ARAB ACADEMY FOR SCIENCE, TECHNOLOGY
AND MARITIME TRANSPORT

COLLEGE OF ENGINEERING AND TECHNOLOGY

ALEXANDRIA - EGYPT

Doctor of Philosophy (PhD)

in

INDUSTRIAL ENGINEERING

CURICULUM

VOLUME II

2020

Contents

VOLUME 2

INDUSTRIAL ENGINEERING

PhD Program

Program Title: Doctor of Philosophy (PhD) in Industrial Engineering

OVERVIEW

The PhD program in Industrial Engineering at the Arab Academy for Science, Technology and Maritime Transport (AASTMT) prepares engineers for broad research in academia and industry. This program is benefical for the society because our nation will have experts and researchers in this filed. In addition, it is an extremely attractive program to working engineering professionals who are seeking to advance to positions of greater managerial and technical responsibility. The program is based on an integrated approach to the management of product, process and information technology and provides the opportunity to develop expertise in these areas.

The professional society for Industrial Engineers, the Institute of Industrial and Systems Engineers (IISE), defines Industrial Engineering as:

> *Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of people, materials, and equipment. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis, to design, specify, predict, and analyze the results obtained from such systems.*

FUNCTIONS OF THE INDUSTRIAL ENGINEER

In a nutshell, Industrial Engineers make things work better, safer, and more economically. Unlike the other engineering disciplines that focus their attention purely on the technical aspects of a system, the Industrial Engineer incorporates human and economic considerations in system design.

Industrial engineers design processes and systems that improve quality and productivity. Using knowledge of engineering, mathematics, business administration, and management, industrial engineers focus on the way products and services are made and performed. Through a combination of technical abilities, people skills, and business know-how, they analyze, design, build, and manage systems. Industrial Engineers integrate combinations of people, information, materials, and equipment that produce innovative and efficient organizations. In addition to manufacturing, Industrial Engineers work and consult in every industry, including hospitals, communications, e-commerce, entertainment, government, finance, food, pharmaceuticals, semiconductors, sports, insurance, sales, accounting, banking, travel, and transportation.

PROGRAM OBJECTIVES

The PhD program in Industrial Engineering aims at:

Preparing engineers to become researchers and experts with the human aspects, organizational and financial issues, project considerations, resource allocation, and extended analytical tools required for effective decision making and business management.

The PhD program at the AASTMT specific objectives are:

- To offer the necessary analytical, organizational, and managerial skills to bridge the gap between a technical specialty and technical management.
- To help the engineers understand methods and techniques discussed in the literature in his/her area(s) of interest.
- To prepare engineers to conduct independent research work and to think analytically, creatively, and independently.
- To help the engineers to become competent researchers in the field of industrial engineering.

PROGRAM ADMISSION REQUIREMENTS

To join the program of PhD. in Industrial Engineering, the following minimum prerequisites are required:

- A Bachelor's degree (or higher) in Industrial Engineering or equivalent field.
- A Master of Science Degree In Industrial engineering or equivalent field.

PROGRAM STRUCTURE

Program duration: (3 Years Min – 6 Years Max)

CREDIT HOURS: 48 Cr. Hrs.
Course work for the PhD. degree requires the completion of minimum of (**48**) credit hours as follows:

A. Core Courses	2 Compulsory Courses	**(6 Cr.H)**
B. Elective Courses	4 Elective Courses	**(12 Cr.H)**
C. Research Thesis	Part 1 (10 Cr. H.) + Part 2 (10 Cr. H.) + Part 3 (10 Cr.H.)	**(30 Cr.H)**
Total Credit Hours		**(48 Cr.H)**

Note: The PhD. electives list is classified into IM8XX and IM7XX. The IM7XX represents the MSc list of courses. The candidate can register up to **two** courses from the MSc list of courses (IM7XX) in condition that he did not take this course in any previously accomplished degree.

List of Master of Science Courses

Course Code	Course Title	Credit Hours
IM711	Materials Properties and Selection Criteria	3
IM712	Engineering Materials for New Applications	3
IM713	Manufacturing Systems Engineering	3
IM714	Non-Destructive Testing of Materials	3
IM715	Computer Integrated Manufacturing	3
IM721	Manufacturing Systems Management and Analysis	3
IM722	Applications of Artificial Intelligence in Industry	3
IM723	Advanced Operations Management	3
IM724	Industrial Ergonomics and Human Factors Engineering	3
IM725	Production, Inventory Control, and Scheduling	3
IM726	Advanced Techniques of Operations Research	3
IM727	Special Topics in Industrial Engineering	3
IM728	Industrial Facilities Planning and Design	3
IM729	Discrete Systems Simulation	3
IM732	Warehouse and Distribution Management	3
IM733	Supply Chain Management	3
IM734	Supply Chain Design	3
IM738	Advanced Project Management	3
IM742	Design and Statistical Analysis of Experiments	3
IM743	Advanced Reliability Engineering	3
IM744	Productivity and Quality Improvement	3
IM746	Lean Six Sigma	3

Program Detailed Structure

List of PhD Courses

A. Core Courses (2 Compulsory Courses)

Course Code	Course Title	Credit Hours
IM 804	Research Methodology	3
IM 805	Advanced Modeling Techniques	3
Subtotal	**2 Courses * 3 Credit Hours**	**6**

B. Elective Courses (4 Courses Required)

Course Code	Course Title	Credit Hours
GROUP 1: MANUFACTURING AND MATERIALS SYSTEMS		
IM 811	Selected Topics in Manufacturing	3
IM 812	Selected Topics in Material Engineering	3
IM 813	Selection of Materials for Engineering Applications	3
IM 814	Smart Manufacturing	3
IM 815	Sustainable Manufacturing	3
IM 816	Additive Manufacturing Processes	3
GROUP 2: QUALITY AND PRODUCTION SYSTEMS		
IM 821	Selected Topics in Management and Planning	3
IM 822	Inventory Management and Production Planning	3
IM 823	Scheduling and Sequencing	3
IM 824	Quality Design and Control	3
IM 825	Total Quality Improvement	3
GROUP 3 : SYSTEM ENGINEERNG		
IM 831	Engineering Cost Analysis	3
IM 832	Risk Assessment and Management	3
IM 833	Systems Safety Engineering and Management	3
IM 834	Advanced Reliability Engineering	3
GROUP 4: SIMULATION, OPTIMIZATION AND MODELLING		
IM 841	Discrete Systems Simulation	3
IM 842	Statistical Aspects of Digital Simulation	3
IM 843	Life Cycle Engineering	3
IM 844	Design of Experiments and Applications in Decision Analysis	3
IM 845	Sustainable Supply Chains	3
Subtotal	**4 Courses * 3 Credit Hours**	**12**

C. Research Thesis

Course Code	Course Title	Credit Hours
IM 801	PhD's Research Thesis (Part 1)	10
IM 802	PhD's Research Thesis (Part 2)	10
IM 803	PhD's Research Thesis (Part 3)	10
Subtotal	**3 Parts * 10 Credit Hours**	**30**
	Total	**48**

IM 8XX Courses Description

PhD. Program

Core Courses

PhD. Program

Course Code: **IM 804**

Course Title: **Research Methodology**

Credit Hours: **3**

Course Description

This course aims to give an introduction to the research methods most often used in fundamental and applied research. Students will gain a knowledge and understanding of concepts and terminology of empirical methods used in the field. Research design, data collection, analysis, validity, quantitative research methods and thesis writing are covered. .

Course Objectives

The student should be able to:

- Acquire skills to locate problem areas in organizational settings, and plan, organize, design, and conduct research to help solve the identified problems.
- Gather and analyze data, using both qualitative and quantitative methods.
- Write and present research reports.
- Develop skills and knowledge to discriminate "good" from "bad" research reported in academic, business, and trade journals.

Course Topics

Week 1: Introduction to Research.
Week.2: The Research Process.
Week.3: Choosing a Research Problem: Reviewing Literature.
Week.4: Why do we need research?
Week.5: Formulating the Research Problem.
Week.6: Identifying Variables.
Week.7: Selecting the Sample.
Week.8: Data Collection.
Week.9: Data Processing (Statistical Analysis).
Week 10: Displaying Data.
Week.11: Technical Writing: Complies 3 Parts.
Week.12: Part a: Writing a Research Proposal.
Week.13: Part b: Writing a Report.
Week.14: Part c: Writing a Thesis.
Week.15: Part c: Writing a Thesis.
Week 16: Final Exam

Textbooks

- D. V. Thiel, *Research Methods for Engineers*. Cambridge University Press, 2014.
- J. Blackwell and J. Martin, *A Scientific Approach to Scientific Writing*. Springer, 2011.
- R. A. Day and B. Gastel, *How to Write and Publish a Scientific Paper*. Greenwood, 2011.

Course Code: **IM 805**

Course Title: **Advanced Modeling Techniques**

Credit Hours: **3**

Course Description

This course introduces mathematical tools necessary and sufficient to formulate and solve problems arised in industrial and Management Engineering research works. It gives an overview for different types of programming such goal programing, dynamic programing and integer programing. In addition, stochastic processes and fuzzy variables are included.

Course Objectives

To solve problems that arise in Industrial and Management Engineering.

Course Topics

Week 1: Introduction and objectives
Week.2: Goal Programming
Week.3: Dynamic Programming
Week.4: Integer Programming
Week.5: Multiple Regression Analysis
Week.6: Tests For Goodness of Fit
Week.7: Decision Analysis under Uncertainty
Week.8: Mathematics of Fuzzy Variables
Week.9: Decision Analysis under Epistemic Uncertainty
Week 10: Theory of Markov Analysis
Week.11: Applications of Markov Analysis
Week.12: Stochastic Processes
Week.13: Theory of Games and its Applications
Week.14: Clustering Techniques
Week.15: Revisions
Week 16: Final Exam

Textbooks

- Hillier and Lieberman, Introduction to Operations Research, ISBN-978-0-07-352345-3. MHID 0-07-352345-3, Publisher: McGraw-Hill, 10th edition (2015)
- D. Montgomery, Applied Statistics and Probability for Engineers, ISBN-10: 1118539710, ISBN-13: 978-1118539712, Wiley; 6th edition (2013)
- Charles Yoe, Principles of Risk Analysis: Decision Making Under Uncertainty, 978-1439857496, CRC Press; 1 edition (April 19, 2016)
- Abel Rodríguez, Bruno Mendes, Probability, Decisions and Games: A Gentle Introduction using R, 978-1119302605, Wiley; 1 edition (April 24, 2018)

Elective Courses Group1

Course Code: **IM 813**

Course Title: **Selection of Materials for Engineering Applications**

Credit Hours: **3**

Course Description

The course introduces the students to the different classes of materials and their use in the design process. The use of different materials in designing a component for a particular application. The use of the suitable material involves providing the adequate properties and requirements in terms of mechanical, physical and environmental conditions. The selection process is a fairly complicated task; however, it can be made easy by using special techniques and charts which collate different properties and parameters influencing the selection. In addition, different optimization techniques are utilized.

Course Objectives

- To provide the students with the basic knowledge about structure and properties of different engineering materials and structure-property relationships.
- To introduce the students to the different classes of engineering materials in addition to new classes of materials and nanomaterials.
- To enable the students to understand the concept of designing with materials and the important criteria used in selecting materials for a particular engineering application.

Course Topics

Week 1: Introduction to the general Classes of Materials and their Characteristic Properties
Week 2: The Role of Materials Selection in the Design Process.
Week 3: Performance of Materials in Service.
Week 4: Fundamentals of Materials Selection and Selection Charts.
Week 5: Environmental Aspects of Material Selection/Eco-Design of Materials.
Week 6: Case Study on the Selection of Materials Liable to Environmental Degradation.
Week 7: Selection of Materials to Resist Failure.
Week 8: Case Study on the Selection of Materials to Resist Failure.
Week 9: Influence of Material Properties on Design.
Week 10: Effect of Manufacturing Processes on Design.
Week 11: Case Study on the Effect of Material Properties and Manufacturing Processes on Design.
Week 12: Economics of Materials and Processing.
Week 13: Case Study on the Economics of Materials and Processing.
Week 14: Selection of Materials based on Aesthetics and Forces for Change.
Week 15: The Systematic Approach in the Materials Selection Process and the use of Selection Charts.
Week 16: Case Study on the Materials Selection Process Including Multi-objective Optimization.

Textbooks

- Ashby, M., Shercliff, H. and Cebon, D., “Materials: engineering science, processing and design”, 3rd ed., Butterworth-Heineman, 2013.
- Ashby, M.F., “Materials Selection in Mechanical Design”, 5th ed., Butterworth-Heinemann; 2017.
- Farag, M. M., Materials and Process Selection for Engineering Design, 3rd ed. Routledge; 2013.

Course Code: IM 814

Course Title: Smart Manufacturing

Credit Hours: 3

Course Description

The course introduces Smart Manufacturing & Automation with introduction to Industry 4.0. It addresses on one hand the current state of the art in smart automation and on the other hand provides an outlook on new technologies, businesses and opportunities arising out of the digitalization approach and the use of smart devices and in conclusion the Industry 4.0. The concerted objective of the lectures is the provide basic knowledge of smart automation and Industry 4.0 within production systems.

Course Objectives

To introduce the students to the new trends in industry and how the world is heading to the 4th industrial revolution.

Course Topics

Week 1: Introduction and objectives
Week.2: Road to Industry 4.0
Week.3: Introduction to Automated Production Systems
Week.4: Sensors, Controls and Drive Technology
Week.5: Handling Systems and Industrial Robots
Week.6: Automated Quality Control
Week.7: Condition monitoring
Week.8: Cyber security
Week.9: Manufacturing and Assembly Technology
Week 10: Multi Machine Systems
Week.11: Design and planning of automated production facilities
Week.12: Block-chain in manufacturing
Week.13: Industrial Big Data analytics
Week.14: Use Cases: Industry 4.0 in Industry
Week.15: Revisions
Week 16: Final Exam

Textbooks

- Digital Twin Driven Smart Manufacturing, ISBN10 012817630X, ISBN13 9780128176306, Elsevier Science Publishing Co Inc, (2019).
- Cybersecurity for Industry 4.0 : Analysis for Design and Manufacturing, ISBN10 3319506595, ISBN13 9783319506593, Springer International Publishing AG, (2019)
- The Internet of Things 2018 : Industry 4.0 Unleashed, ISBN10 3662549034 ISBN13 9783662549032, Springer Fachmedien Wiesbaden, (2018).

Course Code: **IM 815**

Course Title: **Sustainable Manufacturing**

Credit Hours: **3**

Course Description

This course introduces the basic concepts and techniques in the emerging field of sustainable manufacturing. It covers green manufacturing techniques, material conservation through product end of life options, process impact assessment, and energy efficiency measures in manufacturing to achieve sustainability of manufacturing operations. The course also addresses social and business aspects related to manufacturing as well as basic optimization techniques applied for sustainable manufacturing.

Course Objectives

To design and optimize a manufacturing process for sustainability.
To assess the sustainability of manufacturing process.

Course Topics

Week 1: Introduction to Sustainability.
Week.2: Green Manufacturing as a Means for Sustainability.
Week.3: Metrics for Green Manufacturing.
Week.4: Green Manufacturing Techniques (I).
Week.5: Green Manufacturing Techniques (II).
Week.6: Sustainable Solutions for Machine Tools.
Week.7: Product End of life options: remanufacturing, refurbishing, and recycling.
Week.8: Energy-efficient Manufacturing.
Week.9: Renewable Energy Resources in Manufacturing
Week 10: Water Management in Sustainable Manufacturing.
Week.11: Optimization Methods in Sustainable Manufacturing.
Week.12: Enabling Technologies for assuring Green Manufacturing.
Week.13: Human Centered Automation.
Week.14: Sustainable Business Models for Manufacturing.
Week.15: Revision
Week 16: Final Exam

Textbooks

- Rainer Stark, Günther Seliger, Jeremy Bonvoisin, (eds.) Sustainable Manufacturing: Challenges, Solutions, and implementations Perspectives, Springer, (2017).
- D. Dornfeld (ed.), Green Manufacturing: Fundamentals and Applications, Springer,
  New York, (2013).
- J. Paulo Davim (ed.), Green Manufacturing Processes and Systems, Springer-Verlag berlin Heidelberg, (2013).
- Wen Li, Efficiency of Manufacturing Processes: Energy and Ecological Perspectives, Springer International Publishing Switzerland, (2015).

Course Code: **IM 816**

Course Title: **Additive Manufacturing Processes**

Credit Hours: **3**

Course Description

This course introduces the 3d printing and additive manufacturing technologies to engineering students to cope with the quick advances in manufacturing around the world. The course covers introduction to additive manufacturing technologies: polymers and metal processes. In addition, different materials used, design for AM. Applications of AM are presented. Finally, the future of AM is presented.

Course Objectives

1. Explain the terminology used in additive manufacturing.
2. Explain the basic types AM technologies.
3. Design for AM processes.
4. Acquire the knowledge about the different material used in polymers processes.
5. Acquire the knowledge about the different material used in metals processes
6. Work with the open source AM processes

Course Topics

Week 1: Introduction to Additive Manufacturing and Applications
Week 2:Overview of AM Polymeric Processes
Week 3: Overview of AM Polymeric Processes
Week 4: Overview of AM Metallic Processes
Week 5: Overview of AM Metallic Processes
Week 6: Design for Additive Manufacturing
Week 7: 7th week exam
Week 8: Design for Additive Manufacturing
Week 9: Design for AM Topology Optimization
Week 10: Open Source Printers and G-Code
Week 11: AM Materials for Polymeric Technologies
Week 12: AM Materials for Metallic Technologies
Week 13: 4D Printing and the Future of AM
Week 14: AM Project Discussion and presentation
Week 15: AM Project Discussion and presentation
Week 16 : Final Exam

Textbooks

- Gibbson I. rosen D and B Stuccker, “Additive manufacturing technologies, 3d printing, rapid prototyping and direct digital manufacturing” Springer 2015. ISBN 978-1-4939-2113-3
- Wimpenny, David Ian, Pandey, Pulak M., Kumar, L. Jyothish “Advances in 3d printing and additive manufacturing technologies”, Springer 2017. ISBN 978-981-10-0812-2
- Milewski, John O.” Additive manufacturing of metals”, Springer 2017. ISBN 978-3-319-58205-4

Elective Courses Group 2

Course Code: **IM 822**

Course Title: **Inventory Management and Production Planning**

Credit Hours: **3**

Course Description

The course explains the concept and foundations of Inventory Management and presents a complete treatment of inventory theory and models. Many recent developments related to or impacting inventory such as supply chain management, aggregate planning, and MRP and ERP systems are handeled in the course as well.

Course Objectives

The student should be:

- Able to apply various inventory and production planning models to products of different characterstics and nature of demand.
- Able to bridge the gap between the theoretical solutions and the real Inventory Management and Production Planning problems through a multitude of decision models that would allow students to capitalize on readily implementable improvement to current practices.

Course Topics

Week 1: Introduction and Course Overview
Week 2: Importance of Inventory Management and Production Planning
Week 3: Frameworks for Inventory Management and Production Planning
Week 4: Order Quantities When Demand Is Approximately Level
Week 5: Lot Sizing for Individual Items with Time-Varying Demand
Week 6: Individual Items with Probabilistic Demand
Week 7: Midterm Exam
Week 8: Managing the Most Important (Class A) Inventories
Week 9: Managing Slow-Moving and Low-Value (Class C) Inventories
Week 10: Style Goods and Perishable Items
Week 11: Coordinated Replenishments at a Single Stocking Point
Week 12: Multiechelon Inventory Management
Week 13: Medium-Range Aggregate Production Planning
Week 14: Linear Programming Models for Aggregate Production Planning
Week 15: Material Requirements Planning and Its Extensions
Week 16: Final Exam

Textbooks

- E.A. Silver, D.F. Pyke, and D.J. Thomas; “Inventory and Production Management in Supply Chains”, 4th Edition, Taylor & Francis Group, CRC Press, 2016.
- P. Zipkin; “Foundations of Inventory Management”, 1st Edition, McGraw-Hill/Irwin, 2000.
- Sven Axsaeter, Inventory Control ,978-3319157283, Springer; 3rd ed. 2015 edition (July 7, 2015)

Course Code: **IM 823**

Course Title: **Scheduling and Sequencing**

Credit Hours: **3**

Course Description

This course introduces the principles, techniques and algorithms for solving machine (resource) scheduling problems of the manufacturing and service systems. The topics covered in this course are overview of terminology, characteristics and classification of scheduling and sequencing problems, an overview of computational complexity theory, single machine, parallel machines, flow shop, job shop, and open shop scheduling problems with various scheduling criteria, dispatching rules, branch-and bound, dynamic programming, local search, and metaheuristic approaches.

Course Objectives

- To identify basic concepts and issues for scheduling and sequencing problems in manufacturing and service systems.
- To introduce the techniques for modelling scheduling problems using appropriate mathematical models of linear and integer programming types.
- To solve the scheduling problems using different types of algorithms.

Course Topics

Week 1: Introduction to scheduling and sequencing
Week 2: Deterministic and stochastic models: preliminaries
Week 3: Deterministic single machine scheduling problems
Week 4: Advanced deterministic single machine scheduling problems
Week 5: Stochastic single machine scheduling problems
Week 6: Deterministic parallel machines scheduling problems
Week 7: Advanced deterministic parallel machines scheduling problems
Week 8: Stochastic parallel machines scheduling problems
Week 9: Deterministic flow shop scheduling problems
Week 10: Stochastic flow shop scheduling problems
Week 11: Deterministic job shop scheduling problems
Week 12: Stochastic job shop scheduling problems
Week 13: Open shop scheduling problems
Week 14: General purpose procedures for scheduling in practice
Week 15: Modeling and solving scheduling problems in practice
Week 16: Final Exam.

Textbooks

- K.R. Baker, D. Trietsch, “Principles of Scheduling and Sequencing”, Wiley, 2009.
- M. Pinedo, “Scheduling Theory, Algorithms, and Systems”, Prentice Hall, 2008.
- Fatos Xhafa, Ajith Abraham, Metaheuristics for Scheduling in Industrial and Manufacturing Applications ,978-3642097782, Springer; 1st ed. (November 23, 2010)

Course Code: IM 824

Course Title: Quality Design and Control

Credit Hours: 3

Course Description

This course introduces concepts and methods for quality design and control, including statistical process control (SPC), acceptance sampling, control charts, process capability, product and process design and improvement for reliability, Taguchi methods, case studies.

Course Objectives

To be able to build and manage an effective Quality Control system.

Course Topics

Week 1: The Evolution of Quality Design and Control
Week 2: Conceptual Framework for Quality Design and Control
Week 3: Statistical Methods and Probability Concepts for Data Characterization
Week 4: Conceptual Framework for Statistical Process Control
Week 5: Importance of Rational Sampling
Week 6: Statistical Thinking for Process Study: A Case Study
Week 7: Presentations and Evaluation of Project I
Week 8: Designing Quality Systems
Week 9: Quality Systems Audits
Week 10: Review of Quality System Design
Week 11: Design for Reliability
Week 12: Quality by Experimental Design
Week 13: Presentations and Evaluation of Project II
Week 14: Robust Design and Taguchi Method
Week 15: Revisions
Week 16: Final Exam

Textbooks

- Douglas C. Montgomery, Introduction to Statistical Quality Control, 6th edition (2009), ISBN: 978-0-470-16992-6, Publisher: John Wiley & Sons, Inc.
- Dale H. Besterfield, Quality Improvement, Pearson, 9th edition, (2013).
- Richard E. DeVor, Statistical Quality Design and Control: Contemporary Concepts and Methods, ISBN: 978-0-023-29180-7, Publisher: Pearson (1992).

Course Code: IM 825

Course Title: Total Quality Improvement

Credit Hours: 3

Course Description

This course presents several TQI frameworks, concepts, and quality improvement tools necessary for implementing the quality culture that characterizes world-class organizations of 21st century. The course examines the concepts of TQI as systematic process in the context of continuous improvement and quality management initiatives that improves customer satisfaction. It also covers methodologies and tools that will aid the students to understand how TQI can be used as a strategic tool that helps the organization achieve a competitive advantage in a global economy.

Course Objectives

This course aims to teach the student how to create both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. The course focuses on TQI results: increased productivity, efficiency, customer satisfaction/delight, and world-class performance.

Course Topics

Week 1: Introduction to Total Quality Improvement
Week 2: Overview of quality and its dimensions
Week 3: Quality Assurance and Auditing
Week 4: Obstacles in implementing TQI program in an organization
Week 5: How to Improve any Process
Week 6: How to Control any Process
Week 7: Role of employee team work for successful team Performance
Week 8: Performance Measures for TQI
Week 9: Quality Management System
Week 10: Statistical Process control for QI
Week 11: Advanced Product Quality Planning (APQP)
Week 12: Problem solving tools II
Week 13: Problem solving tools III
Week 14: Final Project, Report Submission & Presentations
Week 15: Revisions
Week 16: Final Exam

Textbooks

- Nancy R. Tague, The Quality Toolbox, Second Edition, ISBN: 978-0-87389-871-3, Publisher ASQ (2013)
- Duke Okes, Root Cause Analysis: The Core of Problem Solving and Corrective Action, ISBN: 978-0-87389-764-8, Publisher ASQ (2009)
- Fiorenzo Franceschini and Maurizio Galetto, Benchmarking in total quality management, Bradford, England, Emerald Group Pub. (2006).

Elective Courses Group 3

Course Code: IM 831

Course Title: Engineering Cost Analysis

Credit Hours: 3

Course Description

The course addresses the basics of cost estimation and cost control over the product life cycle. Break-even models and their uses in decision making. The relation between cost and the environmental impact of products and processes. It covers wide field of applications in industrial and service facilities and across supply chains.

Course Objectives

The student should be:

- Understand the basic cost estimation and control techniques.
- Apply the life cycle costing approach in decision making.
- Analyze break-even charts and use them in decision making.

Course Topics

Week 1: Introduction to Cost Elements.
Week 2: Cost Estimation Techniques: Universal Methods.
Week 3: Cost Estimation Techniques: Operation Method.
Week 4: Cost Estimation Techniques: Product Methods.
Week 5: Cost Estimation Techniques: Activity-based Costing.
Week 6: Life Cycle Costing Principles.
Week 7: Break-even Models: Part I.
Week 8: Break-even Models: part II.
Week 9: Budgeting.
Week 10: Cost Control.
Week 11: Cost and Environmental Aspects.
Week 12: Cost Management in Supply Chains: Part I.
Week 13: Cost Management in Supply Chains: Part II.
Week 14: Cost Management in Services.
Week 15: Application and Case Study.
Week 16: Final Exam

Textbooks

- J. V. Farr, Systems Life Cycle Costing. CRC Press, 2011.
- J.K. Shim and J. G. Siegel, Modern Cost Management & Analysis. Barron's Business Library, 2009.
- M. B. Baum, Service Business Costing: Cost Accounting Approach for the Service Industry, Gabler Verlag, Springer Fachmedien Wiesbaden, 2013.
- J. Anklesaria, Supply Chain Cost Management - The AIM & DRIVE Process for Achieving Extraordinary Results, AMACOM – Book Division of American Management Association, 2008.
- Gregory K. Mislick, Daniel A. Nussbaum, Cost Estimation: Methods and Tools, 978-1118536131, Wiley; 1 edition (May 4, 2015).

Course Code: **IM 832**

Course Title: **Risk Assessment and Management**

Credit Hours: **3**

Course Description

This course introduces mathematical models necessary and sufficient to formulate and solve problems arised in Assessment and Management of Different Industrial and Project Risks

Course Objectives

- To perform risk assessment for systems and projects.
- To analyze system behavior and perform fault analysis.

Course Topics

Week 1: Introduction and objectives of the course
Week 2: Probability and Its Application to Risk Assessment
Week 3: Project Risk Analysis and Management
Week 4: Project Risk Analysis and Management
Week 5: Aleatory and Epistemic Modeling
Week 6: Event Tree Analysis
Week 7: Event Tree Analysis
Week 8: FaultTree Analysis
Week 9: FaultTree Analysis
Week 10: Risk Matrix
Week 11: Modeling and Analysis of Common Cause Failures
Week 12: Risk Based Inspection
Week 13: Risk Based Inspection
Week 14: Human Reliability Anakysis
Week 15: Revisions
Week 16: Final Exam

Textbooks

- Marvin Rausand, Risk Assessment, Theory, Methods and Application, 2011, ISBN: 978-0-470-63764-7, Wiley.
- Paul Hopkin, Fundamentals of Risk Management, 3rd edtioon, 2014, ISBN-13: 978-0749472443 ISBN-10: 0749472448
- Probabilistic Risk Assessment, Procedures Guide for NASA Managers and Practitioners, Washington DC 20546, August 2002

Course Code: **IM 833**

Course Title: **Systems Safety Engineering and Management**

Credit Hours: **3**

Course Description

The course introduces the different types of hazards and injuries related to products and work environment. The course covers occupational safety and health standards, hazard analysis, accident prevention methods, and product safety and liability.

Course Objectives

The student should be:

- Identify the sources and type of hazardous in the work environment.
- Know the occupational and safety health standards.
- Assess the risk associated with workplace and product.
- Identify accident prevention methods.

Course Topics

Week 1: Introduction to System Safety, Hazards, Risks and Risk Reduction.
Week 2: Probability Safety Assessment (PSA).
Week 3: Hazard Analysis Types and Techniques.
Week 4: Failure Mode and Effect Analysis.
Week 5: Event Sequence Modeling.
Week 6: Fault Tree Analysis.
Week 7: Common Cause Failure Analysis.
Week 8: Risk Assessment.
Week 9: Occupational Safety and Health (OSHA) Regulations.
Week 10: Applications for PSA: Part I.
Week 11: Applications for PSA: Part II.
Week 12: Dynamic PSA.
Week 13: Uncertainty Analysis in Safety Assessment: Part I.
Week 14: Uncertainty Analysis in Safety Assessment: Part II.
Week 15: Case Study and Discussion.
Week 16: Final Exam

Textbooks

- C. A. Ericson, Hazard Analysis: Technique for System Safety. Wiley Interscience, 2005.
- R. C. Jensen, Risk-Reduction Methods for Occupational Safety and Health. Wiley, 2012.
- A. K. Verma, S. Ajit, and D. R. Karanki, Reliability and Safety Engineering. Springer, 2016

Course Code: IM 834

Course Title: Advanced Reliability Engineering

Credit Hours: 3

Course Description

This course introduces mathematical and computational models necessary and sufficient to formulate and solve problems of Systems Reliability

Course Objectives

- To evaluate reliability and avaialability of complex engineering systems.
- To understand the basic concepts of Failure Mode Effect and Criticality Analysis (FMECA)
- To design robust engineering systems.

Course Topics

Week 1: Fundamental Definitions and Expressions of Reliability Engineering
Week 2: Reliability and Availability of Complex Systems by Monte Carlo simulation
Week 3: Reliability and Availability of Complex Systems by Monte Carlo simulation
Week 4: Optimum Reliability Allocations
Week 5: Computational Intelligence in Reliability Engineering
Week 6: Optimization of Preventive Maintenance Intervals in case of Perfect and Imperfect Maintenance and Repair
Week 7: Midtrem exam
Week 8: Reliability Analysis based on Fuzzy Variables
Week 9: Failure Mode Effect and Criticality Analyses (FMECA)
Week 10: Failure Mode Effect and Criticality Analyses (FMECA)
Week 11: Robust System Design
Week 12: Reliability and Availability of Repairable Systems
Week 13: Reliability and Availability of Repairable Systems
Week 14: Human Reliability Analysis
Week 15: Revisions
Week 16: Final exam

Textbooks

- Igor Bazovsky, (2004), Reliability Theory and Practice, Dover Publications.
- Marvin Rausand, (2004), System Reliability Theory, Wiley-Blackwell.
- Smith D. J. (2005), Reliability, Maintainability and Risk, Butterworth-Heinemann.

Elective Courses Group 4

Course Code: **IM 841**

Course Title: **Discrete Systems Simulation**

Credit Hours: **3**

Course Description

This course covers the modern methods for simulating discrete event models of complex stochastic systems. Topics covered include the proper collection and analysis of data, the use of analytic techniques, verification and validation of models, and designing simulation experiments. Furthermore, it presents the application of modelling and simulation in manufacturing and material handling systems, and service industries.

Course Objectives

By the end of this course students should be able to:

- Learn the concepts and techniques required to build sound simulation models using computers.
- Simulate various popular industrial engineering problems using spreadsheets.
- Develop simulation models an advanced simulation package (ExtendSim).
- Apply the learnt simulation concepts to a real-life problem (individual project).

Course Topics

Week 1: Introduction to Modelling and Simulation
Week 2: Steps in a Simulation Study
Week 3: Monte Carlo Simulation
Week 4: Spreadsheet Simulations
Week 5: Principles of DESS
Week 6: Input Modelling
Week 7: Mid-Term Exam
Week 8: Random-Number and Random Variate Generation
Week 9: Introductory Simulation Examples using ExtendSim
Week 10: ExtendSim Labs and Case Studies 1
Week 11: ExtendSim Labs and Case Studies 2
Week 12: ExtendSim Labs and Case Studies 3
Week.13: Verification, Calibration, and Validation of Models
Week 14: Output Analysis
Week 15: Individual Project Presentation and Final Report Submission
Week 16: Final Exam

Textbooks

- J. Banks, et al. “Discrete Event System Simulation”; Prentice-Hall, 2010.
- Averill Law and W. David Kelton. “Simulation Modelling and Analysis”; McGraw-Hill, 2015., 5th edtion. New York,NY:McGraw-Hill Education.
- W. D. Kelton, et al. “Simulation with Arena”; McGraw-Hill, 2010.
- C. Harrell, et al. “Simulation Using ProModel”; McGraw-Hill, 2004.
- Gabriel A. Wainer, Discrete-Event Modeling and Simulation: A Practitioner's Approach, 978-1420053364, CRC Press; 1 edition (December 21, 2017)
- Laguna and Marklund; “Business Process Modelling, Simulation, and Design”; Prentice-Hall, 2004.

Course Code: **IM 842**

Course Title: **Statistical Aspects of Digital Simulation**

Credit Hours: **3**

Course Description

This course reviews the basic concepts of statistics and fundamentals of simulation concepts. The topics covered in this course are queueing models, input data analysis, random number generation, random variate generation, verification and validation of simulation models, Statistical analysis of output for a single model, Output analysis for terminating simulations, Output analysis for steady state simulations, Simulation experimentation, Comparison and evaluation of alternatives, and Variance reduction techniques.

Course Objectives

- To ensure the basic techniques for modelling and simulating industrial systems in the presence of uncertainty.
- To understand the major capabilities and limitations of simulation as applied to industrial problems.
- To apply simulation to model and analyze engineering design problems.

Course Topics

Week .1: Review of basic probability and statistics
Week .2: Fundamental simulation concepts
Week .3: Queueing models
Week 4: Input data analysis
Week 5: Random number generation
Week.6: Random variate generation
Week 7: Verification of simulation models
Week 8: Validation of simulation models
Week 9: Statistical analysis of output for a single model
Week 10: Output analysis for terminating simulations
Week 11: Output analysis for steady state simulations
Week 12: Simulation experimentation
Week 13: Comparison of alternatives
Week 14: Evaluation of alternatives
Week 15: Variance reduction techniques
Week 16: Final Exam.

Textbooks

- J. Banks, J.S.Carson, B.L.Nelson, and D.M.Nicol, “Discrete Event System Simulation”, Prentice Hall, 2005.
- W. D. Kelton, et al. “Simulation with Arena”; McGraw-Hill, 2010.
- Averill Law and W. David Kelton. “Simulation Modelling and Analysis”; McGraw-Hill, 2015., 5th edtion. New York,NY:McGraw-Hill Education .
- S.Robinson, “Simulation: The Practice of Model Development”, Wiley, 2003.
- Gabriel A. Wainer, Discrete-Event Modeling And Simulation: Theory And Applications ,978-1420072334, T&F India (2011).

Course Code: **IM 843**

Course Title: **Life Cycle Engineering**

Credit Hours: **3**

Course Description

This course introduces the basic concepts and tools of Life Cycle Engineering (LCE), which is mainly concerned with the environmental and economic assessment of products throughout its life cycle. The course discusses the basic aspects of LCE, specifically Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) focusing on the modeling techniques, and standardized methods. The course finally introduces the concept of eco-efficiency of products and systems, which is an indicator for product/process economic and environmental performance.

Course Objectives

To assess the environmental and economic impacts associated with a product throughout its life cycle from design, through production and usage to its end-of-life options.

Course Topics

Week 1: Introduction: Life Cycle Thinking, Engineering and Sustainability
Week.2: Life Cycle Modeling
Week.3: Life Cycle Assessment: Goal and Scope Definition
Week.4: Life Cycle Assessment: Life Cycle Inventory Analysis
Week.5: Life Cycle Assessment: Impact Assessment
Week.6: Life Cycle Assessment: Interpretation
Week.7: Software for Life Cycle Assessment
Week.8: Uncertainty Management in Life Cycle Assessment
Week.9: Life Cycle Assessment Case Study
Week 10: Components of Life Cycle Model
Week.11: Estimating Life Cycle Costs
Week.12: Costing of Complex Systems
Week.13: Life Cycle Costing Case Study
Week.14: Eco-efficiency of Products and Processes
Week.15: Revisions
Week 16: Final Exam

Textbooks

- Micheal Z. Hauschild, Ralph K. Rosenbaum, and Stig Irving Olse, (Eds.), Life Cycle Assessment, Springer International Publishing, (2018).
- Jörg Niemann, Srge Tichkiewitch, and Engelbert Westkämper, (EDs.), Design of Sustainable Product Life Cycles, Springer Verlag Berlin Heidelberg (2009).
- V. Ratna Reddy, Mathew Kurian, and Reza Ardakanian, Life-cycle Cost Approach for Management of Environmental Resources, Springer, (2015).
- John Vail Farr, Systems Life Cycle Costing, ISBN-978-0-07-352345-3. MHID 0-07-352345-3, Publisher: CRC Press, Taylor & Francis Group, (2011).

Course Code: IM 844

Course Title: Design of Experiments and Applications in Decision Analysis

Credit Hours: 3

Course Description

This course introduces the application of the three basic techniques of experimental design (Replication, Blocking and Randomization) in solving problems of Decision Making .

Course Objectives

- To understand the basic concepts of design of experiments.
- To be able to perform factorial design and to interpret the results.
- To apply Response Surface Methodolgy for different enginnering problems.

Course Topics

Week 1:	Introduction to basic concepts of comparative experiments
Week 2:	Analysis of Variance
Week 3:	Latin Square Design
Week 4:	Factorial Design
Week 5:	Factorial Design
Week 6:	2^K Factorial Design
Week 7:	Blocking and Comfounding
Week 8:	Fractional Factorial Design
Week 9:	Regression Models
Week 10:	Response Surface Methodolgy in Process and Product Optimization
Week 11:	Response Surface Methodolgy in Process and Product Optimization
Week 12:	Process Robustness
Week 13:	Uncertain Factors
Week 14:	Uncertain Factors
Week 15:	Revisions
Week.16:	Final Exam.

Textbooks

- D. C. Montgomery (2005),Design and Analysis of Experiments, John Wiley &Sons
- Khuri A. I. and J. A. Cornell (1996), Response Surface Designs and Analyses, Dekker, New York
- Myers R. H. and Montgomery D.C (2002), Response Surface Methodology: Process and Product Optimization Using Designed Experiments, Wiley, New York

Course Code: **IM 845**

Course Title: **Sustainable Supply Chains**

Credit Hours: **3**

Course Description

This course introduces sustainability within supply chain management field by addressing the economic, environmental, and social aspects of sustainable supply chains. It provides a guide for decisions made along different supply chain operations and/or phases including product design, sourcing, manufacturing, packaging and physical distribution, reverse logistics and recovery. It also presents sustainability measurement and risk management for sustainable supply chains.

Course Objective

- To understand the basic concepts underlying sustainable supply chains.
- To design and manage sustainable supply chains.
- To assess economic, environmental, and social sustainability of supply chain operations.

Course Topics

Week.1: Introduction and Course Overview.
Week.2: Sustainable Supply Chain Management.
Week.3: The Economic Aspect of Sustainable Supply Chain Management.
Week.4: The Environmental Aspect of Sustainable Supply Chain Management.
Week.5: The Social Aspect of Sustainable Supply Chain Management.
Week.6: Measuring Sustainability.
Week.7: Sustainability and New Product Design.
Week.8: Sustainability and Procurement.
Week.9: Sustainability and Production.
Week 10: Sustainability and Inventory Management.
Week.11: Sustainability and Logistics, Physical Distribution and Packaging.
Week.12: Reverse Logistics Management and Closed-Loop Supply Chain.
Week.13: Risk and Uncertainty Management for Sustainable Supply Chains.
Week.14: Moving from a Product-Based Economy to a Service-Based Economy for a more Sustainable Future.
Week.15: Revision.
Week.16: Final Exam.

Textbooks

- Joëlle Morana, Sustainable Supply Chain Management, ISBN: 978-1-118-60413-7, Wiley (May 2013).
- Valeria Belvedere and Alberto Grando, Sustainable Operations and Supply Chain Management, ISBN: 978-1-119-28537-3, Wiley (January 2017).
- Bouchery, Y., Corbett, C.J., Fransoo, J.C., and Tan, T., Sustainable Supply Chains, ISBN: 978-3-319-29791-0, Springer, 1st Edition (2017).