types of tools (lathe, Milling, drilling etc.) using tool makers (or any type of available) microscope.
4. To perform different type of sheet metal shearing/bending operations (Punching, Piercing), Blanking, Notching, Perforating, Slitting, v-bending, edge bending etc.) using power (any type of available) press

## **Tool and Die Design**

**4 (3,1)**

***Prerequisites: Mechanics of Materials***

### **Objective:**

This course would familiarize the students with: Jigs and Fixtures, Dies for various sheet metal operations, Fixtures for welding and riveting

### **Contents:**

Tool and die design, Tool materials, Work holding principles, Jigs and Fixtures design, Tools for inspection and gauging, Forming and drawing tools, Tool design for joining processes, Computers in tool design. Terminology for press working operations, Mechanical, hydraulic and pneumatic presses, Design of piercing, Blanking and shearing dies, Design of bending, forming and drawing dies, Design of Plastic injection dies, dies for pressure die casting.

### **Recommended Books:**

1. David Splitter, Fundamentals of Tool Design, Society of Manufacturing Engineers
2. CAD/CAM/CAE-Technology and Design Tools
3. Tool and Manufacturing Engineers Handbook, Society of Manufacturing Engineers
4. Prakash Hiralal, Jigs and Fixtures Design Manual

### **Suggested Labs:**

1. To Study/survey different metals for making/manufacturing of tools
2. To study different clamping, locating and locking components for jigs fixtures
3. To Study the working of power/hydraulic press.
4. To design a blanking die for a typical part.
5. To study the function of compound dies
6. To Study of Progressive Dies
7. To study the function of different components of an injection mould and their working principles.
8. Designing of Plastic Injection Moulds using CAD software.

## **Automation and Robotics**

**4 (3,1)**

***Prerequisites: Instrumentation & Control, Manufacturing Systems***

### **Objective:**

The course will enable students to understand control fundamentals, design of control system focusing process control, manufacturing systems, interfacing etc.

### **Contents:**

Process control fundamentals, Relay logic and various control devices, Architecture of programmable logic control units, Introduction to distributed control system (DCS) and SCADA Sensors for industrial processes, D/A and A/D converters, Industrial processes interfacing with micro-processors, practical applications, Introduction to Robotics, Robot anatomy, Robot configuration, accuracy & Repeatability, Robot specifications, end effectors, Kinematics and Dynamics, Characteristics of Robot applications, Robot Cell Design, types of Robot Applications.

### **Recommended Books:**

1. Computer Automation in Manufacturing by Thomas O. Boucher, Chapman & Hall.
2. Automation, Production Systems & Computer Integrated Manufacturing by Mikell P. Groover, Prentice Hall.

### **Suggested Lab:**

1. Practicals on various control devices.
2. PLC introduction and Programming (Ladder Diagram)
3. Simulation and Interfacing with Programmable Logic Controller (PLC)
4. SCADA System (Automation Applications)
5. Study and use of Robot for various applications
6. Any other lab on discretion of the instructor.

## **Reliability Analysis**

**3 (3,0)**

***Prerequisites: Probability and Statistics***

### **Objective:**

The course will enable students to analyze failure mode & effects, to optimize reliability and to develop system reliability models.

### **Contents:**

Introduction to Reliability Engineering, Catastrophic failure models and reliability functions, Failure distributions, Failure data analysis, System reliability evaluation techniques, Reliability optimization, Fault tree analysis, Reliability testing; Load-strength interference models.

### **Recommended Books:**

1. An Introduction to Reliability & Maintainability Engineering by C. E. Ebeling, McGraw-Hill.
2. Reliability in Engineering Design by K. C. Kapur & L. R. Lamberson.

## **Human Resource Management**

**3 (3,0)**

### **Objectives:**

To understand the historical evolution of Human Resource Management and the different motivational theories, applications and influences in an organization and to equip students with the process of man power planning, recruitment, industrial relations and administration.

### **Contents:**

Theory and practice of HRM, Work groups and their implications for motivation and job satisfaction, Theories of motivation, Manpower planning, Recruitment and selection process, Training and Development, Appraisal Methods. Principles of wage and salary administration, Job analysis & Description, Job Design, Industrial Relations, Causes of Industrial disputes and their resolutions.

### **Recommended Books:**

1. Managing Human Resources by Wayne Cascio.
2. Human Resource Management by De Cenzo Robbins
3. Elements of Personnel Management by Pratt, K. J. and Bennett, S. G. Gee & Co.

## **Total Quality Management**

**4 (3,1)**

### **Objective:**

To make the students understand the philosophy of total quality management and ways of its implementation in the organisation.

### **Contents:**

Understanding quality, commitment and leadership, design for quality, planning for quality, quality system requirements, quality measuring tools and the improvement cycle, Quality assurance, ISO 9001, Six sigma, Kaizen, Balanced score card.

### **Recommended Books:**

1. Total Quality Management with text cases by John S. Oakland, Butterworth-Heinemann
2. Total Quality Management by Besterfields, Prentice Hall

### **Suggested Labs:**

Use of Minitab/SPSS/Excel

## **Logistic & Supply Chain Management**

**3 (3,0)**

***Prerequisites: Production Planning and Control***

### **Objective:**

The aim of the course is to help students learn how to develop facility requirement profile and to eliminate the non value added activities.

### **Contents:**

The logistical system of material management, Developing a value based Supply Chain, optimization of Supply Chain, Strategic relationships in logistics, process methodology, Issues concerning marketing channels functions, Determining the facilities requirement profile, Managing logistics facilities. Developing the logistics organization for effective supply chain management, Customer service and Customer retention.

### **Recommended Books:**

- 1) Managing the supply chain: A strategic Prospective by J. L. Gattorna and D. W Walters, MacMillan Business Company
- 2) Logistic and supply chain management: Strategies for reducing costs and improving services by Martin Christopher, Pitmann Publishing Company.
- 3) Supply Chain Management, Theories & Practices. R. P. Mohanty & S. G. Deshmukh. Biztantra Publishing.

## **Marketing Management**

**3(3,0)**

### **Objective:**

To understand the intricate relationships of various factors which influence the Marketing Environment and also the determining factors which help in understanding the consumers' behaviour.

### **Contents:**

Role and scope of marketing, classification of marketing activities, needs, wants and demands, exchange process, Customer value & satisfaction, Retaining Customers, Social influence on consumers, Informational influences on consumers, Consumer Behaviour and Market Segmentation, Principal Marketing Strategies, Strategic Alternatives, Selecting the pricing objectives, Factors affecting price sensitivity, Selecting a Pricing Method, Setting Advertising objectives and methodologies.

## **Recommended Books:**

1. Marketing Management by Parag Diwan, Progressive International Agency, London
2. Marketing Management by Philip Kotler, Prentice Hall

## **Financial Management**

**3 (3,0)**

### ***Prerequisites: Managerial Accounting***

### **Objective:**

The objective of this course is to introduce to the students the basic tools and techniques required in modern financial management. The course will improve the analytical skills of the future managers.

### **Contents:**

Scope and importance of Financial Management, Functions of Financial Manager, Valuation, Ordinary, Due and Perpetuity, Amortization of Loan, Bond Valuation, Financial Statements, Trend Analysis, Common size and Index Analysis, Funds Analysis, flow and Funds statement. Sources and Uses of Funds, Working Capital Management, Factors influencing working capital requirements, Cash Management, Motives for holding cash, Speeding up cash receipts, slowing down cash payments, Receivable Management, Credit & Collection policies, Analyzing the credit applicant, Inventory Management and control, Short term Financing. Spontaneous financing, Factoring A/R Capital Budgeting process.

## **Recommended Books:**

1. Fundamentals of Financial Management, by Van Horn.
2. Fundamentals of Financial Management, by Rao.
3. Financial Management by George E. Pinches, Harper Collins College Publishers
4. Financial Management by George E. Pinches, Harper Collins College Publishers

## **Managerial Accounting**

**3 (3,0)**

### **Objectives:**

To train the students to prepare balance sheet, profit and loss statements.  
To assess and analyse any business organization financially with the help of financial reports and utilize the resources and assets effectively to make them profitable.

### **Contents:**

Managerial accounting, Money measurement concept, Financial accounting and managerial accounting, Balance sheet, Financial statement, Income Statement, Book keeping, Debit & Credit, Applications to investment decisions, Return on investment, Cash in-flow, Economic life, Rate of return, Investment turn over and profit margin, Tests of investment utilization, Assets and their types, liabilities and owners equity, cost accounting and control, basic frame work of budgeting.



### **Recommended Books:**

1. Managerial Accounting (Concept for Planning, control, decision making), by Ray H. Garrison & Eric W. Noreen
2. Managerial Accounting by Jack L. Smith, Robert M. Keith & William L. Stephens

## **ENTREPRENEURSHIP**

**3 (3,0)**

### **Objective:**

After studying this course the students should be able to evaluate & improve their entrepreneurial potential and be able to generate and test innovative ideas suitable for commercialization.

### **Contents:**

Role of Entrepreneurship in Economic Development, Characteristics of Successful Entrepreneurs, Types of Start-ups. Creativity, Methods of generating innovative ideas. Legal Issues including Patents, Trademarks, Copyrights, Trade Secrets, Licensing, Liability, Insurance, Contracts etc. The Concept of Planning Model, Pre-start-up Stage, Start-up Stage, Early Growth Stage, Later Growth Stage, Fundamentals of a Feasibility Plan. Role of Manufacturing, Products and Technology, Identifying Opportunities.

### **Recommended Books:**

- 1) Entrepreneurship. by Hisrich, Peters & Shepherd (6<sup>th</sup> Ed.). McGraw-Hill/Irwin
- 2) Entrepreneurship: New Venture Creation by David H. Holt. Prentice Hall

## **Management Information Systems**

**4 (3,1)**

### ***Prerequisites: Introduction to Computing***

### **Objective:**

To enable the students to understand the industrial information and retrieval systems, collecting and recording, analyzing and presenting data, data processing technologies, databases and security issues.

### **Contents:**

Analysis, design and implementation of Industrial information and retrieval systems with special emphasis given to manufacturing systems, gathering, recording, analyzing and presenting the data requirements of an organization, Data processing technologies, Databases and their applications, Data protection, Networking, Backup and security.

### **Recommended Books:**

1. Management Information Systems by K. C. Laudon & J. P. Laudon, Prentice Hall

### **Suggested Lab:**

Use of Microsoft Access to create databases

## Organizational Behaviour

3 (3,0)

**Prerequisites:** *Human Resource Management*

### **Objective:**

To make the students aware of organizational structures and work environment.

### **Contents:**

Organizational behaviour with reference to global and cultural diversity. Behaviour and perception of individuals, Attitudes and job satisfaction, Basic motivation concept, Group behaviour, Team work, Communication, Leadership, power and Politics, Conflict and negotiations, Organization structure, Technology, Work design and stress management, Approaches to managing organizational change.

### **Recommended Books:**

1. *Organizational Behaviour by Robbins*; Stephen R., Prentice Hall.

## **E. INTER-DISCIPLINARY ENGINEERING BREADTH (ELECTIVES)**

### **Introduction to Thermo-fluids**

4 (3,1)

### **Objectives:**

To introduce basics of thermodynamic properties, laws of thermodynamics and their application to power and refrigeration cycles. Introduction of basic modes of heat transfer. Formulation of basic equations for Fluid Engineering problems. To determine the friction energy loss for various pipes/ducts geometries and Fluid engineering applications. Introduction to hydraulic machinery.

### **Contents:**

Introductory concepts & definitions, using energy and the laws of thermodynamics, evaluating properties, Control Volume analysis using energy, Second law of thermodynamics, Vapour power and refrigeration systems, Brayton and Rankine cycles, Regeneration cycles. Psychometric Applications. Modes of heat transfer and their rate equations, Fluids and their properties, Fluid Statics, Pressure measurement: Bourdon pressure gauge, Manometers, Forces on a plane area and curved surfaces. Kinematics of fluid flow: Laminar and Turbulent flow, Flow through pipes: loss of head due to friction in pipes, Moody Charts. Introduction to hydraulic machinery.

### **Recommended Books:**

1. Fundamentals of Engineering Thermodynamics by Michael J. Moran and Howard N. Shapiro
2. Introduction to thermal systems engineering: Thermodynamics, fluid Mechanics and heat transfer by Michael J. Moran, Howard N. Shapiro, Bruce R. Munson.
3. Fundamentals of Fluid Mechanics by Bruce R. Munson, Donald F. Young and Theodore H. Okiishi

### **Suggested Lab:**

- 1) Determination of time constants of various temperature measuring devices
- 2) Study of Ideal Vapour-Compression Cycle
- 3) Study of Rankine Cycle
- 4) Study of Bryton Cycle
- 5) Hydrostatic pressure on submerged plane
- 6) Differential pressure measurements using various manometers
- 7) Reynolds experiment (laminar and turbulent flow)
- 8) Flow from orifice in the side of a tank (Bernoulli's Equation)
- 9) Flow measurement with Venturi meter
- 10) Conservation of momentum (Impact of a Jet)
- 11) Pressure loss calculations in pipe networks
- 12) Conductive heat transfer rate calculations.
- 13) Determination of heat transfer rate in free convection
- 14) Determination of heat transfer rate in forced convection

### **Design of Experiments**

**3 (3,0)**

**Prerequisites:** *Probability and Statistics*

#### **Objective:**

The course enables the students to understand modern techniques based on statistical analysis and apply those to improve productivity & quality.

#### **Contents:**

Introduction to design of experiments and its applications in industry, Hypothesis testing on means and variances, Analysis of variance, fixed and random effects models, error analysis, Block designs, randomized complete and incomplete block design, Latin square design, factorial design, fixed, random and mixed factors designs, Introduction to response surface methodology. Packages like Minitab & Design Expert can be used.

#### **Recommended Books:**

1. Design and Analysis of experiments, Douglas C. Montgomery, John Wiley and Sons.
2. Experiments: Planning, Analysis and Parameter design Optimization, Wu and Hamada, John Wiley.

#### **Suggested Labs:**

1. Comparison of results of paired t-test with those from pooled and un-pooled variance for a given data set.
2. Coding/ scaling of variables while designing an experiment.
3. Validation of modeling assumptions (normality, constant variance, randomness).
4. Transformation and its effect on the validity of modelling assumptions.
5. Blocking of a nuisance variable.
6. Performing full factorial and fractional factorial analyses and comparison of coefficients by undoing the confounding effect.
7. Contrast formulation and comparisons,
8. Application of nested design.

# NON-ENGINEERING DOMAIN

## English-I (Functional English)

3 (3,0)

### Objectives:

To enhance language skills and develop critical thinking

### Course Details:

Basics of Grammar

Parts of speech and use of articles

Sentence structure, Active and passive voice

Practice in unified sentence

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 (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

### Listening

To be improved by showing documentaries/films carefully selected by subject teachers)

### Translation skills

Urdu to English

### Paragraph writing

Topics to be chosen at the discretion of the teacher

### Presentation skills

Introduction

**Note: Extensive reading is required for vocabulary building**

### Recommended Books:

#### a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises. Third edition. Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A. J. Thomson and A.V. Martinet. Exercises. Third edition. Oxford University Press. 1997. ISBN 0194313506

#### b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

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

d) Speaking

**English II (Communication Skills)**

**3 (3,0)**

**Objectives:**

To enable the students to meet their real life communication needs

**Course Details:**

**Paragraph writing**

Practice in writing a good, unified and coherent paragraph

**Essay writing**

Introduction

**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 and minutes of the meeting, use of library and internet recourses

**Presentation skills**

Personality development (emphasis on content, style and pronunciation)

**Note: documentaries to be shown for discussion and review**

**Recommended Books:**

**a) Grammar**

1. Practical English Grammar by A.J. Thomson and A.V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.

**b) Writing**

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

### **c) Reading**

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
2. Reading and Study Skills by John Langan
3. Study Skills by Richard Yorky.

## **English III**

**(Technical Report Writing and Presentation Skills) (3,0)**

### **Objectives:**

To enhance language skills and develop critical thinking

### **Course Details:**

#### **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 and presentation**

***Note: Extensive reading is required for vocabulary building***

### **Recommended Books:**

#### **a) Essay Writing and Academic Writing**

1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
3. Patterns of College Writing (4<sup>th</sup> edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

#### **b) Presentation Skills**

#### **c) Reading**

The Mercury Reader. A Custom Publication. Compiled by northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

## Applied Linear Algebra

3 (3,0)

### Objective:

To familiarize the students with vectors, matrices, determinants, linear combinations and spaces and enable them to understand the related Geometry.

### Contents:

Vector Algebra, Matrix Algebra, Determinants, Linear System of Equations, Linear Transformations, Eigen-values and Eigenvectors

### Recommended Book:

1. Linear Algebra and its Applications by David C Lay, Addison-Wesley

## Calculus

3 (3,0)

### Objective:

To learn fundamentals of mathematics, calculus and analytical geometry.

### Contents:

Complex Numbers, De'Moivre's Theorem, Functions: Hyperbolic, Trigonometric and Exponential Functions, Differentiation and its Application to Rate, Speed and Acceleration, Leibnitz's Theorem, Equations of Tangents and Normals, Curvature, Radius and Centre of Curvature, Maxima and Minima of Function, Convexity and Concavity, Taylor's and McLaurin's Series and Expansion of Functions, Errors and Approximations and Limiting Values of Functions, Partial Differential, Euler's Theorem, Integral Calculus: Standard Integrals, Integration by Substitution, by Partial Fractions and by Parts, Integration of Trigonometric Functions, Definite Integrals, Two and three dimensional integration, Volumes of Solids of Revolution

### Recommended Books:

1. Schaum's series, Calculus, Schaum's Series (Latest Edition)
2. Schaum's series, Complex, Schaum's series, (Latest Edition)
3. Antom, H. Calculus and Analytic Geometry, John Wiley and Sons. (Latest Edition)
4. Talpur, Calculus and Analytic Geometry, Feroz Sons (Latest Edition)
5. Yousuf, S. M. Mathematical Methods, Ilmi Kutab Khana (Latest Edition)
6. Mathematics for Engineers by Robert D. Wesley, McGraw-Hill
7. Multivariate Calculus by Robert T. Smith, Roland B. Minton, McGraw-Hill

## Differential Equations

3 (3,0)

### Objective:

To introduce basic techniques pertaining to matrices and formulation/solution of differential equations.

### Contents:

#### **Ordinary Differential Equations:**

Basic concepts of ordinary differential equation, General and particular solutions, Initial and boundary conditions, Linear and nonlinear differential equations, Solution of first order differential equation by separable variables and its applications in our daily life situations, The techniques like change of variable,

homogeneous, non homogeneous, exact, non-exact, linear and nonlinear Bernoulli could be used in case of complications. Solution of second order differential equation by theory of operators and its applications as forced and free oscillations, The extension of second order solution criteria to higher order differential equations, Solution of the system of differential equations by theory of operators and its applications in our daily life situations, Laplace solution of ordinary differential equations.

### ***Partial Differential Equations:***

Basic concepts, Linear and nonlinear p.d. equations, Quasi linear and Quasi nonlinear p.d. equations, Homogeneous and non-homogeneous p.d. equations, Solutions of p.d. equations, Boundary and initial conditions as Dirichlet condition, Neumann condition, Robbins/Mixed condition, Classification of p.d. equations as Elliptic, Parabolic and Hyperbolic.

Analytic solution by separation of variables of the Steady-state Two-Dimensional Heat equation/Laplace equation and Unsteady-State One-Dimensional Heat equation/Diffusion equation with homogeneous and non homogeneous boundary conditions. D' Alembert's solution of two-dimensional wave equation with homogeneous and non homogeneous boundary conditions.

Fourier Series:

Periodic waveforms and their Fourier representations, Calculating a Fourier series, Fourier series of odd and even functions, Half range Fourier series, Fourier series solution p.d. equations.

### **Recommended Books:**

1. Modern Differential Equations by Abell and Braselton, McGraw-Hill
2. Advanced Engineering Mathematics by Louis C. Barrett, McGraw-Hill
3. Ervin and Kreyszig, E. Advanced Engineering Mathematics, John Wiley and Sons, (Latest Edition).
4. Speigal M. R., Theory and Problems of Laplace Transforms, Schaum's Outline Series.

## **Engineering Economics**

**3 (3,0)**

### **Objective:**

The course would expose students to Engineering Economy techniques, primarily related to performing analysis, synthesizing and coming to a conclusion on projects of all sizes covering a wide range of engineering oriented examples.

### **Contents:**

Introduction to engineering economics, Micro and macro economics, Break even analysis, Balance sheet, Cost and investment analysis, Basis for comparison of alternatives, Time value of money, Decision making in present economy, Evaluating replacement alternatives, Cash flow, Interest formulas and equivalence, Depreciation, Economic analysis of operations, Economic analysis of projects.

### **Recommended Books:**

1. Engineering Economy by Leland T. Blank, Anthony J. Tarquin McGraw-Hill
2. Fundamentals of Engineering Economics (2<sup>nd</sup> Edition), Chan S. Park, Pearson Education.



3. Engineering Economy (15<sup>th</sup> Edition) by William G. Sullivan, Elin M. Wicks and C. Patrick Koelling, Pearson Education.

## **Introduction to Engineering Management**

**3 (3,0)**

### **Objective:**

The course would enable students to widen their knowledge and understanding of a range of current and developing engineering management issues, management principles and practices.

### **Contents:**

The vision and mission of management, The management process and strategy, Strategic management, The planning process, Organization structures, Human factors, Motivation & leadership, Basics elements of control, Managing, designing and new product development, Managing the supply systems, Marketing, introduction to entrepreneurship.

### **Recommended Books:**

1. Managing Engineering and Technology by Babcock and Morse, Prentice Hall
2. Management by Herald Koontz
3. Management by Robbins Coulter
4. ISO-10007 Quality management systems-Guidelines for configuration management.
5. MIL-HDBK-61A (SE) Military handbook-configuration management guidance.
6. MIL-STD 31000 Technical data packages.

## **Islamic Studies/Ethics**

**2 (2,0)**

### **Objectives:**

The course is to enhance vision and facilitate application of Islamic ideology in the real world. The student should be able to find solutions to problems within Islamic practices comfortably instead of alien. Know how a Muslim could essentially use Islamic tools in the world and earn eternal peace as grater value assumption.

### **Contents:**

(A) ISLAMIC STUDIES (For Muslims)

QURAN SHARIF.

Fazail Quran (Importance of Quran) as the ultimate source of knowledge for the betterment of mankind.

Importance of Sunnah, as practical demonstration of Al-Quran and Huqooq-ul-Ibaad.

DEEN-E-ISLAM.

Tauheed, Risalat and Aakherat for eternal peace of mankind.

Concept of Rizk-e-Halal (verses from Al-Quran) and Professional Ethics in the light of Al-Hadith.

Importance of Prayers, Fasting Zakat, Hajj and Jihad in professional performance.

Uswatul Hassanah as vision for workplace and social environmental improvement

Learning from Makki and Madani life of Prophet Muhammad (SAWW) and Sahaaba as leadership and team for commitment and continuous improvement.

Core policies behind Spreading of Islam تبليغ اسلام and the application of Philosophical thoughts behind Mithaq-Madina, ميثاق مدينه, Fateh-e-Mecca, فتح مكة and Hajjatul-vida حجة الوداع for regional and global relations.

Islamic lawfulness, Heritage, Solutions to humanitarian problems, future, oneness, political solidarity as road map to civic civilization.

Importance of honest character, practicing ways for avoiding of sins according to Islam.

Application of Sidq, ,esimorp fo tnemlifluf eht ةوقته ,auqaT لكوٲ ,lakkawaT قٲصٲ اسٲ ,yticilpmiS دلھعإڊيا .ssenevigrof eht dna ytilauqe ,ecneidebo ,tcepsr اسٲ

## **(B) Ethics (For Non-Muslims)**

Ethical techniques of world religions with special reference to Hinduism, Budhism, Judaism, Christianity and Islam. One hundred ethical presentations from Quran and sayings of the Prophet.

Islam's attitude towards minorities

Promotion of moral values in the society.

A brief review of ethical systems in philosophy

## **Logic and Critical Thinking**

**3 (3,0)**

### **Objective:**

The primary objective of this course is to impart a functional ability to reason well; to improve analytical skills and instincts, familiarizing with elementary methods of argument composition, analysis and reasoned decision making.

### **Contents:**

- The Power of Critical Thinking
  - Claims and Reasons, Reasons and Arguments, Arguments in the Rough
- The Environment of Critical Thinking
  - Perils of Haunted Mind, Self and the Power of the Group, Subjective and Social Relativism, Skepticism
- Making Sense of Arguments
  - Arguments Basics, Patterns, Diagramming Arguments, Assessing Long Arguments,
- Reasons for Belief and Doubt
  - Conflict Experts and Evidence, Personal Experience, Fooling Ourselves, Claims in the News
- Faulty Reasoning
  - Irrelevant Premises, Genetic Fallacy, Composition, Division, Appeal to the Person, Equivocation, Appeal to Popularity, Appeal to Tradition, Appeal to Ignorance, Appeal to Emotion, Red Herring, Straw Man
- Unacceptable Premises

- Begging the Question, False Dilemma, Slippery Slope, Hasty Generalization, Faulty Analogy
- Deductive Reasoning: Propositional Logic
  - Connectives and Truth Values, Conjunction, Disjunction, Negation, Conditional, Checking for Validity, Simple Arguments, Tricky Arguments, Streamlined Evaluation
- Deductive Reasoning: Categorical Logic
  - Statements and Classes, Translations and Standard Form, Terms, Quantifiers, Diagramming Categorical Statements, Sizing up Categorical Syllogisms
- Inductive Reasons
  - Enumerative Induction, Sample Size, Representativeness, Opinion Polls, Analogical Induction, Casual Arguments, Testing for Causes, Casual Confusions
- Inference to the Best Explanation
  - Explanations and Inference, Theories and Consistency, Theories and Criteria, Testability, Fruitfulness, Scope, Simplicity, Conservatism
- Judging Scientific Theories
  - Science and Not Science, The Scientific method, Testing Scientific Theories, Judging Scientific Theories, Copernicus versus Ptolemy, Evolution Versus Creationism, Science and Weird Theories, Making Weird Mistakes, Leaping to the Weirdest Theory, Mixing What Seems with What is, Misunderstanding the Possibilities, Judging Weird Theories, Crop Circles, Talking with the Dead

### **Recommended Books:**

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

## **Project Management**

**4 (3,1)**

**Prerequisites:** *Engineering Economics, Introduction to Engineering Management*

### **Objective:**

The course enables the students to understand and implement modern project management techniques (using software) related government regulations.

### **Contents:**

Project management concepts, project proposals and feasibility, initiating, Planning, execution, monitoring and control, closing and Exit strategy, knowledge areas as per PMBOK/PRINCE-2, introduction to any Project Management's Software.

### **Recommended Books:**

1. Project Management: A Systems Approach to Planning, Scheduling, and Controlling by Harold Kerzner, John Wiley
2. Case studies in project management, 2<sup>nd</sup> edition, by Harold Kerzner, John Wiley

3. Project Management Body of Knowledge (PMBOK) 4<sup>th</sup> edition, by P.M.I.

### **Suggested Labs:**

Hands on practice using M.S. Project/Primavera etc.

## **Numerical Analysis**

**3 (3, 0)**

**Prerequisites:** *Probability & Statistics, Introduction to Computing*

### **Objective:**

To enable the students to apply their knowledge of calculus for solving such mathematical problems that cannot be solved using analytical techniques.

### **Contents:**

Finite differences and operators form, Interpolation and extrapolation; Lagrange's interpolation, Numerical differentiation based on differences, Numerical integration: Trapezoidal and Simpson's approximations, Romberg integration process, Numerical Solution of non-linear equations; Bracketing and iteration methods, Direct solution of system of linear equations; Gauss-elimination, Direct and indirect factorization, symmetric factorization, tri diagonal factorization, Iterative methods like Jacobi's iteration and Gauss-Seidel iteration, Single and Multi-step methods, Higher order differential equations, System of differential equations, Numerical solution of linear and nonlinear boundary value problems.

### **Recommended Books:**

1. Numerical Methods for Engineering, Science and Mathematics by Mumtaz Khan
2. Ordinary & Partial Differential Equations with Numerical Techniques for Engineering, Science and Mathematics by Mumtaz Khan

## **Pakistan Studies**

**2 (2,0)**

### **Objectives:**

- To develop vision of Historical Perspective, Government, Politics, Contemporary Pakistan, ideological background of Pakistan.
- To study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

### **Contents:**

#### **1. Historical Perspective**

- a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
- b. Factors leading to Muslim separatism
- c. People and Land
  - i. Indus Civilization
  - ii. Muslim advent
  - iii. Location and Geo-Physical features.

## 2. Government and Politics in Pakistan

Political and constitutional phases: 1947-58, 1958-71, 1971-77, 1977-88, 1988-99, 1999 onward

## 3. Contemporary Pakistan

Economic institutions and issues, Society and social structure, Ethnicity, Foreign policy of Pakistan and challenges, Futuristic outlook of Pakistan

### Recommended Books:

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

## Applied Physics

3 (2,1)

### Objective:

To familiarize the students with basic sciences and their applications in practical life.

### Contents:

Vectors and Scalars, Motion along a Straight Line, Work and Energy, Impulse and momentum, Coulomb's Law, Electric Field, Electrical Potential, Capacitance and Dielectrics, Current, Resistance and Electromotive Force, Magnetic Field and Magnetic Forces, Isotopes and mass spectroscopy, Sources of Magnetic

Field, Induction Phenomenon, Motional electromotive force, Faraday's Law, Lenz's Law, Eddy Currents.

### **Recommended Books:**

1. University Physics by Sears, Zemansky and Young, Addison-Wesley Publication Company.
2. Fundamentals of Physics, 5<sup>th</sup> Edition by Halliday, Resnick and Walker

### **Suggested Lab:**

As suggested by the instructor

## **Probability and Statistics**

**3 (3,0)**

**Prerequisites: Calculus**

### **Objective:**

To develop an understanding of the basic concepts of probability and statistics.

### **Contents:**

Measures of central tendency and dispersion, Moments, Introduction to classical Probability theory, Bayes theorem, Random variables (discrete and continuous), Probability distributions (Normal, Binomial, Poisson etc.), Expectation, Conditional distribution and conditional expectations, Correlation and regression.

### **Recommended Books:**

1. Probability & Statistics for Engineers & Scientists by Walpole, Myers, Myers & Ye, Prentice Hall
2. Engineering Statistics by D. C. Montgomery, John Wiley
3. Business Statistics by Mark L. Berenson and David Livine.

# Master of Industrial Engineering

## ***Program Structure:***

The ME/MS Industrial Engineering programme was reviewed thoroughly. It was agreed by the committee that for ME/MS minimum credit hours earned by a student shall be 30 as per following distribution:

<b>Component</b>	<b>Credit Hours</b>
Core Courses	12
Electives	12
Thesis *	06
<b>Total</b>	<b>30</b>

**Students can opt for non-thesis option by taking two additional courses in place of Thesis**

## ***Programme Objectives:***

The objectives of MS/ME Industrial Engineering program shall be to produce graduates, who:

Are highly valued and technically sound professionals, well prepared for their subsequent assignments, duties and responsibilities as professional engineers, in public as well as private sector organizations.

Have been provided core education in this programme.

Can apply foundational scientific concepts and sound engineering principles efficiently and effectively starting from conceptual design till final deliverables, utilizing advanced technological capabilities in the country.

Have experience in conducting independent research work and document it with fact finding approach.

Can professionally support and communicate technical solutions and results.

While there can be many tracks, the committee identified and developed coursework in four areas namely:

- 1 Manufacturing**
- 2 Operations Research**
- 3 Quality Management**
- 4 Engineering Management**

<b>1. Manufacturing Track</b>			
<b>Core Courses (select at least 4)</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Manufacturing Planning & Control	3	0	3
Optimization	3	0	3
Quality Engineering	3	0	3
Manufacturing Systems	3	0	3
Advanced Manufacturing Processes	3	0	3
CAD/CAM	3	0	3
Computer Simulations	3	0	3
Concurrent Engineering	3	0	3
Advanced Mathematics	3	0	3
Computer Applications	3	0	3
<b>Electives:</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Computer Integrated Manufacturing	3	0	3
Engineering Economics	3	0	3
Finite Element Analysis	3	0	3
Human Resource Management	3	0	3
Benchmarking	3	0	3
Scheduling	3	0	3
Tool Design	3	0	3
Artificial Intelligence	3	0	3
Ergonomics	3	0	3
Supply Chain Management	3	0	3
Research Methodology	2	0	2
Business Process Re-engineering	3	0	3
Project Management	3	0	3
Six Sigma Methodologies	3	0	3
Special Topic	3	0	3

<b>2. Operations Research Track</b>			
<b>Core Courses (select at least 4)</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Deterministic Optimization	3	0	3
Stochastic Optimization	3	0	3
Computer Simulations	3	0	3
Mathematical Statistics	3	0	3
Computer Applications	3	0	3
Real Analysis	3	0	3
<b>Electives:</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Queuing Theory	3	0	3
Dynamic Programming	3	0	3
Game Theory	3	0	3
Network Analysis	3	0	3
Stochastic Processes	3	0	3
Artificial Intelligence	3	0	3



Replacement Models	3	0	3
Supply Chain Management	3	0	3
Combinatorial Optimization	3	0	3
Research Methodology	2	0	2
Business Process Re-engineering	3	0	3
Special Topic	3	0	3

<b>3. Quality Management Track</b>			
<b>Core Courses (select at least 4)</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Inferential Statistics	3	0	3
Organizational Systems	3	0	3
Project Management Framework & Tools	3	0	3
Six Sigma Methodologies	3	0	3
Operations Research	3	0	3
Reliability Analysis	3	0	3
Computer Simulations	3	0	3
Statistical Quality Control	3	0	3
Total Quality Management	3	0	3
Advanced Mathematics	3	0	3
Computer Applications	3	0	3
<b>Electives:</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Quality Assurance	3	0	3
Supply Chain Management	3	0	3
Design and Analysis of Experiments	3	0	3
Manufacturing Planning & Control	3	0	3
Lean and Agile Manufacturing	3	0	3
Maintenance & Safety	3	0	3
Benchmarking	3	0	3
Quality Engineering	3	0	3
Cost and Management Accounting	3	0	3
Research Methodology	2	0	2
Business Process Re-engineering	3	0	3
Special Topic	3	0	3

<b>4. Engineering Management Track</b>			
<b>Core Courses (select at least 4):</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Operations Management	3	0	3
Project Management	3	0	3
Management Information System	3	0	3
Engineering Economics	3	0	3
Human Resource Management	3	0	3
Total Quality Management	3	0	3
Supply Chain Management	3	0	3
Computer Simulations	3	0	3
Advanced Mathematics	3	0	3
Computer Applications	3	0	3
Research Methodology	2	0	2
Organizational Behaviour	3	0	3
<b>Electives:</b>			
<b>Course Title</b>	<b>Lec</b>	<b>Lab</b>	<b>CR</b>
Project Evaluation & Feasibility Analysis	3	0	3
Computer Integrated Manufacturing	3	0	3
Business Forecasting	3	0	3
Energy Management	3	0	3
Environmental Management & Safety	3	0	3
Operations Research	3	0	3
Marketing Management	3	0	3
Cost & Management Accounting	3	0	3
Benchmarking	3	0	3
Business Process Re-engineering	3	0	3
Special Topic	3	0	3

# Details of Postgraduate Courses In Industrial Engineering

## **Advanced Manufacturing Processes** **3 (3,0)**

Non traditional machining and thermal cutting processes - Super finishing processes - Selection of manufacturing materials and processes - Joining and assembly processes - Design for manufacturing (processing and assembly) - Product and production relationships.

## **Advanced Mathematics** **3 (3,0)**

Approximations and error analysis, methods to find roots of non-linear algebraic equations, solution of systems of linear algebraic equations, deriving empirical equations to suit experimental data, numerical differentiation and integration, numerical solution of differential equations, the determination of Eigen values, Fourier analysis and its engineering applications.

## **Lean and Agile Manufacturing** **3 (3,0)**

Products and product development processes, Processes and process development, Requirements of materials, Planning and control of material, Capacity planning and control, Supply chains, The KISS principle, Operations support and administration, Implementing and Running Leanness and Agility, Staying Lean and Agile, Selling the concept internally, Applying the knowledge to develop your program.

## **Artificial Intelligence** **3 (3,0)**

Introduction to AI, expert systems, knowledge-based systems, inductive logic programming, fuzzy sets and systems, evolutionary computation techniques, hyper heuristics, machine learning, hybrid intelligent systems, data mining and knowledge discovery, Genetic algorithm and artificial neural networks.

## **Benchmarking** **3 (3,0)**

Strategic planning and the evolution of benchmarking, types of benchmarking, common criticisms of benchmarking; Steps in benchmarking, planning benchmark study- seven 'to-do' items, determination of activities to benchmark, identifying the benchmark team, scheduling the study and determination of key factors to measure, Identification of target organization (benchmark partner). Execution of the study: Data collection, data analysis. Implementing improvement, strategy assessment.

## **Business Forecasting** **3 (3,0)**

Forecasting alphabet, applications, classification of forecasting methods, Importance of sales forecast, Forecasting approaches (deterministic and probabilistic), Time series causal forecasting, Time series projective forecasting, Service level models, Information for dependent demand, Use of computer software in business forecasting.

## **CAD/CAM** **3 (3,0)**

Computer methods in industrial design, Advanced computer geometric modeling, transformations and projection, CAD/CAM databases, Introduction to automated machine tools and cutting tools, tool path planning, Management of cutting tools,

Numerical control, Motion control, Robotics, CNC machine tools programming, use of modelling software.

### **Combinatorial Optimization** **3 (3,0)**

Algorithmic and structural approaches in combinatorial optimization with a focus upon theory and applications. Topics include: polyhedral methods, network optimization, the ellipsoid method, graph algorithms, matroid theory and sub modular functions.

### **Computer Applications** **3 (3,0)**

Computer hardware and software, Databases, Communication and networks, Constants and variables, Arithmetic operations, Intrinsic functions, Algorithm design, Flowcharts, and Pseudo codes, IF statements, Do loop, While loop, Data files, Formatted Input and Output, Logical and character data type, Arrays: one-dimensional, two-dimensional, Subprograms: Functions and subroutines, Numerical Applications, Introduction to programming language.

### **Computer Integrated Manufacturing** **3 (3,0)**

CIM strategy, CIM components, Concurrent engineering, GT and cellular systems, FMS, Robotic systems, Systems integration, Selection of CIM systems, Modeling and implementation of CIM systems, Enterprise resource planning, Future trends in CIM.

### **Computer Simulations** **3 (3,0)**

Concept of simulation modelling, selecting the appropriate input distribution, random number generation, simulation languages, output analysis, alternatives comparison, variance reduction technique, models of complex systems, case studies for simulation using any simulation software.

### **Cost and Management Accounting** **3 (3,0)**

Financial Accounting, Income statement and principles of accrual accounting, Balance sheet and recording of transactions, Accounting process, Revenue recognition, Inventory/cost of goods sold, Statement of cash flow, Long term assets/depreciation, long term debt, Current liabilities and contingencies, Marketable securities, intangibles, Cost concepts, Indirect allocation of cost.

### **Concurrent Engineering** **3 (3,0)**

Theory and philosophy of Concurrent Engineering, Planning the transition and Reducing organizational and cultural barriers, Product cycle time, Customer satisfaction, Reduction in engineering change orders or reworks, Strategies for selecting, staffing and managing multi-disciplinary functional project-teams. Principles of DFA/DFM for parts reduction and assembly, Learn design for X concepts (e.g., DFM, DFA, DFS, etc.) Pinpoint organization change and the effects of new engineering order, QFD, Taguchi method, Axiomatic design.

### **Design and Analysis of Experiments** **3 (3,0)**

Sampling and descriptive statistics, Parameter estimation, Tests of hypothesis on the means, variance, and ratios, Testing for goodness of fit, Non-parametric tests, Experiments with single factor, Randomized blocks, Latin squares and incomplete block designs, Factorial and fractional factorial designs, Regression

analysis, Taguchi's concepts and approach to parameter design, Response surface methodology, use of Minitab software.

### **Deterministic Optimization**

**3 (3,0)**

Selection of an OR tool for a particular production/operations management application, Formulating deterministic optimization models, Defining objectives, decisions and constraints, Writing symbolic models and implementing those using optimization software, Using Excel data table functions to conduct sensitivity analysis, Interpretation of sensitivity tables, simplex tableaus, duality analysis, application of OR methods.

### **Dynamic Programming**

**3 (3,0)**

Introduction: Sequential decision processes, DP functional equations, problem formulation and solution, State transition graph models, state-space generation, complexity, greedy algorithms, probabilistic dynamic programming. Applications of DP: Optimal allotment, all-pairs shortest path problems, assembly-line balancing, optimal binary search tree problem, optimal covering problem, discounted profits problem, flowshop problem, Integer linear programming.

Integer knapsack problem, mini max problem, optimal distribution and optimal permutation problems, optimal selection problem, Process scheduling problem, Transportation problem, Traveling salesman problem. Modelling of DP problems. Introduction to DPS.

### **Energy Management**

**3 (3,0)**

Attitudes to energy efficiency, objective of energy management, priorities, and strategies. Plant control, control and use of an energy management system.

Monitoring: Remote monitoring and out-station operation, degree days performance lines and targeting, Audits, Environmental, energy and social.

Energy Modelling and Forecasting, reserves and relation of resources to future options. Energy demand models, Energy Transmission & Utilization, Waste Heat Recovery System, Energy Resources, Solar Energy Conversion Systems.

### **Engineering Economics**

**3 (3,0)**

Cost concepts and design economics, cost estimation techniques, developing project cash flows, lease versus buy decisions, replacement analysis, dealing with uncertainty, impact of Income tax and inflation on economic analysis, capital financing and allocation.

### **Environmental Management & Safety**

**3 (3,0)**

Professional and self development, Quality and resource planning, Integrated business risk management, Environmental and waste management, Workplace evaluation and control, Health and safety management and legislation, Environmental impact assessment, ISO 14000, Reduction of carbon footprint.

### **Ergonomics**

**3 (3,0)**

Principles of ergonomics, Human characteristics relevant to Ergonomics, the system approach and aspects of Ergonomics, role of human factors engineering in Artificial Intelligence, anthropometry, types of anthropometry, body dimensions of various organs, failure of design, anthropology and its types, climatic factors,

sound and its measurements, effects of noise on various organs, principles of good lighting.

Basic cognitive capabilities and limitations of the workers, environmental situation and limitations conducting an ergonomic assessment, Developing an ergonomic program, Ergonomic issues related to posture, materials Handling/Lifting using the NIOSH, Frequent types of injuries related to workplace design, Repetitive motion, and cumulative trauma disorders, Preventing ergonomically related injuries by redesigning the workplace, Designing displays for Workers, Transfer and design of information, Controls and control arrangements.

### **Finite Element Analysis**

**3 (3,0)**

Matrix forces method, Matrix stiffness method, variational formulation and approximation ( Boundary and initial-Value problems, gradient and divergence theorems), Ritz methods, method of weighted residuals, time-dependent problems. Finite Element Error Analysis (Approximation Errors, Various measures of errors, Convergence of solutions and accuracy of solutions), Numerical integration & computer implementation, Coordinate transformation (Integration on a Master Element, Modeling, Mesh Generation), Load Representation, use of finite element software.

### **Game Theory**

**3 (3,0)**

Theory of rational choice, integration with intelligence and decision making, axioms, the expected utility maximization theorem, Bayesian conditional probability systems.

Basic Models: Games in extensive form, strategic forms and normal representation, Equivalence and reduced normal representation, elimination of dominated strategies.

Equilibria of strategic form games: Nash equilibrium theory, computation and significance of Nash equilibria, the Focal point effect, Purification of randomized strategies in equilibria, infinite strategies sets, The two person zero-sum game with equilibrium points, two-person non-zero sum game, Mixed strategies and behavioural strategies, Auctions, bargaining and cooperation in two-person games.

### **Human Resource Management**

**3 (3,0)**

Role and Organization of Personnel Function, Behaviour Aspects, Human Resources Planning, Recruitment, Job Analysis and Design, Managing Performance. Training and Development, Pays and Benefits, Industrial Relations.

### **Inferential Statistics**

**3 (3,0)**

Fundamentals of hypothesis testing: one-sample t-test, Two-sample t-tests, ANOVA and other tests with numerical data, Two-sample and c-sample tests with categorical data, multiple regression and response surfaces.

## **Maintenance & Safety**

**3 (3,0)**

Planned and preventive maintenance, Predictive maintenance, Corrective maintenance, Advanced concepts (Reliability centred maintenance, Total productive Maintenance), Concepts of maintainability engineering, Design for maintainability, Availability, Decision models in maintenance management. National and international standards for preventing accidents in the workplace, recent developments in industrial systems' safety and risk analysis techniques.

## **Management Information System**

**3 (3,0)**

Introduction of MIS, Meaning & Role, organization structures, Business Process, Systems Approach. Programmed & Non- Programmed, Strategic & Project Planning for MIS, Models of Decision Making different types of IS: MIS, DSS, ESS. MIS and the information Concepts, System Concepts, Handling system complexity MIS and system concepts, need for system analysis, SSAD, MIS and System Analysis. Development of MIS, Ascertaining the Class of information, Management of quality in MIS, MIS: the factors of success and failure. EMS and MIS, MIS Service industry, choice of IT in MIS.

## **Manufacturing Planning & Control**

**3 (3,0)**

Deterministic inventory problems, Material requirement planning, manufacturing resource planning, Enterprise resource planning, Just-in-time manufacturing, Variability basics and their influence, Push-Pull and hybrid production systems and Supply chain management.

## **Manufacturing Systems**

**3 (3,0)**

Introduction to modern manufacturing strategy and the importance of Quick Response Manufacturing. Manufacturing systems and models, assembly lines, single model assembly line, mixed models assembly lines, line balancing, transfer lines, group technology, coding schemes, cellular manufacturing, production flow analysis, flexible manufacturing systems, planning and control hierarchy of FMSs, machine setup and operations sequencing, material handling systems, storage and retrieval systems

## **Marketing Management**

**3 (3,0)**

Introduction to the fundamental concepts of marketing, customer orientation, competition and core strengths, introductory finance, Marketing research and analysis, Marketing strategy, Implementation planning, Project, Process and supplier management, market segmentation, product life cycle, distribution networks, social marketing, product promotions, Marketing Mix.

## **Mathematical Statistics**

**3 (3,0)**

Probability spaces and random elements, Integration and differentiation, probability distributions and their characteristics, conditional expectations, asymptotic theory; Populations, samples, and models; statistics, sufficiency and completeness; statistical decision theory; statistical inference; asymptotic criteria and inference; Unbiased statistics, their variances, the Least squares estimates (LSE) in Linear models, the UMVUE and the BLUE, robustness of LSEs, Bayes

decisions and estimators, invariance, maximum likelihood, the likelihood function and the MLEs, Uniform, Gamma, and Beta processes, Normal and the exponential family of processes, Sampling statistics, probability generating function, moment generating function.

## **Network Analysis**

**3 (3,0)**

Formulation of network problems as linear programming problem, The trans-shipment problem, trees and feasible tree solutions, economic motivation for network Simplex method, degeneracy and cycling, termination and initialization issues, decomposition into sub problems, computer implementation, Inequality constraints, scheduling production and inventory, the Caterer problem, the Integrality theorem, doubly stochastic matrices, covers and matchings in bipartite graphs, chains and antichains in partially ordered sets, The assignment and transportation problems as network problems, Upper-bounded trans-shipment problems, Maximum flow through networks: The primal-dual method for network flows.

## **Operations Management**

**3 (3,0)**

Operations and productivity, operations strategy for competitive advantages, forecasting, design of goods and services, managing quality including SPC, capacity planning, location and layout strategies, supply chain management, inventory management including JIT, aggregate planning, MRP, maintenance and reliability, decision making tools, linear programming, transportation models, waiting lines model, learning curves, introduction to simulation, statistical tools for management.

## **Operations Research**

**3 (3,0)**

How the simplex method works, Tableau and Dictionary methods, pitfalls (initialization, iteration and termination) in Simplex method and ways to avoid those, Speed of computation, How fast is Simplex method, The Duality theorem, Gaussian Elimination and matrices- number of steps, speed and accuracy issues, the LP decomposition of matrices, the revised Simplex method, General LP problems and their solution by Simplex Method, Theorems on Duality, Feasibility and infeasibility of problems, Primal-dual relationship, sensitivity analysis, Efficient allocation of scarce resources, scheduling production and inventory, the cutting stock problem, matrix games.

## **Optimization**

**3 (3,0)**

Introduction to design and optimization, Mathematical formulation of design optimization Problems, Multi-criteria optimization, Fundamental concepts of optimality. Gradient vector, Hessian matrix, Taylor series expansion, Quadratic forms, and Eigenvalues of matrices, Necessary and sufficient conditions for optimality of unconstrained and equality constrained problems, Necessary and sufficient conditions for optimality of constrained problems, Kuhn-Tucker conditions, and post optimality analysis, Global, optimality, convex functions, convex programming problems, Linear Programming and Sequential Linear Programming, One dimensional minimization, polynomial interpolation and Golden section search, Unconstrained Minimization, Exterior, Interior, and



Extended Interior Penalty function approaches, Augmented Lagrange Multiplier Method for equality and inequality constrained problems.

### **Organizational Behaviour 3 (3,0)**

Management functions and roles. Need for systematic study of human behaviour. Challenges and opportunities for O.B., Responses to Global and Cultural Diversity. Foundations of Individual Behaviour, Perception and Industrial Decision Making. Values, Attitudes and Job Satisfaction, Motivation Concepts, Group Behaviour & Work Teams, Organization System.

### **Organizational Systems 3 (3,0)**

Integrating management systems, management, safety, managing indirect costs, controlling risks and cost, Management commitment and policy, responsibility and authority, objectives and targets, plan consideration, plan implementation, standard operating procedures, employees involvement, management and control of contactors and vendors, emergency preparedness and contingency planning, document control and record keeping processes, process risk analysis and assessment, measurement and evaluation, non-conformances and incident investigations.

### **Project Evaluation & Feasibility Analysis 3 (3,0)**

Project Planning & Appraisal, Managing Project with Project Management Tools, Project Management Control, Indicators and Measurement of Monitoring and Evaluation, General Management Skills, Financial aspects of new project, Feasibility analysis of a model project, Sensitivity analysis.

### **Project Management 3 (3,0)**

Project Management and Project Control, Qualitative and Quantitative Risk Management, Project Management Structures Strategy, Portfolio and Program Management, Project cost estimation, Project procurement management, Managing Data and Configurations for effective project management, Managing Technology: Innovation, Learning and Maturity. Time, Cost and Critical Chain Management, Project Performance Measurement & Value Management, Improving quality in project and program, use of MS Project or Primavera.

### **Project Management Framework and Tools 3 (3,0)**

Define project, program and portfolio management, project structure, project life span, modelling project management, project management model in three decades, model with portfolio potential, logical progression, Marasco pyramid model, Project dynamics, project environment, project control, program and portfolio management, optimization portfolio management

### **Quality Assurance 3 (3,0)**

Basic elements of a quality assurance system, Quality standards such as ISO 9001 and ISO 17025, Structuring quality management system documentation: quality manual, quality plans, procedures, work instructions, records, QMS

implementation and maintenance, Strategic and competitiveness issues in QMS, Computer-based information systems for QMS, Role of TQM and statistical methodologies in QMS, Quality auditing and management reviews, Continuous improvement through corrective and preventive action, Familiarization with other standards such as ISO 14001, SA 8000, OHSAS 18000,

## **Quality Engineering**

**3 (3,0)**

Principles of modern quality control techniques, KAIZEN by TQC/TQM, Management and Planning Tools, Affinity Diagrams, Interrelationship Digraph, Tree Diagram, Project teams, Project Management Techniques, Adventure based team building and leadership, Basic Tools, Prioritization matrices and Matrix diagrams, Organizational and cultural issues, Implementing change and new technologies, Deming, Baldrige and other total quality awards, Introduction to Six Sigma, Quality assurance Audit Programs, and ISO certification.

## **Queuing Theory**

**3 (3,0)**

Description and characteristics of queuing systems, Poisson process and exponential distribution, Markovian property, stochastic processes and Markov Chain.

Birth-death queuing models: Kendall notation, steady-state solution for M/M/1 models, steady-state difference equation, M/M/c, and M/M/c/k models, Erlang formula, queuing with unlimited services, Network, Series and Cyclic queues, Models with general arrival and service patterns: Single server and multiple server queues with Poisson arrivals and general service, multi-channel queues with Poisson arrivals and constant service.

## **Real Analysis**

**3 (3,0)**

Topological properties of the real numbers, Completeness and least upper bound property. Cardinality of sets. Theory of metric spaces, Cauchy and convergent sequences, compactness, completeness, and connectedness, Continuous functions between metric spaces, Differentiability of functions of one variable, Differentiability of functions of several variables.

## **Reliability Analysis**

**3 (3,0)**

Models and Uncertainties, Standards and Guidelines, Failure Models, Qualitative System Analysis, Systems of Independent Components, Component Importance, Dependent Failures, Counting Processes, Markov Processes, Reliability of Maintained Systems, Reliability of Safety Systems, Life Data Analysis, Accelerated Life Testing, Bayesian Reliability Analysis, Reliability Data Sources, use of Minitab or some other software.

## **Replacement Models**

**3 (3,0)**

Introduction to replacement models, decision whether to repair or replace, modelling the decision, assumptions related to replacement decision, uncertainty in replacement acquisition costs, modelling and estimation of model parameters, modelling maintenance requirements and estimation of maintenance as well as life cycle costs.

## **Scheduling**

**3 (3,0)**

Introduction to scheduling problem, performance measures of scheduling, single and multi-machines scheduling, parallel machines scheduling, flow shop scheduling, job shop scheduling, open shop scheduling and project scheduling.

## **Six Sigma Methodologies**

**3 (3,0)**

Introduction to Six Sigma, Internal & External Customers, Define Measure Analyse Improve Control (DMAIC) Cycle, Six Sigma goals and Matrices, Six Sigma Training, Six Sigma Teams, Green, Black and Master Black Belt, Design for Six Sigma, Define Measure Analyse Design Verify (DMADV) , Case Studies.

## **Statistical Quality Control**

**3 (3,0)**

Review of Probability Theory, Effect of sample size on Control charts for variable (X-Bar and R or S) and attributes (p, np, c, u, CUSUM etc), determining the control limits and plotting the data; interpretation of charts, Gauge R & R analysis, identification of out-of-statistical control situations, trends and control mechanisms, Process capability and related indices, Type I and Type II errors, Single, double, multiple and sequential sampling, developing operating characteristic curves, acceptance Sampling: Sampling Plans, the ABC and Mil Standards.

## **Stochastic Optimization**

**3 (3,0)**

Approaches to optimization with uncertainty, stochastic optimization, and dynamic (multi-stage) stochastic optimization, two-stage and multistage stochastic programs, dynamic programming (Markov decision process) approach, finite and infinite horizon problems, deterministic DP approximation method for large-scale problems. Usage of computational techniques and applications.

## **Stochastic Processes**

**3 (3,0)**

Review of probability theory, expected value, Moment and probability generating functions, characteristic functions, Laplace transform, Conditional expectations, Exponential distribution, hazard rate function, Probability related inequalities; limit theorems, random variables and random processes, Poisson process: Inter-arrival and waiting time distributions, conditional distribution of arrival times, non-homogeneous and compound Poisson processes, Renewal Theory, branching processes, Stationary and non-stationary processes, random walk, discrete and continuous time Markov chains, Chapman-Kolmogorov equations, Brownian motion, Martingales.

## **Supply Chain Management**

**3 (3,0)**

The era of Physical Distribution Management, the Concept of Supply Chain, Channels Strategy and Alliances, the Changing Business Environment, Customer Focus in the Supply Chain, Achieving Customer Satisfaction Objectives, Transportation Choices in the Supply Chain, Inventory Management in the Supply Chain, Supply Chain Communications, International Supply Chain

Management. Issues and Implications, Information for Supply Chain Management.

## **Tool Design**

**3 (3,0)**

Tool design objectives and nomenclature, Tool Materials, Work holding principles, Jig Design, Fixture Design, Tool Design for Inspection and Gauging, Forming and Drawing Tools, Tool Design for Joining Processes, Computers in Tool Design.

## **Total Quality Management**

**3 (3,0)**

The concepts and principles of quality management, the quality management leading companies in the implementation of total quality management, techniques philosophies of modern quality leaders, the strategies used by some of the for process management, introduction and application of tools.

## **Business Process Reengineering**

**3 (3,0)**

Fundamentals of process management; importance of process decisions and process choices; strategic process decisions for manufacturing and service environments. Costs, quality, and timeliness as the primary attributes of value; creation of value through strategies and processes.

Process improvement tools and frameworks; process maps, value stream mapping, service blueprinting, reengineering, Poka-Yoke, lean systems and six-sigma. Simulation and modelling of discrete event systems and processes. Implementing BPR methodology, building the reengineering organization; identifying BPR opportunities, understanding existing processes, reengineering processes, blueprinting new business systems, performing transformation.

## **Research Methodology**

**2 (2,0)**

Introduction to research, definition and objectives of research, types of researches, Building blocks of research, Formulation and statement of problem; Theoretical framework, hypothesis development, elements of research design, sampling design, data collection instruments, measurement of variables, data analysis techniques, hypothesis testing, inference, preparation of research report and presentation; use of Minitab, MS Excel or some other software for analysis.

## **Special Topic**

**3 (3,0)**

Any subject can be offered depending upon the available expertise and local needs.

# RECOMMENDATIONS

1. University-Industry Linkage:
  - a. At least four Industrial visits in a year should be organized and properly monitored by the University.
  - b. Lectures/seminars from the industry should be organized
  - c. Industrial Internships are very important part of the students' education. It should preferably start after second year examinations followed by a proper feedback mechanism from the Industry.
  - d. Final year projects should be Industry-Based and of Practical Nature (Real Life Problem) to the extent possible and each group should be of up to four students.
  - e. Industry representation should be ensured in the project viva-voce.
2. Communications Skills  
To strengthen the communications skills of the engineering graduates, regular presentations including seminars by the students should be arranged.
3. Non-Engineering Courses  
All non-engineering courses should be linked and taught from the engineering perspective. Rote learning should be discouraged.
  - a. Islamic Studies: How to inculcate Islamic Values in Daily Life / Engineering Profession.
  - b. Pakistan Studies: Emphasis on where Pakistan Stands in terms of international benchmarks compared to other countries of the region.
4. The focus of the English courses should be on enhancing the presentation skills of students and preparing them for interviews and tests/ exams like ToEFL, IELTS, GRE, ESOL etc.

